IBES DISKUSSIONSBEITRAG
Institut für Betriebswirtschaft und Volkswirtschaft

Nr. 223

JANUAR 2018

Development and Prospects of Standardization in the German Municipal Wastewater Sector

Version 1.0

Claudia Freimuth, M.Sc.
Prof. Dr. Mark Oelmann
Prof. Dr. Erwin Amann

WIWI INF
FAKULTÄT WIRTSCHAFTSWISSENSCHAFTEN
UNIVERSITÄT DUISBURG ESSEN

IBES DISKUSSIONSBEITRAG

Nr. 223

JANUAR 2018

Development and Prospects of Standardization in the German Municipal Wastewater Sector

Version 1.0

Claudia Freimuth, M.Sc. (claudia.freimuth@uni-due.de)

Prof. Dr. Mark Oelmann (mark.oelmann@hs-ruhrwest.de)

Prof. Dr. Erwin Amann (erwin.amann@uni-due.de)

Impressum: Institut für Betriebswirtschaft und Volkswirtschaft (IBES)

Universität Duisburg-Essen

Universitätsstraße 12

45141 Essen

E-Mail: IBES-Diskussionsbeitrag@medman.uni-due.de

Contents

Abstract*

Given the significance of wastewater treatment and disposal for society and the economy together with the omnipresence of standards in the sector, we studied the development and prospects of the rules governing the formal standardization in the German municipal wastewater sector.

We find that the German Association for Water, Wastewater and Waste (DWA) has significantly improved its rules on standardization over time by aligning them closer to the generally accepted superordinate standardization principles. However, by focusing on theoretical findings of committee decision-making and committee composition, we argue that there is still significant scope for improvement with respect to rule reading and rule compliance. We show that the incentives at work in standardization committees are manifold, whereas the representation of the different stakeholder groups needs' remains unbalanced.

Due to vested interests and potential strategic behavior of the various agents involved in standardization rule compliance does not happen naturally. To this end, we claim that the implementation of monitoring or control mechanisms, respectively, can be a significant contribution to the institutional design of standardization and briefly discuss the advantages and disadvantages of external and internal monitoring. Finally, we show that there is ample need for future research on the optimal design of such a scheme.

Even though the analysis relates specifically to the DWA our claims apply to a wide range of standards development organizations.

* The project was supported by the Ministry of Innovation, Science and Research of North Rhine-Westphalia (MIWF NRW) as part of the Fortschrittskolleg NRW: FUTURE WATER coordinated by the Center of Water and Environmental Research of the University of Duisburg- Essen (ZWU). The authors thank the German Association for Water, Wastewater and Waste (DWA e.V.) for their helpful support and the provision of valuable information.

1 Introduction

Formal standards are a necessary means of structure and, hence, are essential to a well-functioning economy, even more so in a world of increasing technological variety and complexity. Moreover, standards are not neutral technical descriptions and instructions, but rather arise as a result of complex negotiation processes. (Mai, 2011) Amongst others, incentives, bargaining power, intrinsic motivation, incomplete or asymmetric information as well as personal judgment of the parties concerned, influence the standardization process and, hence, ultimately the outcome. The development of formal standards takes place in so called standards development organizations (SDOs). These are

> multifaceted institutions, and there is no standard economic model of how they work. (Simcoe, 2014)

The standardization process is shaped by widely accepted general principles, their specification within the SDOs' as well as standardization culture within these SDOs. For the German municipal wastewater sector the German Association for Water, Wastewater and Waste (DWA, Deutsche Vereinigung für Wasser, Abwasser und Abfall) is the most important SDO. With the wastewater sector exhibiting several features which make standards and standardization an issue of particularly high relevance, our analysis' focus is on the DWA.

Public sanitation constitutes a service of general interest and is accordingly within the responsibility of the public sector. In fact, it is a sovereign responsibility of the municipalities and is as such for the most part also undertaken by utilities under public law of which owner-operated municipal utilities and special-purpose as well as water associations constitute the largest fraction. In total the German wastewater sector is highly fragmented with over 6,900 wastewater disposal utilities. (ATT, 2015) The regulatory framework is set in accordance with the federal structure of Germany by the Bund and completed by the Länder. It is of course also bound to implementation of European law. Unlike other network industries, such as the electricity, gas, telecommunications, post and railway sectors, it is, however, not regulated by the Bundesnetzagentur. Moreover, the DWA and the German Association of Energy and Water Industries (BDEW, Bundesverband der Energie- und Wasserwirtschaft) have a comparatively high influence.

Several further features, characteristic to the wastewater sector, make it valuable to conduct a sector specific analysis. Firstly, Wastewater disposal and treatment is of major significance to the economy and society. As an important part of the environmental sector it clearly influences economic welfare. At the same time, it has direct influence on individual well-being. The increasing demand for health but also environmental protection measures as well as the growing need for fostering sustainability greatly impact on the wastewater sector and vice versa. Sustainability in a holistic sense may, however, only be facilitated if ecological and social goals are reached cost- and resource-efficiently. Secondly, the centralized municipal wastewater sector constitutes a natural monopoly. A market is said to be a natural monopoly

if meeting demand is costlier in the case of multiple firms than in the case of a single firm. To this end, there are hardly any means counteracting the disregard of efficiency considerations in the development of standards. Whereas, market forces counterbalance these effects in competitive sectors, in sectors like wastewater there exists a tendency to overvalue effectiveness, since this improves the reputation of SDOs as well as public utilities and additional costs can be transferred to customers comparably easily. (Oelmann, 2005) In addition, with wastewater utilities being local monopolies together with the legal obligation for connections to the sewage system, particular attention is due to the incentives to innovate in the wastewater sector. Thirdly, with public sanitation being part of the public sector, public procurement and its interrelation with technical standards play a particularly significant role.[1]

The strand of economic literature on standardization in general[2] began to evolve — apart from a few early exceptions — in the mid-1980s. In particular, the author teams Katz and Shapiro (e.g., 1985, 1986) and Farrell and Saloner (e.g., 1985, 1986) but also David (1985) motivated the development. Swann (2000) subdivides the literature into eight areas. The early literature focuses mainly on (1) the classification of standards and (2) their development in market- based processes. Work on (3) standardization in SDOs and (4) the comparison of the two approaches was intensified in the late 1990s. Likewise, (5) standard diffusion and the effects of standards on (6) the macro-economy, (7) companies, and (8) consumers was not the field of attention of the early studies. Recently, the number of studies addressing more than one of these areas at the same time seem to be on the rise. Blind and Gauch (2009), for example, in their study on standardization in nanotechnology, develop a new classification scheme linking functional categories to stages in the innovation process (1&7). Wiegmann et al. (2017), as another recent example, explicitly target the issue of multi-mode standardization, i.e., standardization processes that combine at least two of the following modes: market-based standardization, committee-based standardization, and government-based standardization (2,3,4).

Whereas the main body of sector-specific analyses focuses on the ICT sector, Böhm et al. (1998) is the only comprehensive study the authors are aware of on standardization in the (German) wastewater sector. Böhm et al. (1998) conclude that the net effect of standards in the wastewater sector is positive and, hence, that the question is not whether to go ahead with standardization but rather on how to minimize the shortcomings of the current standardization scheme. In their analysis they distinguish between coordinating and regulating standards and show that the DWA is the main standardizing body with respect to the latter. Whereas coordinating standards act predominantly decreasing on production and transaction costs through ensuring compatibility and conformity, regulating standards may have a market

[1] Concerning the ambit of the DWA in particular public procurement in the area of construction services are relevant. In fact, the DWA recently published a Merkblatt on tendering and evaluation of bids for construction services. (DWA, 2017a)

[2] For a comprehensive literature review see, e.g., Swann (2000) together with (Swann, 2010).

foreclosure effect by explicitly targeting products, processes and services related to the planning, construction, operation and maintenance of facilities.

Given the fact that there has been no thorough wastewater sector specific study following Böhm et al. (1998) and that the DWA is celebrating 60 years of standardization in 2017 we believe that it is just the right time to take a closer look at the development and prospects of the standardization landscape in the German municipal wastewater sector. In addition, the 2016 draft for a new standard governing the rules and procedures (DWA, 2016) of the DWA exhibits several amendments to the current version. Not least this highlights that standardization procedures are not absolute and far from trivial.

Hence, the aim of this paper is to analyze the development and prospects of standardization practices in the German municipal wastewater sector by focusing on the rules governing the formal standardization process in the DWA. From there we highlight the complexity of the standardization process and the significant influence of the design and conduct of the standardization process on the resulting standards. Finally, we argue that, no matter how sophisticated the rules on standardization may be, improvements with respect to rule reading and rule compliance can still be made and deduce that this does not happen naturally, such that a monitoring scheme appears to be a natural prerequisite. Yet, even though the analysis relates specifically to the DWA our claims apply to a wide range of SDOs.

The paper is structured as follows. Section 2 sets the general scene and is followed by a brief description of the main standardization bodies in the German Municipal Wastewater Sector (section 3). The DWA rules for standards development are addressed in section 4 by describing their current state (section 4.1), elaborating on their development (section 4.2) and giving an outlook on the currently planned amendments to the rules (section 4.3). Section 5 analyzes committee decision-making and composition on theoretical grounds. In section 6 possible improvements in the form of the adoption of a monitoring and control scheme are discussed and areas requiring further research are highlighted. Section 7 concludes.

2 General Considerations

2.1 Basic Legal Framework

The German standards landscape is characterized by technically highly sophisticated standards in conjunction with high compliance rates although their adoption is voluntary by definition. Technology Law is to a large extent confined to specifying essential protection targets. Standardization then serves as a means of specification. Hence, standardization takes place at the interface between state and industry. This cooperation principle is in fact one of the main pillars of the German as well as the European Technology Law.

Standards may be integrated into legal norms by means of direct incorporation, direct references (i.e., references to a specific standard of a certain date), dynamic references (i.e., references to a specific standard as currently applicable), or blanket clauses (i.e., non-descript

legal terms like Generally Acknowledged Rules of Technology)[3]. The latter is a widely used method in German legislation, not least due to the relieving of burden to government. Meeting Generally Acknowledged Rules of Technology does not necessarily equate to complying with certain standards. Non-standardized processes, products and services may likewise fulfill the necessary requirements. However,

> by virtue of their status as standards, their public availability and their amendment or revision as necessary to keep pace with the state of the art, international, regional, national and provincial standards (...) are presumed to constitute acknowledged rules of technology. (DIN EN 45020:2007-03)

Serving as a universal language together with a strict and complex structure of legal consequences of defective products, standards foster reliability and enforceability of contracts. Given the legal framework, formal standards become quasi-binding. Exceptions to adoption being — at least in the wastewater sector rare. The quasi-bindingness is intensified by European standardization in the course of the so called New Approach. The New Approach seeks the harmonization of legal norms with respect to essential protection targets and targets concerning the common weal. Primarily, these targets are related to health and safety issues. The definition of technical specifications in line with these targets are then with the official SDOs. To put it in the words of Borraz (2007),

> the concept of risk became a vehicle for the setting of standards. (Borraz, 2007)

For these standards conformity is presumed. Since the burden of proof concerning the fulfillment of the targets is with the producers, the incentives to deviate from the standards are in general small. Additionally, the harmonization of European standards in fulfillment of the single market, will certainly drive back the influence of national SDOs. Kloepfer (2011) Yet, due to the ambit of the DWA and the structure of the wastewater industry the DWA is presumably less prone to this effect.

In any case, neither the German nor the European cooperation principle are free from criticism. There are clearly several reasons in favor of this approach, not least concerning the relief of burden to government or high legitimacy. Nevertheless, striking the right balance between the different responsibilities is a topic to bear in mind.

Cabral and Salant (2014), for example, show that a mandated standard — in this case for second generation wireless telecommunications by the EU — is only socially beneficial if consumers significantly suffer from the existence of several standards and at the same time firms' profits and consumer welfare are misaligned. They, hence, argue for the decision on government intervention on a case-by-case basis.

[3] See, e.g., Reinhardt (2012).

Blind et al. (2017) show that standards as opposed to regulation negatively impact on innovation in markets with low uncertainty and vice versa. In their analysis market uncertainty is related to the perception of the predictability of technological developments in the market together with the possibility to pre- assess the benefits of a product before purchase. In comparison with other sectors, like for example the ICT sector, uncertainty in the wastewater sector with its long-lasting infrastructure, exhibits less uncertainty (even though it has surely increased in recent years — and will continue to increase — due to, e.g., digitalization or the necessity of the industry to adapt to the consequences of the climate change). Wiegmann et al. (2017) in their study on multi-mode standardization argue, that such circumstances foster committee- and government-based standardization. Furthermore, they postulate that in any case multi-mode standardization will become more important and frequent in the future. In fact, in the wastewater sector the interdependencies between governmental regulation and committee-based standardization are already particularly pronounced, with wastewater disposal and treatment being closely linked to safety, health and environmental — and, hence, essential protection — targets.

Not least, standards play also a significant role in public procurement. German Procurement Law clearly demands the use of formal standards in specification for tenders.[4] The adoption of standard in public procurement tenders affords the opportunity to push innovation. Yet, there are also drawbacks: Standards will only immediate a positive impact if appropriate standards are incorporated in tenders. This in turn requires profound knowledge on the relevant market and technologies. (Blind, 2017)

A fortiori, the development of efficient — as opposed to (solely) technically effective — standards is of major importance.

2.2 Classification of Standards

When analyzing standards and standardization it is, however, important to bear in mind that not all standards are alike. It is necessary to distinguish between different categories within the heterogeneous and complex array of standards. To account for the fact that our analysis does not apply to the entire range of standards and standardization activities, yet to a significantly wider range than DWA standards and standardization, the following section identifies the relevant class(es) of standards for the problem at hand.

With respect to their origin we are concerned with formal standards. Formal standards are developed on conscious grounds within committees of recognized SDOs in consensus-based processes. According to the European and, hence, also German standard DIN EN 45020 Standardization and Related Activities General Vocabulary a

> standard is a document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules,

[4] See, e.g., 7a VOB/A (Construction Tendering and Contract Regulations/*Vergabe- und Vertragsordnung für Bauleistungen – Teil A*).

> guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. NOTE Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits. (DIN EN 45020:2007-03)

From this it can be deduced, that good standards strike the balance between order and freedom in favor of the common weal.

There also exist conscious standards not developed in SDOs, namely govern- mental standards or so called de facto standards stemming from other parties such as companies or industry consortia. Even if standards are not developed due to conscious decisions they may still evolve due to historical or factual circumstances. (Vries, 1998, 1999b) Closely related is the distinction of standards according to their mode of development. Standards may be the outcomes of committee-based, market-based, governmental-based or multi-mode standardization. (Wiegmann et al., 2017)

Considering standardization as solving a matching problem between entities — with entities being subjects, concrete objects, abstract objects or any combination of such — the entity-related classification of the standards landscape comprises of the following categories of standards (Vries, 1998, 1999b):

1) Basic standards
2) Requiring standards
    a) Performance standards
        i) Interference standards
        ii) Quality standards
    b) Solution-describing standards
        i) Interference standards
        ii) Compatibility standards
            (1) Horizontal compatibility
            (2) Vertical compatibility
        iii) Quality standards
3) Measurement standards

Whereas basic standards are of descriptive, requiring standards are of prescriptive nature. Measurement standards, in turn, specify methods in procedures in order to test adherence to requiring standards, which may be sub-divided into output-related performance and input-related solution-describing standards. Both categories comprise of interference and quality standards, the latter also of compatibility standards. Interference standards are concerned with the effect of an entity to one or more other entities, prominent examples being health, safety, and environmental standards. Quality standards, on the other hand, are concerned with securing that entities fulfill certain properties. Finally, compatibility standards seek to ensure

that different entities of the same functionality (horizontal compatibility) or of different functionalities (vertical compatibility) work together without interference.

The classification adopted by Böhm et al. (1998), the only existing detailed analysis of standardization in the (German) municipal wastewater sector, distinguishes between coordinating and regulating standards:

- Coordinating standards attempt to achieve compatibility as well as conformity of terminology, metrology and measurement. In sum, they act predominantly cost decreasing through creating positive externalities, facilitating the exploitation of economies of scale and reducing transaction costs.
- Regulating standards, by contrast, are primarily concerned with the protection of life, health, material goods and the environment. In the case of municipal wastewater disposal and treatment they primarily relate to the planning, construction, operation and maintenance of wastewater facilities.

Transferred to the scheme of Vries (1998, 1999b) coordinating standards comprise of basic and measurement plus compatibility standards, whereas the regulating standards coincide with requiring standards without compatibility standards.

What follows builds for reasons of comparability on the distinction of Böhm et al. (1998), yet the adoption of the entity-related scheme would not alter our findings.

Moreover, several approaches have been adopted concerning a categorization according to the functions of standards. According to Swann (2000), Tassey (2000) and Blind (2004) there are four main categories, namely compatibility and interface, minimum quality and safety, variety-reducing and information and measurement standards.[5]

Blind and Gauch (2009) relate these to the innovation process. Whereas information standards, like terminology, standards are necessary even in basic research and in the transmission from basic to oriented basic research, measurement and testing standards become particularly important in transferring knowledge from oriented basic research to applied research. For the facilitation of experimental product or process development interface standards are required to enable the use with other necessary, possibly already existing, components or technologies. For successful commercialization and, hence, diffusion compatibility, quality, and variety-reducing standards are of major importance, i.e., in the entity-related classification scheme of Vries (1998, 1999b) it is the class of requiring standards which play an important role concerning the (failure or success of) the transition from the pilot phase to market introduction and diffusion. In turn, obviously, there will also be a feedback loop from standardization to research and, thus, innovation.

[5] Cf. Jänchen (2008) for an adapted version; cf. Swann (2010) for a more detailed categorization.

Recently Egyedi and Ortt (2017) developed a functional classification scheme disentangling further the different functions of standards. They draw a distinction between primary and secondary functions and relate these to inner workings, generic effects and effects specific to innovation and diffusion. Primary functions are functions inherent to all types of standards, namely variety reduction and information. Secondary functions, on the other hand, are specific to certain standards and, thus, can serve as means of categorization. These secondary functions are compatibility (including the specification of interfaces, complements and substitutes), measurement (including minimum requirements and measurement methods), classification and the specification of behavior protocol.

3 Standardization in the Municipal Wastewater Sector

3.1 Standards Development Organizations in the Wastewater Sector

The two main SDOs in the German municipal wastewater sector are the German Institute for Standardization (DIN, Deutsches Institut für Normung)[6] and the DWA. Within the German waste water sector there is no official distribution of responsibilities concerning areas of standardization. The standards of both organizations are tantamount to each other.[7] Yet, there is an apparent tendency for the DWA to focus on standards specifying design principles, dimensions as well as the operation and performance of wastewater facilities and for the DIN to focus on standards specifying terms and symbols, measurement techniques and uniform measures, quality levels and delivery conditions, thereby facilitating and coordinating activities by focusing on compatibility and interface requirements.

In line with this, Böhm et al. (1998) provide due evidence that, in sum, the DWA is with respect to regulating standards the main actor in the wastewater standardization landscape.[8] Since mainly regulating standards are prone to causing negative economic effects the focus here is on the DWA.

3.2 German Association for Water, Wastewater and Waste (DWA)

The DWA originated in the merger of the Association for Wastewater Technology (ATV, Abwassertechnische Vereinigung) and the German Association for Water Resources and Land

[6] The DIN and the Federal Republic of Germany signed an agreement in 1975 (DIN and Federal Republic of Germany, 1975) establishing a public-private partnership by which the DIN became the official German standardization organization and to this end the only SDO (together with the German Commission for Electrical, Electronic and Information Technologies of DIN and VDE — DKE, *Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDE*) in Germany allowed to represent Germany in European and international standardization.

[7] There exists, however, a cooperation between DIN and DWA in specific circumstances in order to ensure coherent standards across the field. Presumably this will become increasingly important due to the intensification of European and international standardization.

[8] Even though the evidence given by Böhm et al. (1998) is based on data from approximately 20 years ago, there is due reason to assume that the general statement is still valid. The gathering and analysis of up-to-date data is beyond the scope of this paper, albeit desirable.

Improvement (DVWK, Deutscher Verband für Wasserwirtschaft und Kulturbau), on January 1, 2000. The ATV on its part was founded on May 10, 1948, the DVWK on October 5, 1978. For the most part, the ATV is considered the main predecessor of the DWA.

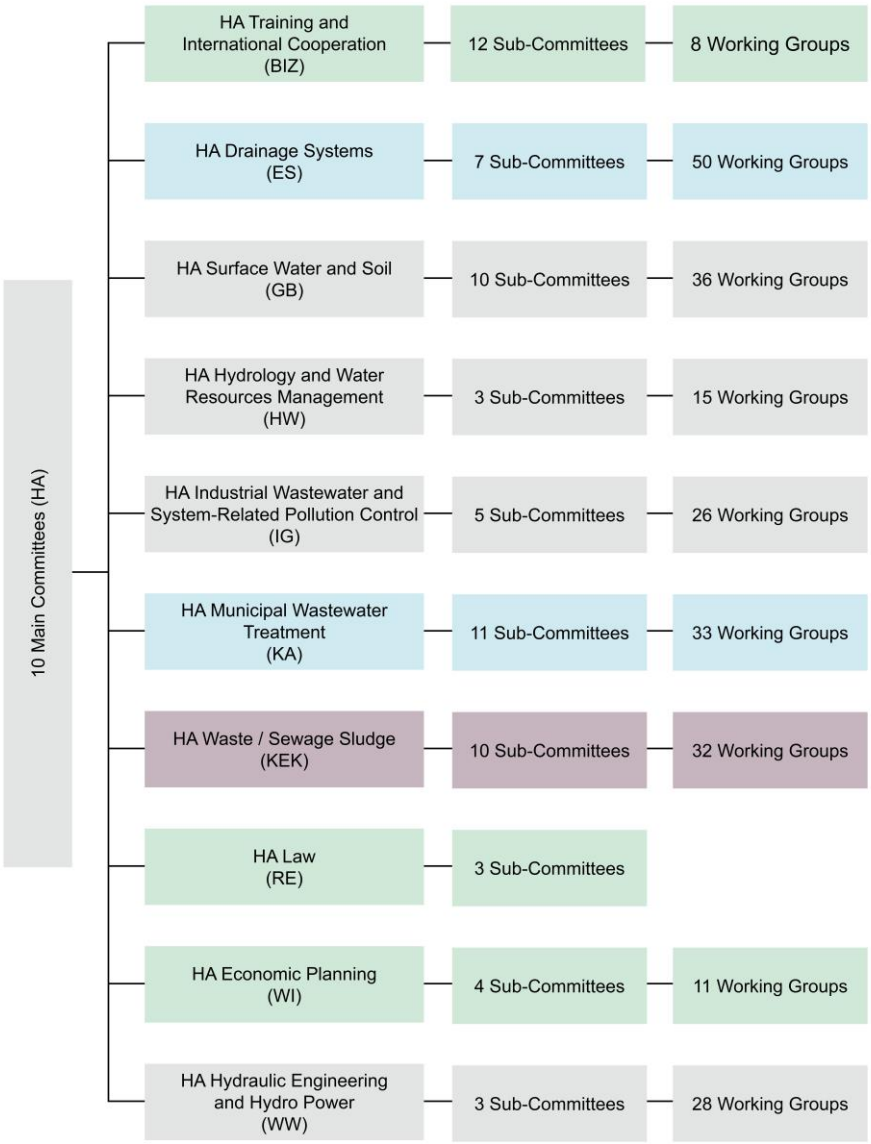
The intentions of founding the ATV were manifold and covered amongst others the pooling and coordination of knowledge, the defense of the interests of the association as well as its members and training of operating personnel. Yet, already from the outset standardization was one of the main concerns. On February 2, 1957, the first four ATV standards[9] were published. (DWA, 2005) Yet, it was not until 1984 that the ATV published its first version of ATV- A 400 (ATV, 1984) the principles for the preparation of rules and standards and, hence, officially institutionalized its standardization process (see Section 4.2). Beforehand, however, a less elaborate process was laid out in the Rules of Procedure for the expert committees (ATV, 1970, 1973, 1983) and even before that in the Articles of the ATV.

The DWA is under the legal form of a registered association and, thus, it constitutes a legal entity and must not pursue a commercial purpose. As of December 2016 the DWA has 14,056 members, of which 60% are individual members and 40% are corporate members (DWA, 2017c). As laid down in the Articles of the DWA (DWA, 2017b) one of its main tasks is the development, updating and publication of the Set of Rules and Standards.[10] The standardization activities take place in a total of 322 main committees, sub-committees and working groups. Within these committees more than 2,500 voluntary experts are actively taking part in the DWA's standardization activities. (see Figure 1).

Out of the ten main committees three are directly concerned with municipal wastewater disposal and treatment, i.e., HA ES Drainage Systems, HA KA Municipal Wastewater Treatment (depicted in blue), and HA KEK Waste/Sewage Sludge (purple) on its part on sludge. HA BIZ Training and International Cooperation, HA RE Law and HA WI Economic Planning (green) deal with superordinate issues. The latter was established in 1998. Its establishment is not least a sign of an increasing awareness for the need to approach standards interdisciplinarily.

[9] These were namely ATV-A 101 Planung einer Ortsentwässerung (Grundlagen und Hinweise) (ATV and KfK, 1957a), ATV-A 102 Industrie und Gewerbebetrieb, allgemein, Planung einer Abwasserableitung und Abwasserbehandlung (Grundlagen und Hinweise) (ATV and KfK, 1957b), ATV-A 103 Milchverarbeitender Betrieb, Planung einer Abwasserableitung und Behandlung (Grundlagen und Hinweise) (ATV and KfK, 1957c) and ATV-A 104 Lederbetrieb, Planung einer Abwasserableitung und Abwasserbehandlung (Hinweise und Grundlagen) (ATV and KfK, 1957d).

[10] Additionally, the DWA pursues the following tasks: representation of common concerns of the water and waste sectors, monitoring and support of the water and waste sectors, contribution to the development of standards within the meaning of the German term *Normen* (i.e., DIN standards, but also European and international standards), educational activity, cooperation with organizations engaged in related subjects as the DWA, promotion of research and publication of research results, as well as exchange of information and views with representatives from politics, industry and science.



Source: Own illustration based on DWA (nd, Fachgremiennavigation)

Figure 1: Structure of the DWA Standards Development Committees

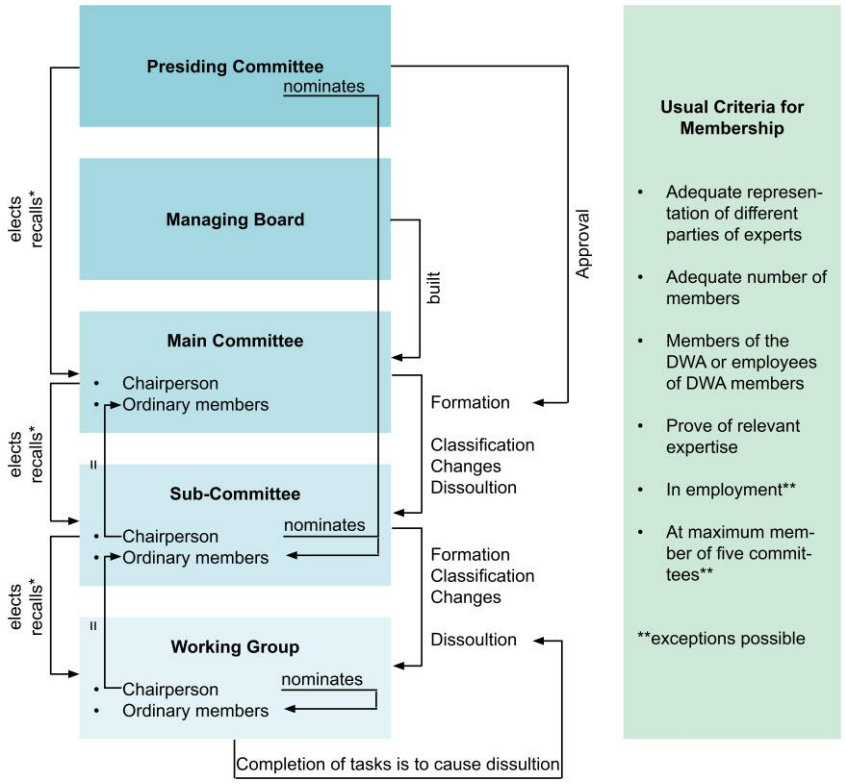
4 Development and Prospects of the DWA Rules for Standards Development

4.1 Current Rules for Standards Development

The DWA Set of Rules and Standards comprises of two types of documents: standards (Arbeitsblätter) and advisory leaflets (Merkblätter). The latter are not standards as such. They lack the required degree of acceptance and prove in practice. In addition, the development

process does not necessarily include a full-fledged public enquiry process (yet). Hence, the following analysis deals solely with the so-called Arbeitsblätter.

The current standardization procedures at the DWA are governed by DWA-A 400 effective from January 2008 (DWA, 2008) and the Rules of Procedure for the DWA Expert Committees (Geschäftsordnung für die Fachgremien) effective from January 2013 (DWA, 2013a).

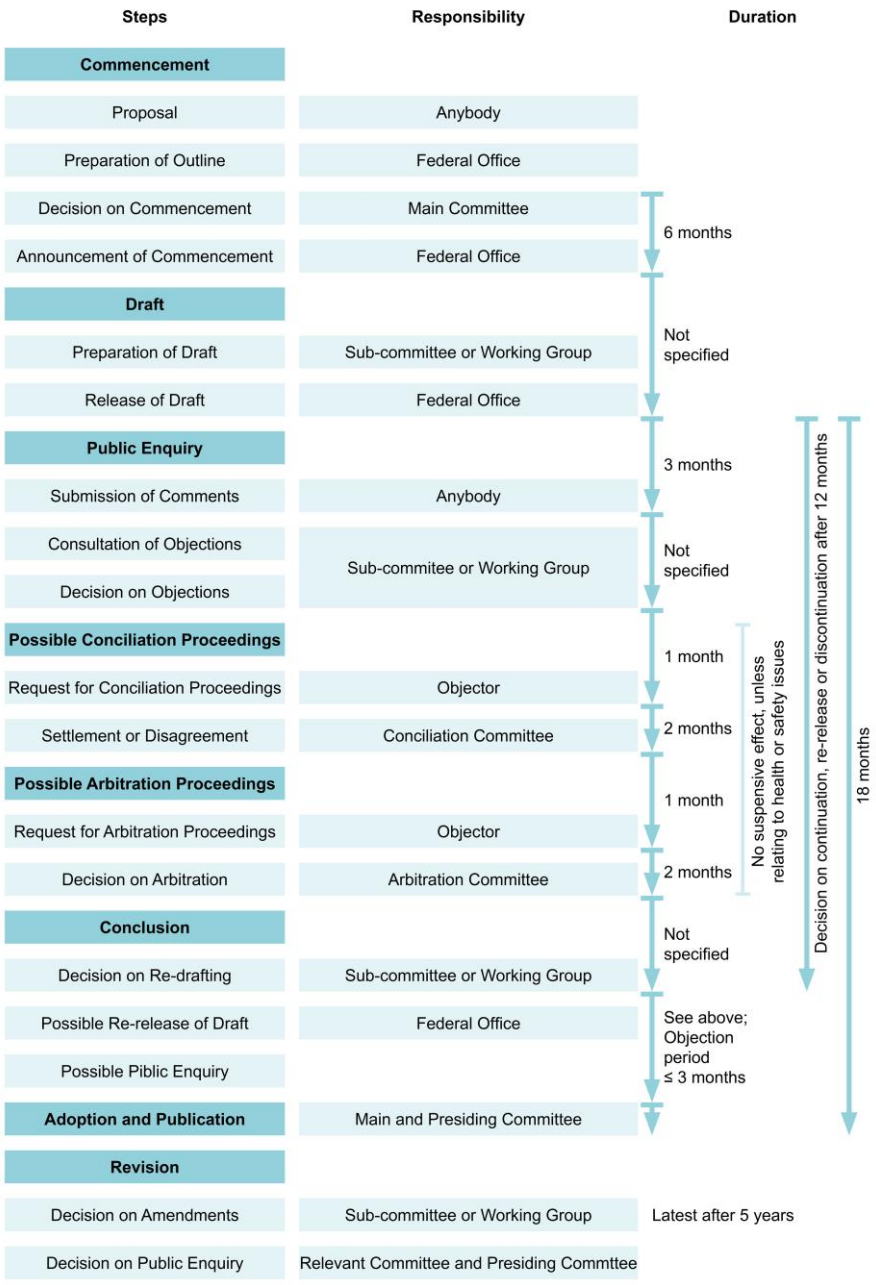


Source: Own illustration based on DWA (2008, 2013b)

Figure 2: Vertical Entanglement of DWA Committees

The DWA-A 400 is concerned with the standardization process itself. The Rules of Procedure for the DWA Expert Committees, on the other hand, specify the principles governing committee composition as well as the interconnections between the different committees. The committee landscape is distinguished by vertical interconnections, i.e., the speakers of the working groups and the chair- persons of the sub-committees are members of the respective superior committees, the chairpersons of the main committees are members of the superordinate Coordination Board. The exact interconnections are depicted in Figure 2.

An ideal-typical standardization process comprises — depending on the course of events — five to seven stages plus the revision stage. The development of a standard is at best concluded within 24 months. The scheme of the processes is sketched in Figure 3.



Source: Own illustration based on DWA (2008, 2013b)

Figure 3: DWA Standardization Process

Commencement. Anybody may initiate the development of a new or the revision of an existing standard. The final decision whether the development proposal will be actually pursued is, however, with the relevant main committee.

Supposedly, the initiatives are to a large extent launched by committee members themselves. Individuals and representatives of companies and other organizations facing net benefits of taking part in standardization will presumably already be part of at least one committee. Outsiders may not have an incentive to take part, may not be aware of the possibilities or may lack the relevant knowledge for participation and in turn supposedly also for a proposal.

In case of a positive decision on conducting the proposed initiative, an outline is published in the DWA's own journal.

Draft. Drafting usually takes place in a working group. Concerning the composition of the committee it is to be ensured, that the relevant fields of expertise are adequately represented. Committee members are supposed to be DWA members, experts in the relevant field and in employment. The final draft is released by the relevant sub-committee and published in the appropriate DWA journal and in the Federal Gazette (Bundesanzeiger). The according circle of experts is informed separately.

Public Enquiry. Anybody may comment on the draft standard usually within a period of three months. A consultation on the comments, particularly on the objections, follows. The submitters of the comments are informed about the decision and are given the possibility to call on his/her objections, if necessary.

Possible Conciliation Proceedings. If no mutual agreement between committee and objector is reached, the latter has the possibility to pursue conciliation proceedings. The conciliation committee consists of a member of the relevant main committee, the claimant or a proxy, the chairperson of the relevant sub- committee and a member of the working group. A member of the Federal Office serves as secretary without vote. The proceedings are considered complete if a phrasing has been carried unanimously.

Possible Arbitration Proceedings. Could no agreement be reached the objector has the possibility to pursue arbitration proceedings. The arbitration committee consists of a member of the DWA managing board as chairperson, a member of the main committee HA Law, a member of the responsible main committee and two experts nominated by the objector but not in direct employment to him/her. A member of the Federal Office serves as secretary without vote. Members of the relevant sub-committee and working group are not permitted in the arbitration proceedings. Decisions are taken by simple majority.

Conclusion. In the case of considerable amendments to the draft following the consultation on the comments a re-draft may be published.

Adoption and Publication. Upon completion of the public enquiry process — including possible conciliation and arbitration procedures — the final standard is adopted by the responsible

main committee and the DWA Presiding Committee and subsequently published by the Federal Office at least in the relevant DWA journal and the Federal Gazette.

Revision. Every standard has to undergo a revision process at least every five years. The expert public is to be informed. Only if the decision is taken to amend the standard considerably a new formal public enquiry process is mandatory.

The DWA explicitly states in its A 400 that the application of standards is voluntary. They may not be enforced by SDOs due to the absence of authorization. Standards may, however, become binding as soon as they become part of contracts or — in one way or another — legal norms. In addition, the fact is pointed out that standards are not the sole solution to the addressed problems and that the latitudes shown are to be exploited where appropriate.

4.2 Development of Rules for Standards Development

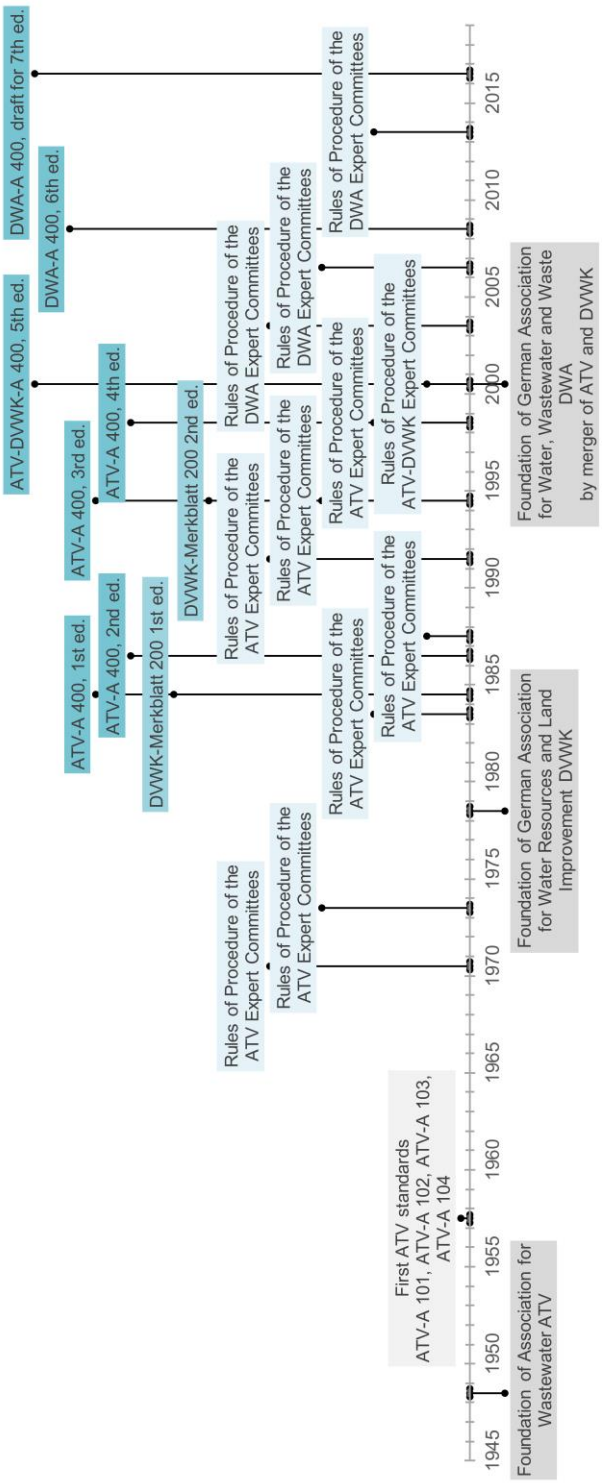
The A 400, as the standard specifying the standardization process, has been amended several times since first published. Figure 4 depicts the chronology of these amendments (including DVWK-M 200 the corresponding rule of the DVWK) in context of the history of the DWA and the Rules of Procedure for the DWA Expert Committees.

The aim of the initial publication of the A 400 was to lay down the rules for a formal public enquiry procedure in order to qualify the DWA standards to constitute Generally Acknowledged Rules of Technology. Whereas several modifications were only of organizational nature, some significant changes have been made. Moreover, from 1983 until 2006 a disentanglement of the A 400 and the Rules of Procedure took place.

Disentanglement. Whereas at the time of the first version of the A 400 a large part of the actual process was determined in the Rules of Procedure, there is now a clear division between process and committees.

Committee Membership. The chronology of the main specifications of the requirements for committee membership is as follows:

- 1970 (ATV, 1970) — Members are to be suitable persons and members of the ATV (respectively, ATV-DVWK and DWA) or otherwise connected to the ATV. In the course of time this has been amended to the requirement that they are to be members of the association or employees of corporate members.
- 1983 (ATV, 1983) — Members need to prove expertise in the relevant field and be actively employed.
- 2003 (ATV-DVWK, 2003) — Additionally, members have to espouse pre- dominantly the ideas of the association. Membership is restricted to a maximum of five committees.



Source: Own illustration

Figure 4: History of DWA Standardization Rules

Scope. From the outset ensuring high quality in planning, constructing and operating — since 2000 also monitoring — wastewater and waste facilities as well as specifying water protection measures were aims of the Set of Rules and Standards. Protecting the environment and thereby serving the public interest by taking into account technical knowledge, functional reliability, safety, hygienic and economic requirements constituted governing principles. Moreover, the sustainability aspect and correspondingly the reference to ecological requirements are explicitly incorporated. In 1998 (ATV, 1998) the obligation to also discuss cost and environmental effects was prescribed in the Rules of Procedure.

Additionally, the scope has been extended from wastewater and waste facilities and water protection measures by adding soil protection measures in 2000 (ATV-DVWK, 2000) and goods and services in 2008 (DWA, 2008).

Committee Composition. With the third edition of the A 400 (ATV, 1994) a restructuring of the conciliation as well as the arbitration committees has taken place.

Table 1: Amendment to Conciliation Committee Composition

Composition from	
1984 - 1994	**1994 - now**
one member of the Advisory Board (Managing Board from 1986 – 1994) as chairperson	one member of the responsible main committee as chairperson
one member of the responsible main committee	
one expert nominated by the objector	the objector or a proxy nominated by him/her
the chairperson of the relevant sub-committee	the chairperson of the relevant sub-committee
one member of the responsible working group (or sub-committee)	one member of the responsible working group (or sub-committee)
the Managing Director or the responsible head of division as secretary without vote	the Managing Director or the responsible head of division as secretary (a member of the Federal Office since 2008) without vote

Table 2: Amendment to Arbitration Committee Composition

Composition from	
1984 - 1994	**1994 - now**
one member of the Managing Board as chairperson	one member of the Managing Board as chairperson
	one member of HA RE, the main committee Law
one member of the responsible main committee	one member of the responsible main committee
two experts nominated by the objector	two experts nominated by the objector (not in direct employment with objector since 2000)
the chairperson of the relevant sub-committee	
one member of the responsible working group (or sub-committee)	
the Managing Director or the responsible head of division as secretary without vote	the Managing Director or the responsible head of division as secretary (a member of the Federal Office since 2008) without vote

- *Conciliation Committee* (see Table 1). The number of members with vote of the conciliation committees has been reduced from five to four. The Advisory Board or Managing Board respectively is no longer represented in the committee, instead a member of the main committee accedes the chair. In addition, the objector himself/herself is now entitled to participate, which gives the objector greater influence. Since a successful completion requires unanimity, the objector has effectively the power to halt the proceedings.
- *Arbitration Committee* (see Table 2). The number of members with vote of the arbitration committees has been reduced from six to five. Since 1994 (ATV, 1994) members of the responsible sub-committee and working group as well as the objector have been no longer permitted in the proceedings. This disentangles the relationship between the conciliation and arbitration proceedings.

From 1986 (ATV, 1986) until 1994 it had theoretically been possible for all members of the conciliation committee to be members of the arbitration committee. In this case the only deviation of the latter from the former would have been a second expert nominated by the

objector. Since in arbitration proceedings decisions are taken by simple majority it is most likely that the final outcome would have been the same, had the conciliation committee decided by simple majority. The influence of the additional expert had been minor.

4.3 2016 DWA-A 400 Draft

In 2016 a new draft for the A 400 (DWA, 2016) was released. The aim of the comprehensive amendment is the enhancement of comprehensibility and transparency.[11]

A note as a preamble on the actual presumption of correctness and general recognition, the voluntariness and the non-exclusive nature of the DWA standards is to become mandatory. The preamble comments — for the first time within A 400 — explicitly on DIN and European standards. The DWA standards are considered equal as long as they ensure the same level of protection. The obligation to include this note together with a section on definitions significantly contributes to comprehensibility.

Further relevant amendments planned are

- the re-inclusion of the formulation, that the Set of Rules and Standards is to serve the public interest not special interests of individuals,
- the explicit non-tolerance of agreements on or coordination of market con- duct and other anti-competitive behavior,
- the obligation to restrict the range of the Set of Rules and Standards to the necessary level,
- the obligation to keep standards as concise as possible and
- the specification of the standardization process as consensus-based process.

Even though much of this was presumably inherently intended already in earlier versions, the amendments significantly increase transparency and adherence to the general underlying principles of formal standardization. Amongst others these principles include the voluntariness of standards application, the development of standards in a consensus-based process, the principal openness of the process to all interested parties, as well as ensuring that standards exhibit technical and market relevance and are beneficial to society. (DIN, nd)

5 Committee Decision-making and Composition

5.1 General Remarks

As discussed in the previous section, over time, especially with the recent draft for the DWA standardization rules laid down in DWA-A 400, positively perceived amendments have been carried. They reflect not only the adaption to changing requirements for standardization activities but also the development of the self-conception of the DWA, i.e., tendencies to

[11] Formal public enquiry proceedings are now also mandatory for Merkblätter.

move from a rather technical/engineering view to a more holistic approach become visible. The assessment of the development and the shortly expected further amendments of the standardization rules of the DWA reveal that there is an increasing coherence between the superordinate standardization principles for formal standards development — which have been relatively stable over time — and the particular rules at the DWA.

Nevertheless, even under the assumption that a large number of rather de- tailed standards is inevitable in the highly fragmented German municipal wastewater sector[12], there is still room for improvement with respect to the standardization process and consequently to the general scope and design of the resulting standards.

However, there is no common understanding within standardization research on the concept of the quality of a standard. It is very much dependent on the perspective, e.g. viewpoint of households, firms or the economy as a whole, taken. (Vries, 2010)

Yet, to some degree there is consent, that a standard in order to be a good standard should exhibit the following properties (see, e.g., Hesser et al., 2006, Vries, 2010): Firstly, it should solely deal with the particular problem at hand, thereby focusing on performance rather than on the description of a single solution. Secondly, it should serve the needs of all relevant parties. It should be consistent, applicable and widely accepted. Thirdly, it should not hinder improvements and innovations. Furthermore, its development should be realized in due time. Finally, it should serve society as a whole and, hence, be socially efficient. Social efficiency is realized where marginal social costs equal marginal social benefits. Total social costs are the sum of total private costs and total external costs. Similarly, total social benefits are the sum of total private benefits and total external benefits. On the side of private costs and benefits standardization influences in particular the production costs and transaction costs. Production costs may be influenced by, e.g., increased rationalization possibilities or the exploitation of economies of scale, but also by the possibility to get locked-in into inferior technologies. Transaction costs may be influenced by, e.g., the need to gather information in the course of standardization, the costs of developing standards and the costs of monitoring whether standards are complied with. But also the benefits from a decrease in search and information costs due to the signaling of specifications, quality levels etc. or the benefits from an increased legal certainty belong to this category. Taking also into account indirect effects, the effects of standards, e.g., on the conduct and performance of markets, on innovation, or trade are significantly important. Concerning the internalization of externalities, the aim of standards is also the protection of for example life, health and the environment. Externalities are costs or benefits that accrue also to non-involved parties. Their presence is a reason for market failure — leading to a socially inefficient outcome. Consequently, they are a justification for formal — as opposed to market-based — standardization.[13] (Böhm et al., 1998, Voelzkow, 1996)

[12] In how far, the high fragmentation of the German municipal wastewater sector is a main driver for the need of a vast number of standards, remains an area for future research.

[13] For a detailed illustration of the purposes and effects of standards see Swann (2010), but also Swann (2000), Blind

Regulating standards in the wastewater sector are in great measure — at least indirectly — related to some sort of environmental and health issues. Thus, as denoted before, the question is not whether to standardize but what, how and by whom.

Focusing on the latter two questions, i.e., decision-making and committee composition, as examples, we will highlight possibilities of optimizing standardization work within the given framework and the ongoing need for further research in this area. Additionally, we will argue that some means of monitoring of the standardization process and the resulting standards has the potential to further improve the current modus operandi. Hence, our main focus is on possible improvements in the SDOs themselves, since the change of external circumstances is by far more challenging; or to put in the words of Hesser et al. (2006):

> The development of standards takes place within a certain framework of constraints which can only be altered with difficulty, if at all. In other words, they are static — at least in the short run. This framework is primarily set by the social order, the political system, the legal system and the state of technical and economic development (Hesser et al., 2006).

5.2 Committee Decision-making

A committee is a group of individuals with all having own preferences and imperfect information deciding on a public issue by utilizing a preset decision rule. The reason for forming committees is the hope for reaching better decision through the aggregation of diverse information (Condorcet jury theorem). (Hao and Suen, 2009)

Concerning standardization individuals may become members of the according standardization committee only if they fulfill the external criteria for membership. In general, these include, for example, possession of relevant expertise, affiliation to the SDO and approval by the institution responsible for appointing committee members. Given these criteria are met, an individual will only join the committee if his/her private benefits or the institutional benefits to the organization sending him/her respectively from joining outweigh the costs.

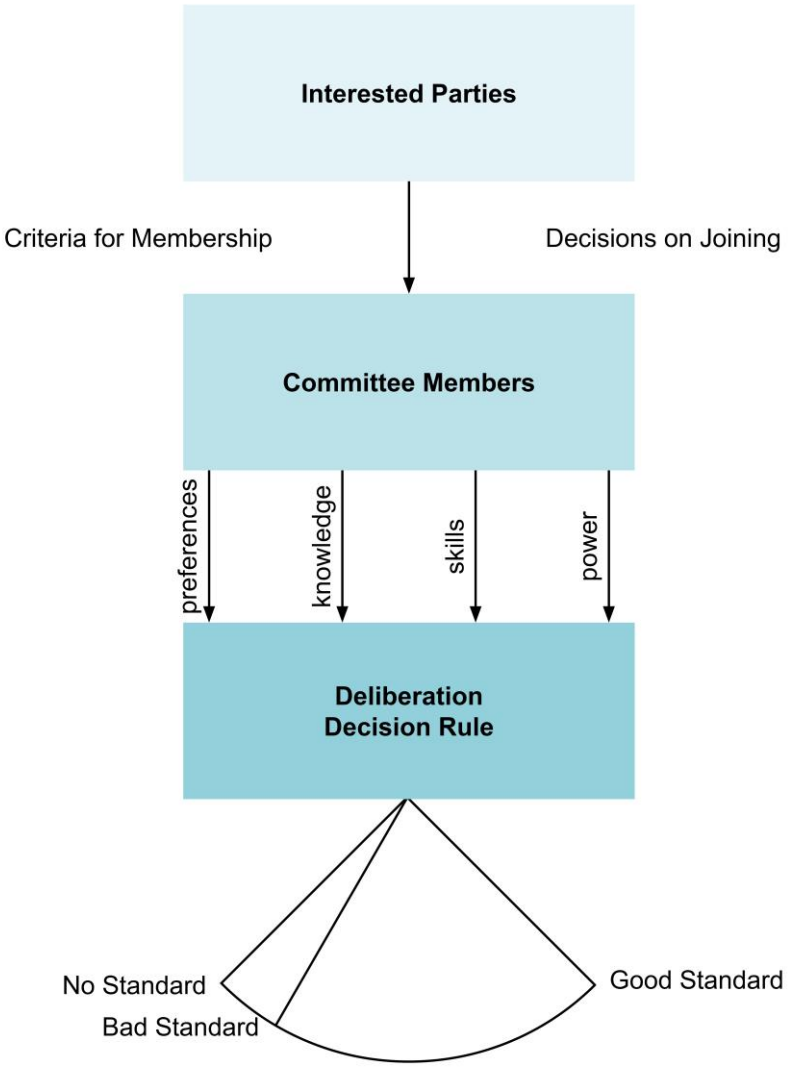
The process itself then consists of three general phases: (1) deliberation, (2) negotiation and (3) taking a decision according to a pre-specified decision rule. The committee members have vested preferences and differ with respect to knowledge, negotiation skills and bargaining power, which in turn will influence the decision outcome. This set of facts significantly impacts on the decision process and its results. Ultimately the process will lead to a standard of certain quality or in no standard at all. Figure 5 highlights the described framework.

A formal standard is by definition to be developed in a consensus-based process. Consensus is defined as a

> general agreement, characterized by the absence of sustained opposition to

(2004) or Jänchen (2008). An elaborate analysis of transaction costs in standardization activities is Reimers (1995).

substantial issues by any important part of the concerned interests and by a process that involves seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments. NOTE Consensus need not imply unanimity. (DIN EN 45020:2007-03)



Source: Own illustration

Figure 5: The Black Box of Committee Decision Making

It seems conventional wisdom that consensus decision-making is the best available procedure, where decisions are to be taken for the common weal. The intention is to encourage the disclosure of all private information in order to being able to decide fully informed on the available alternative best to society. (Austen-Smith and Feddersen, 2006)

In line with this argument Coughlan (2000) shows in a model of jury verdicts that sincere information revelation constitutes a Nash equilibrium under unanimity if decision makers' preferences are sufficiently close such that there exists a common interest, i.e., whenever an underlying consensus exists. In case of criminal trial, the assumption of an underlying consensus, that is, the conviction of the guilty and the acquittal of the innocent, seems reasonable. Yet, in standardization the preferences of the potential decision makers are likely to be vested and — at least to some extent — not necessarily common knowledge.

Possible caveats of consensus decision-making are: The duration of the decision process is likely to be prolonged as opposed to decisions taken under alternative rules. This in turn discriminates against stakeholders with comparatively few resources and might, thus, lower their incentives to participate ex ante. On the other hand, it favors perseverant parties who may benefit from excluding the former and from delaying or even preventing a final decision. Furthermore, consensus decision making does not necessarily foster full information disclosure, which is in stark contrast to one of the main reasons for adopting a consensus rule, i.e. to take fully informed decisions in the common weal.

Obviously if no underlying consensus exits and preferences are common knowledge then sincere information disclosure will not emerge under any decision rule. But even if the preferences of committee members diverge and at the same time are not generally known, there might be incentives for strategic behavior, e.g., for strategic disclosure or non-disclosure of information, finally leading to a non- optimal outcome. Austen-Smith and Feddersen (2006), for example, consider a Condorcet jury model with a committee deciding over two alternatives, where deliberation is possible before voting. They show that with uncertain preferences and the absence of an underlying consensus between members, there will always be some members who will want to restrain from disclosing full information under unanimity voting[14]. On the contrary, under majority voting at least some frameworks exist were full information revelation is optimal.

Transferring their reasoning to a standardization environment consider a committee deciding over two alternatives — adopting a new standard or keeping the status quo. There are two possible states of nature: it is either more beneficial to society as a whole to adhere to the status quo or to adopt the new standard. The state of nature is not known. However, each committee member observes a private signal positively correlated to the true state of nature. All committee members agree that ultimately the alternative in the common weal should be chosen. Yet, they differ with respect to the required indications to be willing to adopt the new standard. Hence, suppose that committee members can be of two types dependent on their bias towards the status quo, where own types are known. Low-bias types will prefer the adoption of the new standard if at least one member, high-bias types if and only if all members observed a signal that adopting is socially more beneficial than refraining from adoption.

[14] In modeling consensus-based decision making unanimity often serves as a proxy.

Hence, in a committee where both types are present, the members prefer the same decision outcome if and only if all receive the same private signal.

One may think of the low-bias types, for example, as members having a vested interest in pushing forward specific technologies through standardization being therefore comparatively less concerned of adopting a socially inefficient standard. The high-bias types, in contrast, are reluctant to adopting the new standard unless it is indisputable in the common weal.

Assume that there is at least one member of each type in the committee and decisions are taken under unanimity rule after truthfully or untruthfully reporting on privately observed signals. Now suppose a low-bias committee member observes a status quo-signal. She knows that any high-bias person will only want to vote for standard adoption if all observed a standard-adoption-signal, implying that she will never report untruthfully in case she observed a status quo-signal. Hence, the low-bias type will report untruthfully, since her vote would only change the final outcome if the high-bias members observed a standard-adoption signal. This in turn would suffice for the low type to vote for standard adoption. Full information disclosure is not incentive compatible in this setting.

Under majority rule, however, lying by the low-bias member who observed a status quo-signal has a downside risk. If all other members also observed a status quo-signal and the majority were low-bias members lying, then the final decision would be to adopt the new standard although all members would have preferred the status quo had information been fully disclosed. Whether truth-telling in this framework constitutes an equilibrium depends on the belief about the precision of the signals. If signals are believed to be sufficiently good, reporting truthfully will be optimal.

From a different perspective Farrell and Simcoe (2012), e.g., also show that under certain circumstances relaxing the consensus principle might lead to more efficient solutions. They analyze consensus decision-making in SDOs as a war of attrition model, where the duration of the process is costly. They find that with strong self-interest of committee members it might be more efficient to reduce duration time at the expense of standard quality.

Farrell and Simcoe (2012) consider a two-person committee where both members advance a proposal of a certain privately known quality. Compromise and side-payments are not possible. The game ends as soon as one player backs down. They share a common discount factor and both prefer a standard to no standard. The costs of duration time are, for example, costs for personnel, time and travel but also forgone earnings due to no standard being in place. Farrell and Simcoe (2012) analyze efficiency by considering the quality of the chosen

proposal, in the sense of technical quality[15], against the costs of process duration relative to the efficiency of randomly choosing a proposal either directly or after one period.[16]

They show that the war of attrition selects the relatively better proposal but at the cost of delay. With strong self-interest direct random choice and a fortiori random choice after one period may be more efficient than the undisturbed war of attrition.

Simcoe (2012) models standard developments committees based on a complete- information stochastic bargaining model. Here side-payments are possible, but costly. In every period each committee member advances a proposal of a publicly observable quality, which is at least as good as his/her offer in the previous period. The member with the proposal of highest quality makes an offer, consisting of the proposed standard and possible concessions, to the remaining members. The latter can either accept or reject this offer. In this framework delays may be efficient due to the possibility to choose a better technology as standard. Yet, delays become more pronounced and inefficient the more distinct are the vested interests of the committee members or as the costs of side-payments increase. Simcoe (2012) tests the models prediction using data on the Internet Engineering Task Force (IETF) and finds that increasing conflicting interests due to commercialization of the Internet correlate significantly with slackening of the standards development process. Hence, the consensus principle is a significant source of costs due to a slowdown in the standardization process.

Similarly, Moldovanu and Shi (2013) show that if committee members are strongly biased toward their own field, each of them will adhere to their own preference for a high standard in this field. On this account reaching consensus becomes more cumbersome and the duration of the process increases significantly. Hence, strong consensus as decision rule is not inevitably optimal in standardization. The brief discussion above points toward a rather broad interpretation of the consensus principle.

Whereas voting rules were already specified in the first edition of the A 400, the term consensus appears not until the recent draft. Yet, there are still precise voting rules stated: In general, decisions are taken by supermajority of 2/3; exceptions are the requirement of unanimity in conciliation proceedings and simple majority in arbitration proceedings. In the light of the discussion above the supermajority rule adopted by the DWA can foster truth-telling and timeliness.

Nevertheless, any decision rule may only lead to a socially efficient outcome if all relevant parties are adequately represented or if decisions are taken as if they were adequately represented (see Section 5.3). The differentiation between these two possibilities closely relates to the concept of input and output legitimacy proposed by Werle and Iversen (2006).

[15] In the case of compatibility standards this may be a reasonable assumption. For regulating standards, however, this cannot be the only dimension of quality to be taken into account due to their greater impact on external effects.

[16] This measure of efficiency, hence, only takes into account the costs and benefits of actual committee members

They argue that legitimacy of the activities of SDOs cannot only be considered in the light of input legitimacy but should also account for output legitimacy (see Table 3).

Table 3: Modes of Achieving Legitimacy in Standardization

Input Legitimacy
Focus on the "production" (standardization process)
• Openness to and direct representation (participation) of all actors interested in or potentially affected by a standard • Work in accordance to impartial and fair procedural rules • Decision-making based on consensus
Output Legitimacy
Focus on the "product" (standard)
• All interests are considered (but not directly represented) in the standardization process • External tracking and monitoring of standardization by stakeholder and advocacy groups • Decision-making in an open inclusive discourse (arguing) to the benefit of all standards addressees ("good" standards)

Source: Werle and Iversen (2006)

Input legitimacy takes an ex ante view, i.e., it focuses on the actual process leading to the standards. The requirements are fulfilled, if compliance with the formal superordinate standardization principles is given. Output legitimacy, on the other hand, takes an ex post view. Here attention is directed towards the actual standards. A good standard is one which exhibits the characteristics as if it had been developed according to the general superordinate standardization principles. In particular, it is argued that in this context it is not necessary that all interested parties are represented in the process but rather that the interests of all parties are taken into account.

At first glance the discussion above may suggest that the process itself is of minor importance. Yet, it is not the process but rather compliance with the principles which is sidelined. However, consequently other aspects of the process become more important. These include, e.g., securing that all relevant interests are known and taken into account by committee members. It also raises the question about who might be able to monitor standardization and judge whether standards are good standards. The judgment requires detailed information and wide-ranging competencies. When assessing the process, in- formation and competencies

needed are moderate in comparison. Hence, we argue that input considerations remain important and both aspects should be considered when assessing standardization. Consequently, without a general and operational scheme on which criteria to judge the output factors in the complex standardization scheme, the adequate committee composition remains — next to the decision-making process — the central issue in assessing standardization.

5.3 Committee Composition

Having focused on the decision-making process within a given committee, we will now turn to the design of the committees themselves. Since standards can be considered a public good, prima facie it appears remarkable that the voluntariness of committee membership does not fully prevent participation. In the case of public good provision, standard theory would suggest free riding to be the equilibrium strategy. The reason for positive membership is twofold. Firstly, the standardization process induces incentives to participate. Secondly and closely related, the heterogeneity in preferences of the interested parties poses strong incentives, at least on those with extreme preferences, to get involved in the process. (Bulkley et al., 2001)

Additionally, as mentioned previously, according to the superordinate standardization principles committees are to be composed such that all interested parties are to be represented by an adequate number of relevant experts.[17] This gives rise to the following questions: Who are the interested parties, what are their interests in standardization and what may be considered an adequate representation?

In general, the interested parties may be subdivided according to their relation to the (potentially) standardized products, services and processes into producers, users, authorities, researchers, consumers, advocacy groups and the SDOs themselves, all of which have particular preferences concerning standardization. (Hesser et al., 2006, Vries, 1999a)

For the producers — i.e., mainly manufacturing companies — standardization is besides a means of solving technological questions an important strategic tool. Companies aim for increasing competitiveness, enhancing the success of their products and services on the market and pushing forward technologies developed or used by them thereby preventing sunk investment costs. (Blind and Mangelsdorf, 2016, Vries, 1999a).

Furthermore, by developing standards and, thus, actively taking part in the framework of technical self-regulation adopted by government, companies try to circumvent the implementation of compulsory regulation. There is only little research carried out on this issue. Nevertheless, it is indicated that this motive may in fact be the strongest for companies to participate in standardization processes. (Blind and Mangelsdorf, 2016)

[17] Standards development is considered common work of a group. Nevertheless, its result is dependent on the composition of the committee. It is therefore an aspect of transparency, that the DWA makes the names of the committee members publicly available.

Additionally, the possibility to acquire knowledge within standardization processes is one of the main reasons for companies' participation. They have the incentive to attain information on the knowledge and developments of participating competitors but also researchers. This information, in turn, can then be used in their own R&D activities. Whereby information acquisition is costly, these costs may be reduced due to the knowledge spillovers in standardization activities. (Blind and Mangelsdorf, 2016)

In fact, Blind and Mangelsdorf (2016) show for German manufacturing companies in the electrical engineering and machinery industry, that the ability to attain knowledge in standardization activities depends on the level of R&D. Additionally, they find that the higher the innovativeness of companies the higher are there incentives to participate in standards development. In this case the aim to push forward their own contents comes to the fore as opposed to knowledge acquisition, which, in turn, is particular important to small companies with the intensity of R&D not exceeding a certain threshold. Blind and Mangelsdorf (2013) provide evidence that SMEs with high levels of R&D activity are significantly less willing to actively take part in standardization in order to prevent their knowledge to spillover to competitors.

The public good character of technical standards may lead to a problem of free riding to benefit from the developed standards. By contrast, as we highlighted, the standards development process bears clear incentives for participation, i.e., the possibility to influence the outcome and to acquire knowledge that is not available to non-participants. A possible resulting first-mover advantage towards outsiders may even give rise to strategic delay of the final decision.

Users of standards and the according standardized products and services in the wastewater sector are mainly utilities and wastewater boards. In general, users seek for affordable, effective, applicable and comprehensible standards. In competitive markets users strongly require cost-efficient standards. However, in the wastewater sector, where higher costs can be transferred to consumers comparably easily, the other aims will presumably be given priority. In a sector that is as closely related to health, hygienic and environmental issues as the wastewater sector, effectiveness will play an essential role. (Oelmann, 2005)

Engineering offices also play an important role in standardization and may be considered as a halfway house between producers and users. Their main aim is to win tenders. These, in turn, usually refer to certain standards. Coupled with a correlation between tender size and remuneration, engineering offices have an incentive to push for incorporating high-end technologies in standards. (Oelmann, 2005).

Technical standardization is a political instruments of self-regulation thereby relieving burden to the government. This does not imply, however, that policy makers have no stakes in standardization issues. Amongst others standards are a means of internalizing external effects, thereby counteracting the distortionary effects of market failure (Blind and Mangelsdorf, 2016).

Hence, municipalities and districts in their function as authorities — not as users — may exhibit some function of control in the standardization process. In particular, they are to ensure the consideration of, e.g., social, health or environmental aspects. Admittedly, especially small municipalities often lack the knowledge and financial resources to perform this function. In addition, authorities also have vested interests which may conflict with their control function. To give an example, municipalities and districts might argue for contents that may be of particular interest to their own region, e.g., concerning regional distinctions with regard to land form, infrastructure, land use or political landscape.

Consumers seek for high-quality wastewater disposal at affordable prices. They also care for related environmental and health issues. Since the lack of relevant expertise on the side of consumers and therewith the incapability of substantially contributing to standardization decisions, the question is, who could potentially serve as proxy for the needs of the consumers.

An obvious assumption is that researchers may have the smallest vested interests of the parties involved. But they may well have the incentive to gain reputation by pushing their own research interests. However, taking a broader perspective, researchers from other disciplines as engineering and natural sciences, in particular from social and economic sciences, do not usually have the incentive to push forward certain technologies. To this end attracting researchers from these disciplines to take part in the development of technical standards seems to have the potential to improve the representation of consumers' needs

The main discipline represented in technical standardization is obviously engineering. There is some evidence that ordinary standardization committee members tend to be from applied sciences rather than basic sciences (Zi and Blind, 2015). Applied scientists are more likely to be affiliated to industry and to be involved in market-ready development. Taken together, this suggests that re- searchers have the incentive to promote content related to their own field of research, amongst others in order to gain reputation, and to favor technologies which are in the domain of their industry partners.

Besides researchers also advocacy groups, not least consumer protection organizations, are stakeholders in standardization activities, speaking for the parties who lack financial resources, skills or knowledge to actively take part in the process. In practice, however, their involvement is comparatively low, in particular in sector-specific, highly specialized standardization. A reason being the need for highly particularized knowledge in order to grasp the complex issues discussed. (David and Greenstein, 1990)

Finally, SDOs themselves have stake in the process and outcome of standardization activities. Even though the SDOs do not actively take part in the standardization process, they can exert influence by their function as facilitator. On the one hand, there is the incentive to ascertain the legitimacy of their existence. As discussed above this may be done by promoting input or output legitimacy or both. Concerning the DWA input legitimacy and, hence, compliance with the superordinate general standardization principles plays the comparatively greater role. On

the other hand, however, SDOs also seek to increase their reputation. Reputation is not least associated with the quantity and, in particular, the effectiveness of the developed standards. The reputation goal is prone to conflict with, amongst others, the superordinate principle to serve the common weal.

In sum, the preferences and motives associated with standardization are manifold and in parts conflicting. Furthermore, actively targeting for the representation of all interested parties within the process will lead to more diverse committees and, hence, decision-making to become more cumbersome and time- consuming. The most striking example is the representation of consumers' needs. The increasing complexity of standards and the laid down technologies, especially in the case of regulating standards, makes the identification as well as the representation of consumers' needs, even by consumer organizations, convoluted, time consuming and costly. Nevertheless, standards are to serve society as a whole and may not neglect consumers' needs. Hence, there are reasons for bearing the burden of consumer representation.

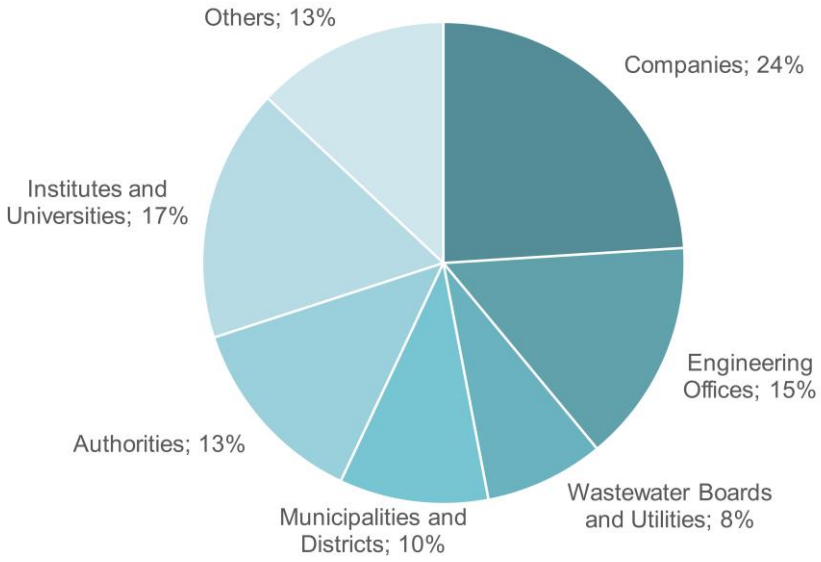
Yet rather limited, consumer representatives will increase the knowledge pool created in the standards development process. Furthermore, in a natural monopoly influencing standardization is one of the few channels for consumers to impact on costs and consequently on prices.

Given the fact, that the industry is regulated through self-regulation by standardization, standards development becomes a means of regulatory capture. The interest of the industry is, thus, given more weight than the public interest. Blind and Mangelsdorf (2016) argue that avoidance of this caveat is to ensure a balanced representation of all stakeholders — including consumers — needs.

A balanced committee composition is then a composition of limited size where, however, multiple stakeholder groups are represented and their needs are taken adequately into consideration.

The composition of the DWA committee members according to their affiliation is depicted in Figure 6. Note, that this is aggregated over all committees involved in standardization throughout the DWA including committees on water, wastewater and waste. There can be significant deviations in composition between single committees.

In sum, the composition at the DWA coincides with findings on other SDOs. The producers (companies) tend to be overrepresented, whereas users (wastewater boards and utilities as well as to some extent municipalities and districts) are underrepresented. Consumers are — if at all — represented by consumer organizations. Yet, in the case of the wastewater sector they are typically not represented at all. (see, e.g., Vries, 2010). Hence, in general, the ideal of balancing the needs of all relevant parties is not achieved, albeit representation issues may be more exaggerated in some committees and less in others.



Source: Internal DWA Document

Figure 6: Aggregate DWA Committee Composition According to Affiliation

Even though it is in the responsibility of the DWA to foster adequate representation, it is not entirely in the sphere of its influence. Amongst others, the lack of relevant knowledge on the side of consumers and small municipalities, or insufficient resources for participation on the side of small municipalities and SMEs may hinder a desirable committee composition. To sum up, the incentives at work in standardization committees are manifold, whereas the representation of the different stakeholder groups needs remains unbalanced.

6 Monitoring and Control Mechanisms

In order to being able to genuinely assess standardization and build on the related results it is necessary to monitor input as well as output factors. Consequently, we argue that there is ample need for a well-defined, institutionalized monitoring and control scheme, which is, of what we are aware of, non-existent. As highlighted above, the A 400 draft (DWA, 2016) by referring to possible distortions to the process through coordination or tacit agreements but also to the need to limit the quantity of standards as well as their granularity is an enhancement from an economic point of view. Obviously, these and other possible problems may not be driven out entirely by incorporating them into the standardization rules. However, they show the awareness of the DWA of possible negative effects to the standardization landscape and, hence, to economy and society.

Even if committee members exhibit some degree of intrinsic motivation to follow the rules, the actual procedure will heavily depend on the committee composition, the committee members and the degree of congruence between the effect of compliance with their self-

interest. As we have shown in the previous sections, vested preferences and unbalanced representation of stakeholders needs may lead to significant distortions. Thus, given that we have vested self-interest in any committee and given that also committee composition is biased, the only way to ensure rule compliance or alternatively that outcomes are as if compliance with rules was realized is an efficient monitoring and control scheme.

On the side of the SDOs the implementation of such a scheme promotes legitimacy by, amongst others, increasing transparency and compliance with the superordinate standardization principles. Furthermore, it may tighten the actual standardization process due to stricter adherence to procedural rules. This in turn may lead to a decrease in transaction costs on the part of the committee members. On the other hand, however, a monitoring scheme will induce costs on the implementer as well as on the monitors, in particular, concerning personnel and time costs.

The competence to establish a monitoring scheme is primarily with government or the SDOs themselves and may be realized either externally or internally. Whereas it is not in the power of the SDOs to enforce an external monitoring scheme — this is only possible on the part of the government — they could nevertheless implement a scheme and foster the participation of non-committee members.

Due to the expected costs SDOs might be reluctant to establish a monitoring scheme on its own terms. If government enforced the implementation through the SDOs this reluctance can be leveraged. In turn, this would then lead to higher costs on the part of the government, in particular, since enforcement and neutrality of the monitors needs to be ensured.

If in contrast government itself implements a monitoring scheme the question is who can act as monitoring body. This could either be a government institution or could be outsourced to a third-party. In any case the burden to government would increase, the degree of technical self-regulation would be reduced, but social efficiency of standardization is expected to enhance. Which of the effects is more pronounced, remains to be clarified.

As noted by Werle and Iversen (2006) one possibility of an external scheme would be structured monitoring through stakeholders and advocacy groups. The latter are particularly important with respect to stakeholder groups who do not have the skills and/or resources to individually take part in the monitoring process. These are consumer organizations but also, for example, environmental organizations, labor unions and associations of utilities or small and medium- sized enterprises.

Whereas a functioning monitoring scheme would facilitate social efficiency, similar problems as in the case of committee membership arise. In general, consumers or their representatives respectively supposedly still lack the relevant knowledge in order to assess discussions on technical peculiarities or the overall quality of a final standard. To evaluate the process particularly with respect to rule compliance, concerning committee composition and decision-making procedures, however, certainly requires less time and knowledge. In how far advocacy

groups would take the opportunity to get involved in monitoring standardization processes remains to be seen.

For some groups exerting control via monitoring will be a strategic instrument. Companies with vested interest conflicting with the expected outcome can interfere with the standardization process. Since monitoring requires less comprehensive information and is less costly and time consuming as compared to actively taking part in the standards development process and, yet, gives the opportunity to influence standardization — yet less than through active participation — will induce incentives for some to refrain from committee membership. Hence, through monitoring the free riding problem may be exaggerated. This effect will be intensified due to the fact that monitoring the process relies on internal information, since information acquisition is one of the main motives for committee membership.

With the implementation of an external monitoring scheme measures that increase incentives in particular on the side of consumer organizations to participate, e.g., by raising awareness about the influence of standards, should be undertaken. Also establishing some sort of rules on who is permitted as monitors and what kind of information needs to be disclosed is of importance in order to keep the free riding problem as small as possible.

Another possibility, which can be shaped and enforced by the SDOs them- selves, is an internal monitoring scheme. In principal this could be organized in three different forms, namely, as vertical inter-committee, horizontal inter- committee, or supra-committee monitoring.

Due to the high degree of vertical entanglement of the committees in the DWA (see Figure 2), a vertical control scheme is potentially biased. The advantage of such a scheme is the fact that is comparatively easy to implement. Since the respective superordinate committees are already involved in the approval of the subordinate committees, they are supplied with a significant amount of in- formation needed to act in the function as monitors. As the chairpersons or the speakers respectively of the subordinate committees are at the same time members of the superordinate committees and as the vertical committee organization follows an issue-specific approach such that committee members may have stakes in decisions taken in each of the vertically entangled committees, the necessary interdependency for an efficient monitoring scheme in place.

Hence, a horizontal monitoring scheme could be considered. Members of thematically unrelated committees would act as moderators of the committee meetings and as DWA internal compliance officers. Interdependence could be depressed to an acceptable level. In comparison to a vertical scheme this would, however, significantly increase the costs for members who are to act as monitors. A drop in participation rates may be the result. The expected tightening of procedures may counterbalance these effect at least partly.

Finally, one may consider the possibility of a full-time employee of the SDO as monitor. The advantage being that incentives induced on stakeholders concerning participation are kept to a

minimum. The design of such a position needs to ensure neutrality concerning the outcome in order to avoid the possibility for the SDO to exert significant influence on the monitoring outcome or the standardization activities. Furthermore, collusion between the monitor and the stakeholders is to be prevented. The major drawback in this case are the additional costs accruing to the SDO.

In any case, a monitoring scheme induces costs on some or all parties involved in standardization. Even though the issues of enforcement, costs, biasedness, limited possibilities of sanctioning, and the rather vague concept of standard quality account for the establishment being a challenging undertaking, we expect positive net social benefits.

Further research needs also to be carried out on the optimal design including the financing, a possible sanctioning mechanism as well as the development and selection of relevant key performance indicators. Firstly, two possibilities of funding to consider are government subsidies or cross-subsidizing within the SDOs from other areas of operation. Secondly, in order for monitoring procedures to lead to increased efficiency non-compliance needs to be sanctioned. One may argue that consequences were to be exclusion from the relevant committee or all committees or the dissolving the relevant committee. Yet, both options are presumably only feasible in extreme cases if at all, since exclusion violates the principle of open participation. We, therefore, argue for an implementation of a staged sanctioning scheme. Possibly, even the potential loss of reputation on the side of the SDOs and the committee members may suffice. Finally, the functioning of a monitoring scheme is very much dependent on the development and selection of appropriate key performance indicators. To date there exists no established set of indicators we are aware of. The performance indicators need to target input factors concerning committee composition and standardization process as well as output factors related to the actual standards.

7 Summary and Conclusion

Standards are an essential part of a well-functioning economy and, thus, also for the wastewater sector. This sector is of major importance to everyday-life, being directly related to environmental, hygienic and health issues. Particularly, the presence of a significant amount of regulating standards and the influence of committee members and decision making procedures on resulting standards call for a profound understanding of the mechanisms at work. Given the significance of wastewater treatment and disposal for society and the economy together with the omnipresence of standards in the sector, it is remarkable that the only comprehensive study of standardization in the (German) wastewater sector dates back to 1998 (Böhm et al., 1998). Consequently, we studied the development and prospects of the rules governing the formal standardization process in the DWA. By pointing out some possible areas for improvements we highlighted the ample need for future research.

We have shown that the DWA, as the main actor in the standardization land- scape of the German municipal wastewater sector, has significantly improved its rules on standardization over time by aligning them closer to the generally accepted superordinate standardization

principles. These principles include amongst others voluntariness of standards application, the development of standards in a consensus-based process, as well as ensuring that standards exhibit technical and market relevance and are beneficial to society. The DWA has also taken steps towards a more holistic, rather than a largely technical, view of standardization and standards.

Only very few attempts have been undertaken, to question the commonly employed standardization procedures in its entirety; Vries (1999c) being a notable exception, arguing in favor of a method from product development theory, namely value analysis. In this context, processes are to be designed in the realm of ensuring the balance of needs of all potentially affected parties.

Under the assumption that the underlying principles are fixed at least in the short-run, we have argued that there is nevertheless ample scope for improvement — even under the existing rules. In particular, a lenient interpretation of the consensus principle especially in the case of lengthy processes might sometimes lead to more efficient outcomes. Yet, there is still scope for future research on a more differentiated view of consensus and the effects of the optimal termination of discussion by voting on a standard or parts of it. To our understanding characteristic features of specific sectors or even single SDOs should be studied.

Additionally, we reasoned, that it is certainly advantageous for the DWA as well as for future research to extent their consideration of output factors. Yet, the input side remains of major importance and may not be neglected. Besides the decision rule adopted, committee composition has great relevance on required resources within the standards development process as well as on resulting standards.

Vested interests of committee members paired with the adoption of a consensus- rule is prone to prolonging the decision-making process and to hindering full information disclosure. As a major reason for the utilization of committees as decision-making units is the expectation that the pooling of knowledge promotes better decisions, strategic disclosure or non-disclosure of information is a potential source of inefficiencies. Various studies suggest that the adoption of a weaker notion of consensus is preferable.

Whereas heterogeneity may have a distortionary effect on process duration and information disclosure it may help to overcome the problem of free riding, since it poses incentives, at least on those with relative extreme preferences, to get involved in the process in order to influence the outcome.

In general, the interested parties may be subdivided into producers, users, authorities, researchers, consumers, advocacy groups and the SDOs, all of which have particular preferences concerning standardization. WE show that the incentives at work in standardization committees are manifold, whereas the representation of the different stakeholder groups needs remains unbalanced. To this end a balanced committee composition is a composition of limited size where multiple stakeholder groups are represented and their

needs are taken adequately into consideration. We emphasize the special role of consumers and consumer organizations respectively. Whereas their knowledge and resources are rather limited their involvement is still desirable, since consumers' needs are not to be neglected. We also show that in aggregate composition of the DWA commit- tees coincides with findings in the literature, suggesting that the problems and possible improvements apply to the DWA.

Ultimately, we claim, that substantial improvements correlate highly with the implementation of effective and efficient monitoring and control mechanisms, as rule compliance and coherence in rule reading does not happen naturally. In this realm we discuss three possible forms of organizing such a scheme, namely vertical inter-committee, horizontal inter-committee and supra-committee monitoring, thereby highlighting the main advantages and disadvantages. As possible implementers we identify government and the SDOs, as possible monitors a governmental institution or a commissioned third-party, stakeholders and advocacy groups, SDO committee members or full-time employees of the SDOs. The actual design and implementation possibilities remain open questions for future research. This also includes the specification of applicable criteria on which to judge process and outcome, financing issues and sanctioning possibilities.

Going even beyond, i.e., not taking the environment in which standardization takes place as given, an interesting question to tackle is to what extent the high fragmentation of the German municipal wastewater sector determines the need for the large number and granularity of standards in this sector. With high fragmentation and, thus, primarily small players in the sector, we expect these players to have a greater need to utilize the knowledge incorporated in standards than large players.

References

ATT, BDEW, DBVW, DVGW, DWA and VKU (2015). Profile of the German Water Sector 2015.

ATV (1970). Geschäftsordnung für die Ausschüsse.

ATV (1973). Geschäftsordnung für die Ausschüsse der ATV.

ATV (1983). Geschäftsordnung für die Ausschüsse und Arbeitsgruppen der ATV.

ATV (1984). ATV-A 400: Grundsätze für die Erarbeitung des Regelwerkes.

ATV (1986). ATV-A 400: Grundsätze für die Erarbeitung des Regelwerkes.

ATV (1994). ATV-A 400: Grundsätze für die Erarbeitung des Regelwerkes.

ATV (1998). Geschäftsordnung für die Ausschüsse und Arbeitsgruppen der ATV.

ATV and KfK (1957a). ATV-A 101: Planung einer Ortsentwässerung (Grundlagen und Hinweise).

ATV and KfK (1957b). ATV-A 102: Industrie und Gewerbebetrieb, allgemein, Planung einer Abwasserableitung und Abwasserbehandlung (Grundlagen und Hinweise).

ATV and KfK (1957c). ATV-A 103: Milchverarbeitender Betrieb, Planung einer Abwasserableitung und Abwasserbehandlung (Grundlagen und Hinweise).

ATV and KfK (1957d). ATV-A 104: Lederbetrieb, Planung einer Abwasserableitung und Abwasserbehandlung (Grundlagen und Hinweise).

ATV-DVWK (2000). ATV-DVWK-A 400: Grundsätze für die Erarbeitung des ATV-DVWK-Regelwerkes.

ATV-DVWK (2003). Geschäftsordnung für die Ausschüsse, Arbeitsgruppen, Kommissionen und Projektgruppen der ATV-DVWK.

Austen-Smith, D. and T. J. Feddersen (2006). Deliberation, Preference Uncertainty, and Voting Rules. *American Political Science Review*, 100(2):209–217.

Blind, K. (2004). *The Economics of Standards: Theory, Evidence, Policy*. Cheltenham, UK, Northampton, MA, USA: Edward Elgar Publishing.

Blind, K. (2017). The Economic Functions of Standards in the Innovation Process. In: *Handbook of Innovation and Standards*, R. Hawkins, K. Blind, and R. Page, eds., Elgar Original Reference Series. Edward Elgar Publishing Limited.

Blind, K. and S. Gauch (2009). Research and Standardisation in Nanotechnology: Evidence from Germany. *The Journal of Technology Transfer*, 34(3):320–342.

Blind, K. and A. Mangelsdorf (2013). Alliance Formation of SMEs: Empirical Evidence from Standardization Committees. *IEEE Transactions on Engineering Management*, 60(1):148–156.

Blind, K. and A. Mangelsdorf (2016). Motives to Standardize: Empirical Evidence from Germany. *Technovation*, 48:13–24.

Blind, K., S. S. Petersen, and C. A. Riillo (2017). The Impact of Standards and Regulation on Innovation in Uncertain Markets. *Research Policy*, 46(1):249–264.

Böhm, E., H. Hiessl, T. Hillenbrand, R. Walz, H. Conrad, V. Kühn, K. Lützner, and H.-W. Rengeling (1998). Effektivität und Effizienz technischer Normen und Standards für kommunale Umweltschutzaufgaben am Beispiel der kommunalen Abwasserentsorgung. UBA Forschungsvorhaben 98-108/2, Fraunhofer ISI, Karlsruhe.

Borraz, O. (2007). Governing Standards: The Rise of Standardization Processes in France and in the EU. *Governance*, 20(1):57–84.

Bulkley, G., G. D. Myles, and B. R. Pearson (2001). On the Membership of Decision-making Committees. *Public Choice*, 106(1-2):1–22.

Cabral, L. and D. Salant (2014). Evolving Technologies and Standards Regulation. *International Journal of Industrial Organization*, 36:48–56.

Coughlan, P. J. (2000). In Defense of Unanimous Jury Verdicts: Mistrials, Communication, and Strategic Voting. *American Political Science Review*, 94(2):375–393.

David, P. A. (1985). Clio and the Economics of QWERTY. *The American Economic Review*, 75(2):332–337.

David, P. A. and S. Greenstein (1990). The Economics of Compatibility Standards: An Introduction to Recent Research. *Economics of Innovation and New Technology*, 1(1-2):3–41.

DIN (2007). DIN EN 45020:2007-03: Normung und damit zusammenhängende Tätigkeiten (EN 45020:2006 E/F/D).

DIN (n.d.) Principles of Standards Work. http://www.din.de/en/about-standards/din-standards/principles-of-standards-work. Accessed: 2017-07-28.

DIN and Federal Republic of Germany (1975). Vertrag zwischen der Bundesrepublik Deutschland und dem DIN Deutschen Institut für Normung e.V. vom 5.6.1975.

DWA (2005). Geschichte der DWA. DWA-Information.

DWA (2008). DWA-A 400 Grundsätze für die Erarbeitung des DWA-Regelwerkes.

DWA (2013a). Geschäftsordnung für die Fachgremien der DWA.

DWA (2013b). Geschäftsordnung für die Fachgremien der DWA.

DWA (2016). DWA-A 400: Grundsätze für die Erarbeitung des DWA-Regelwerkes – Entwurf.

DWA (2017a). DWA-M 808 Handreichungen zur Ausschreibung und zur Wertung von Angeboten für Bauleistungen.

DWA (2017b). DWA-Satzung: Ausgabe März 2017.

DWA (2017c). Jahrbuch mit Vorjahresbericht. Hennef.

DWA (n.d.) DWA Fachgremiennavigation. http://www.dwa.de/hfa/. Accessed: 2017-05-20.

Egyedi, T. M. and R. J. Ortt (2017). Towards a Functional Classification of Standards for Innovation Research. In: *Handbook of Innovation and Standards*, R. Hawkins, K. Blind, and R. Page, eds., Elgar Original Reference Series. Edward Elgar Publishing Limited.

Farrell, J. and G. Saloner (1985). Standardization, Compatibility, and Innovation. *The RAND Journal of Economics*, 16(1):70–83.

Farrell, J. and G. Saloner (1986). Standardization and Variety. *Economics Letters*, 20(1):71–74.

Farrell, J. and T. Simcoe (2012). Choosing the Rules for Consensus Standardization. *The RAND Journal of Economics*, 43(2):235–252.

Hao, L. and W. Suen (2009). Decision-making in Committees. *Canadian Journal of Economics/Revue canadienne d´´economique*, 42(2):359–392.

Hesser, W., A. Feilzer, and H. D. Vries (2006). *Standardisation in Companies and Markets*. Hamburg: Helmut Schmidt University.

Jänchen, I. (2008). *Normungsstrategien für Unternehmen*, 1st edition. Berlin: Beuth.

Katz, M. L. and C. Shapiro (1985). Network Externalities, Competition, and Compatibility. *The American Economic Review*, 75(3):424–440.

Katz, M. L. and C. Shapiro (1986). Technology Adoption in the Presence of Network Externalities. *Journal of Political Economy*, 94(4):822–841.

Kloepfer, M. (2011). Instrumente des Technikrechts. In: *Handbuch des Technikrechts: Allgemeine Grundlagen Umweltrecht – Gentechnikrecht – Energierecht – Telekommunikations- und Medienrecht – Patentrecht – Computerrecht*, M. Schulte and R. Schröder, eds., Pp. 151–199. Springer.

Mai, M. (2011). Technische Normung: eine Mikroebene der Technikgestaltung, In: *Technik, Wissenschaft und Politik*, Pp. 217–225. Wiesbaden: VS Verlag für Sozialwissenschaften.

Moldovanu, B. and X. Shi (2013). Specialization and Partisanship in Committee Search. *Theoretical Economics*, 8(3):751–774.

Oelmann, M. (2005). *Zur Neuausrichtung der Preis- und Qualitätsregulierung in der deutschen Wasserwirtschaft*. Köln: Kölner Wissenschaftsverlag.

Reimers, K. (1995). *Normungsprozesse: Eine transaktionskostentheoretische Analyse*. Wiesbaden: Gabler Verlag.

Reinhardt, M. (2012). Die Regeln der Technik im Wasserrecht - Staatliche und private Standardsetzung in Zeiten des Wandels. *Korrespondenz Abwasser, Abfall - KA*, 59(7):648–651.

Simcoe, T. (2012). Standard Setting Committees: Consensus Governance for Shared Technology Platforms. *The American Economic Review*, 102(1):305–36.

Simcoe, T. (2014). Governing the Anticommons: Institutional Design for Standard-Setting Organizations. *Innovation Policy and the Economy*, 14(1):99–128.

Swann, G. P. (2000). The Economics of Standardization. Report for Standards and Technical Regulations Directorate, Department of Trade and Industry, Manchester Business School, Manchester.

Swann, G. P. (2010). The Economics of Standardization: An Update. Report for the UK Department of Business, Innovation and Skills (BIS).

Tassey, G. (2000). Standardization in Technology-based Markets. *Research Policy*, 29(4):587–602.

Voelzkow, H. (1996). *Private Regierungen in der Techniksteuerung. Eine sozialwissenschaftliche Analyse der technischen Normung*. Frankfurt am Main: Campus Verlag.

Vries, H. J. d. (1998). The Classification of Standards. *Knowledge Organization*, 25(3):79–89.

Vries, H. J. d. (1999a). Actor Needs. In: *Standardization: A Business Approach to the Role of National Standardization Organizations*, H. J. d. Vries, ed., Pp. 55–72. New York: Springer Science+Business Media.

Vries, H. J. d. (1999b). Classification of Standards. In: *Standardization: A Business Approach to the Role of National Standardization Organizations*, H. J. d. Vries, ed., Pp. 55–72. New York: Springer Science+Business Media.

Vries, H. J. d. (1999c). Methods to Develop Standards. In: *Standardization: A Business Approach to the Role of National Standardization Organizations*, H. J. d. Vries, ed., Pp. 159–172. New York: Springer Science+Business Media.

Vries, H. J. d. (2010). Fundamentals of Standards and Standardization. In: *Standardisation in Companies and Markets*, W. Hesser, A. Feilzer, and H. J. de Vries, eds., Pp. 1–43. Hamburg: Helmut Schmidt University.

Werle, R. and E. J. Iversen (2006). Promoting Legitimacy in Technical Standardization. Science, *Technology & Innovation Studies*, 2:19–39.

Wiegmann, P. M., H. J. de Vries, and K. Blind (2017). Multi-mode Standardisation: A Critical Review and a Research Agenda. *Research Policy*, 46(8):1370–1386.

Zi, A. and K. Blind (2015). Researchers' Participation in Standardisation: A Case Study from a Public Research Institute in Germany. *Journal of Technology Transfer*, 40(2):346– 360.

IBES

ISSN-Nr. 2192-5208 (Print)
ISSN-Nr. 2192-5216 (Online)