

Identification of Innovation Barriers in the Water Industry

A Master's Thesis submitted for the degree of
"Master of Business Administration"

supervised by
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Vienna, 7.7.2017



Affidavit

I, **CHRISTIAN WALDER**, hereby declare

1. that I am the sole author of the present Master's Thesis, "IDENTIFICATION OF INNOVATION BARRIERS IN THE WATER INDUSTRY", 80 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Signature

“Stay Hungry. Stay Foolish.”

Steve Jobs

“The best way to predict your future is to create it.”

Peter F. Drucker

“If you want something new, you have to stop doing something old.”

Peter F. Drucker

Abstract

The main goal of this thesis is to identify barriers to innovation in the water industry and to highlight their importance in the innovation process. Water is essential for public health, environmental ecosystems and in general for a nation's social and economic well-being. Water systems are today increasingly facing immense sustainability challenges such as water scarcity, climate change, population growth and urbanization. In order to be able to address these challenges, innovative solutions and radical changes within the water industry are required.

By contrast, water management is facing an innovation deficit, as the industry is widely characterized as being less innovative than other economic sectors. Possible reasons for this situation relate to the characteristics of the industry such as its strong exposure to the public sector, expensive and durable installations and major responsibility towards the general public (provision of drinking water, etc.). The identification of innovation barriers is a first step, which is essential in order to deal with these problems and attempt to overcome them.

The innovation barriers have been identified during in-depth interviews with five water companies and are clustered along the three dimensions comprised by (i) external stakeholders, (ii) the organizational level and (iii) the individual level. Analysis has shown that especially for SMEs the most important barriers relate to the external stakeholder dimension, such as the access to funds, the customer characteristics, or the regulatory frameworks. In addition, it is essential to consider the fact that along with the technological dimension of innovative water products and services, there are also political, cultural, social and economic aspects that have to be taken into consideration.

The future will involve the creation of innovation systems that incorporate different dimensions with the goal of increasing innovation within the water industry. More of the same will neither be economically efficient, nor socially acceptable. This is why innovation is essential to the future of urban water systems and to the water industry as a whole.

Keywords: Innovation barrier · Water industry · Water innovation · Innovation deficit

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1 Introduction

1.1 Problem formulation

Water in sufficient quantity and safe, clean quality is a crucial factor for public health, environmental ecosystems and in general for a nation's social and economic well-being. Consequently, the uses of water resources, as well as the service required to provide clean water play an important role in economies around the world (EPA, 2014). The global water market volume for the provision, distribution and cleaning of water is estimated to be around USD 500 billion per year (TechKNOWLEDGEy Strategic Group, 2013).

The water industry is often described as conservative, risk averse and less innovative than other economic sectors (Daigger, 2016; Markard, 2011). A number of structural characteristics hamper innovativeness in the water industry such as asset durability, capital intensity, regulatory intensity, systemization, public organization, competition intensity and environmental impacts (Markard, 2011). All these factors result in slow, incremental changes and path dependency (Kiparsky *et al.*, 2016). According to the European Commission (2016a) the numbers for R&D intensity and innovation in the water sector are significantly lower than those for other sectors. There is also a high degree of consolidation within the national European water industry with a few large firms playing a dominant role and stagnating employment levels over the last decade. Spending on innovation in the water and waste disposal industry in Germany for example was € 0.42 bn in 2013 and increased slightly to € 0.49 bn in 2014 and € 0.54 bn in 2015. Nevertheless, the percentage of sales generated from new technologies within the industry was only 0.4% and R&D spending declined to 8% in 2014. Only 2% of the companies in this sector practice R&D on a continuous basis (Zentrum für Europäische Wirtschaftsforschung, 2016).

By contrast, the water sector is facing substantial challenges due to the rise and influences of global mega forces (van Bergen *et al.*, 2012). Growing populations, increased pressure on ecosystems, climate and land use change, urbanization and shifting regulatory requirements are just some examples of the forces, which have pushed urban water systems to, and even beyond, the limits of their capacity (Kiparsky *et al.*, 2016).

In order to meet these challenges, substantial innovation and new solutions will be necessary. The importance of water innovation has been realized by policy makers in recent years and has been included in various policy and research agendas. Examples are the Horizon 2020 program, the European Innovation Platform on Water (EIP Water), the Joint

Programming Initiative of EU member states on Water (JPIWater) and the Water supply and sanitation Technology Platform (WssTP).

1.2 Objective of the master thesis

The main goal of this thesis is to achieve a better understanding of the mechanisms of innovation and innovation barriers in the water industry. The analysis is based on a literature review (amongst others: When &, Montalvo, 2014; EIP Water, 2014; etc.) and the results of in-depth interviews carried out with representatives of five water companies.

In addition, suggestions and recommendations based on a literature review and interview results are given with regard to how the acceptance of water innovations can be increased and innovation barriers overcome. There is a degree of awareness within the water industry that new technologies are needed to improve the performance and resilience of urban water systems (Daigger, 2009; Daigger, 2011). But while visions of reinvented systems exist (amongst others: Tove *et al.*, 2016), in practice progress has been slow. A sustainable reinvention of the water sector will be crucial in order to meet the water challenges that lie ahead of us (Kiparsky *et al.*, 2016).

2 Theoretical context

2.1 Water

Water is vital for life on Earth. It is a crucial element both for national and local economies and a prerequisite for the creation and retention of jobs across all sectors of the economy. Consequently, sustainable water management, water infrastructure and access to a safe, reliable and affordable supply of water and adequate sanitation improve living standards, expand local economies and lead to greater social inclusion. Neglecting water issues will have significant negative impacts upon economies, livelihoods and populations with potentially catastrophic and extremely costly results. Sustainable water management, although a very broad term for such a complex problem, is a priority objective in order to be able to achieve sustainable development in both developed and developing countries (WWAP, 2016).

As fresh liquid and atmospheric water, which sustains terrestrial life, makes up less than 1% of the total stock of our planet (excluding the 1.7% currently locked in ice) it must be carefully managed to ensure water security for all. Grey *et al.* (2013) define the concept of water security as, “The availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies” (Grey *et al.*, 2013, p. 3-4).

By contrast, between 2011 and 2050 the global population is expected to grow from 7 to 9.3 billion, which represents an increase of 33% (UN DESA, 2011). At the same time, food demand will rise by 60% (Alexandratos & Bruinsma, 2012) and it is projected that populations living in urban areas will almost double from 3.6 billion in 2011 to 6.3 billion in 2050 (UN DESA, 2011). In future, a larger and more affluent global population will also increase the market demand for water-intensive products, such as meat. This will result in a significantly higher water demand on the part of the agricultural industry, as the water footprint for, e.g. beef is more than nine times higher than the water footprint for cereals (15,400 l of water per kilogram for bovine meat versus 1,600 l of water per kilogram for cereals) (Mekonnen & Hoekstra, 2010). At present, about 70% of freshwater withdrawals are already used for agriculture and this number is moving towards 90% in most of the world's least-developed countries. The growth in population requires the provision of water and food to a significantly higher number of people and therefore if the current statistics are considered, it is obvious that this will be a major challenge for the future (WWAP, 2016).

To date, it is estimated that 663 million people use drinking water from unimproved water sources. These are sources in which human use is kept separate from that by animals and fecal contamination, but this does not necessarily mean that such water sources are free from bacteria or other contamination (UNICEF/WHO, 2015). Examples of unimproved drinking water sources include unprotected wells, springs and surface waters. Nearly half of the people using unimproved drinking water sources live in Sub-Saharan Africa, while one fifth live in Southern Asia. The number of people without reliable access to water in a quality that it is safe for human consumption is at least 1.8 billion (UNICEF/WHO, 2015) and possibly significantly more. Furthermore, in 2015 more than one-third of the global population, which is more than 2.4 billion people, had no access to improved sanitation facilities (UNICEF/WHO, 2015).

In addition, the OECD's Global Environmental Outlook's Baseline Scenario (OECD, 2012) calculates that 2.3 billion people are expected to be living in areas and river basins with severe water stress by 2050. In particular, these areas include North and South Africa and South and Central Asia. Global water demand is projected to increase by 55% due to growing demand from manufacturing, thermal electricity generation and domestic use.

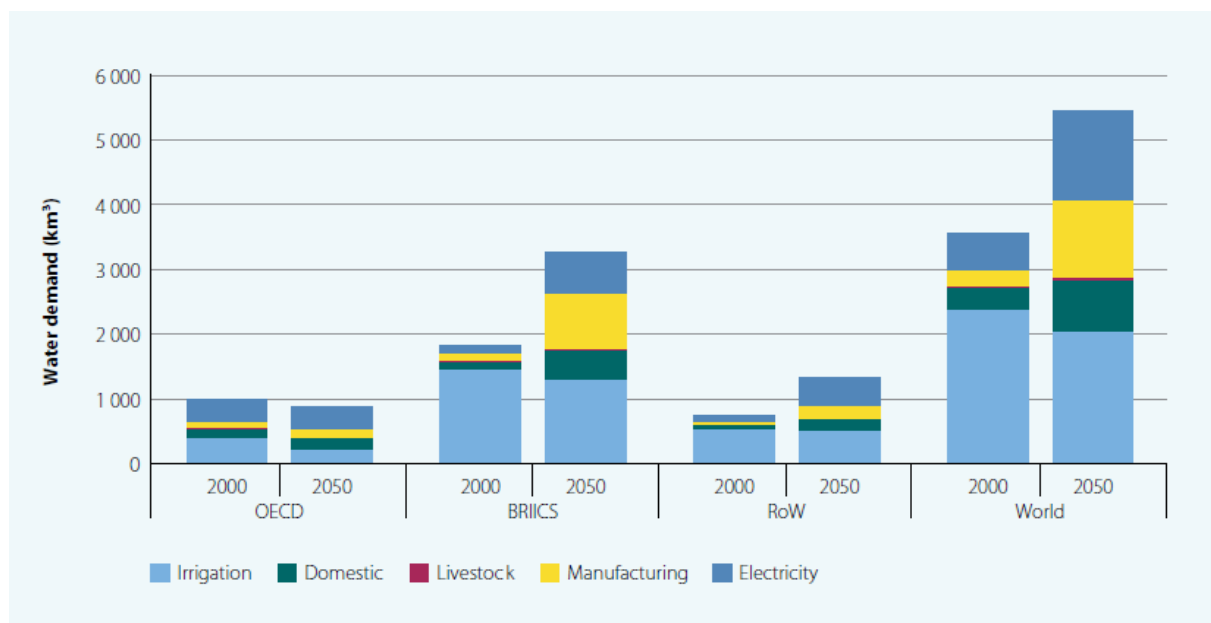


Fig. 1: Global Water Demand (freshwater withdrawals): Baseline Scenario, 2000 and 2050. (Note: BRIICS (Brazil, Russia, India, Indonesia, China, South Africa); OECD (Organization for Economic Co-operation and Development); RoW (rest of world) (Source: OECD, 2012, p. 217).

When looking at these numbers, it has to be considered that modeling and quantifying potential increases in water demand and resulting water deficits is extremely difficult and

afflicted with uncertainty. This is because of uncertainties concerning future biophysical, climatic, economic and socio-political conditions (WWAP, 2012).

Nevertheless, irrespective of the magnitude of actual future global and local water deficits, water scarcity will significantly influence opportunities for future economic growth, the creation of decent jobs and social structures in extensive regions of the world during the upcoming decades (WWAP, 2016).

2.1.1 Sustainable Development Goals and future risks

On 1 January 2016, the 17 Sustainable Development Goals came into force. Over the next 15 years, countries are focusing on the mobilization of efforts aimed at ending all forms of poverty, fighting inequalities and tackling climate change, while ensuring that no one is left behind. The Sustainable Development Goals are a follow-up to the success of the Millennium Development Goals and aim to go further to end all forms of poverty (UN, 2016a).



Fig. 2: Overview of the Sustainable Development Goals.

(Source: <http://www.un.org/sustainabledevelopment/sustainable-development-goals/> - retrieved on: 29.12.2016).

Goal Number 6 is the ensuring of the availability and sustainable management of water and sanitation for all. This goal goes beyond drinking water and sanitation, and also addresses the quality and sustainability of water resources. It highlights the importance of water resources to sustainable development and the crucial role that improved drinking water, sanitation and hygiene play in progress in other areas such as health, education and poverty reduction (UN, 2016b).

As water is closely connected with social, economic, political forces, a decrease in water quantity and water quality represents a serious risk for future global development. Against

this background, the World Economic Forum, WEF (2016), evaluates a water crisis as being a global risk with high impact and highly likely within a time horizon of the next 10 years (see Fig. 3 and Fig. 4).

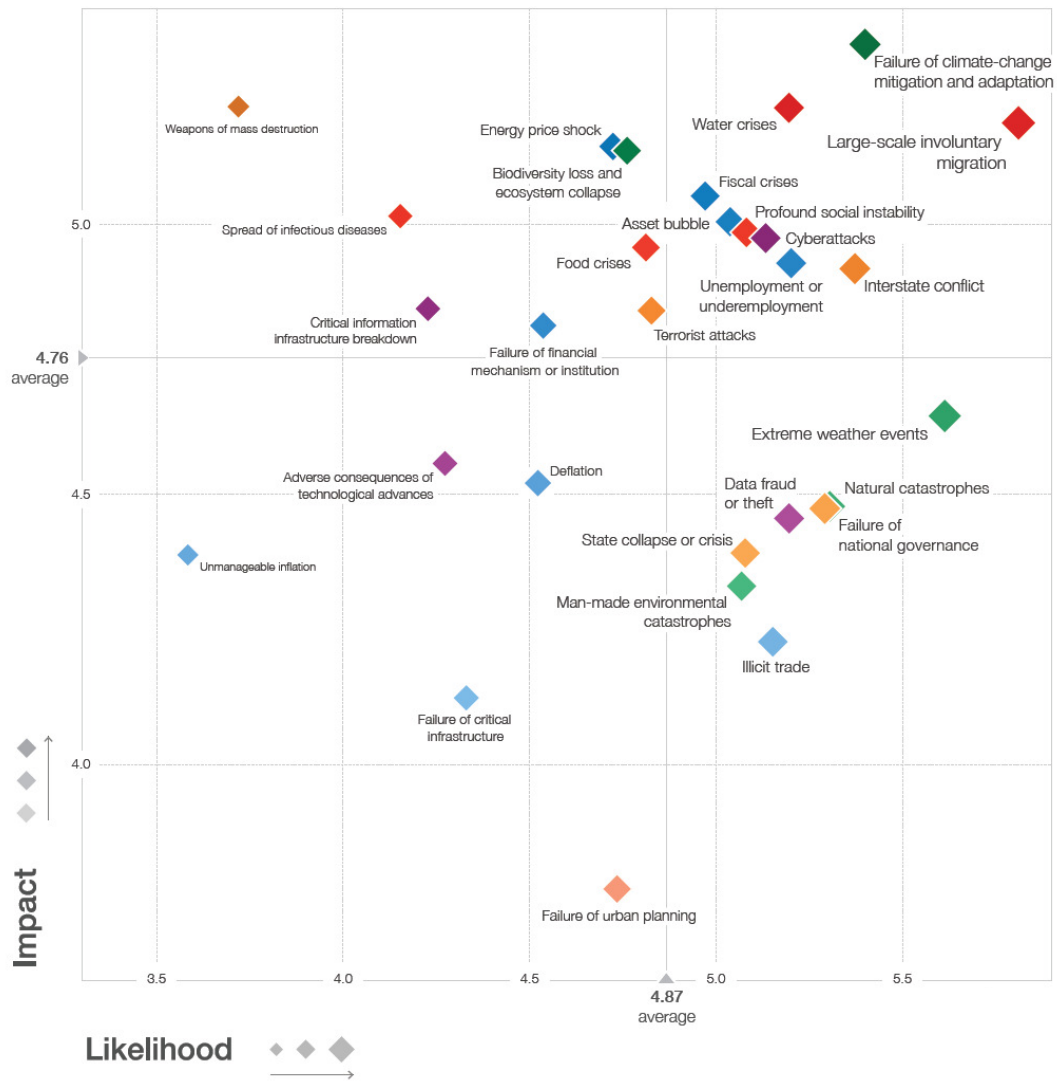
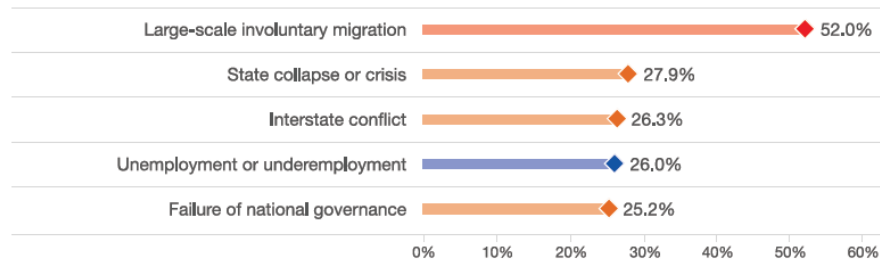


Fig. 3: The Global Risks Landscape 2016 (Source: WEF, 2016, p. 3, own arrangement).

For the next 18 months



For the next 10 years

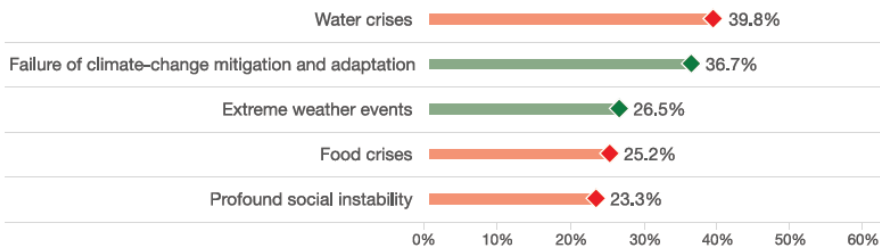


Fig. 4: The top five global risks of highest concern for the next 18 months and 10 years (Source: WEF, 2016, p. 18).

In order to be able to deal with the risk of a water crisis and its interrelated dangers, sustainable water management is mandatory. At the heart of water management on a global, regional and local level lies governance, as it is frequently the case that public authorities at different levels manage water and sanitation. Furthermore, because many investments in infrastructural projects have a long-term perspective and require sizeable funding, the political situation of a country is a crucial factor in successful water infrastructure management. Especially in developing countries, both political and financial challenges hinder the sustainable management of water resources. But even in developed countries, governments are failing to proactively address water-related issues. Instead many only react after extreme weather events or other incidents. Water management is further complicated by the economic pressures derived from the unsustainable use of water (more fresh water needed for energy production and industry). Owing to the growing competition between agriculture, industry, energy and cities, and against the background of increased water demand in the future, tensions are likely to grow within countries, particularly between rural and urban, and poorer and richer areas. At present, more than 60% of the world’s trans-boundary water basins lack any type of cooperative management framework (WEF, 2016).

It is obvious that urgent action and new, innovative solutions in the water sector are required in order to be able to address future challenges and to move towards a sustainable and more just world.

2.2 Innovation in the water industry

Innovation can be defined as the development, application, diffusion, and utilization of new knowledge (Carlsson & Stankiewicz, 1991; Hekkert *et al.*, 2007). It includes the products of invention, as well as their commercialization and introduction into markets and practices (Kiparsky *et al.*, 2013). Innovation is essential for organizations in order to gain and sustain competitive advantage. Innovation is now the most important driver of competitive success in many industries, either through an influence on their environment or a response to changing organizational and environmental demands (Baregheh *et al.*, 2009; Hueske & Guenther, 2015; Schilling, 2017). Innovation always operates within broad social and technical contexts. Especially the institutions that influence decision-making by players such as water managers play a crucial role in determining how innovation does or does not proceed. Institutions can be defined as the rules, norms and conventions that govern decision-making. Examples of formal components are regulations and laws, many other factors such as capabilities, cultural factors and governance structures must also be acknowledged (Kiparsky *et al.*, 2013; Scott, 2001, Kiparsky *et al.*, 2016).

One common method of classifying innovations is the drawing of distinctions between radical innovations and incremental innovations. Radical innovations can be defined as innovations that are very new and different from prior solutions, whereas incremental innovations are those that make minor changes from (or adjustments to) existing practices (Schilling, 2017). Radicalness can be considered as a combination of *newness* and the degree of *differentness*. A technology can be new to an industry, a firm or the world. It can also be significantly different from existing products and processes. The most radical innovations are new to the world and different from existing products and processes. Incremental innovations may not be new or exceptional. They can be known to the firm or industry and merely represent a minor change from existing practices (Schilling, 2017).

For example, membrane bioreactors can be considered as a radical technology owing to their reliance upon physical and chemical principles that differ fundamentally to the filtration systems that they can replace (Melin *et al.*, 2006). The radicalness of an innovation is relative and may alter over time, or with respect to different viewpoints. Consequently, a technology can also change from a radical into an incremental innovation. One example is desalination, which initially opened up radically new sources of drinking water. Over time and following increasing acceptance as a reliable source of drinking water supply, the technology has witnessed incremental technical improvements (membrane technology, flux rates,

membrane costs, etc.) leading to a point at which it is regarded as a mature and commercially viable technology (Elimelech & Phillip, 2011; Schilling, 2017).

The spread of new technologies, their public acceptance and increased use follows a typical conceptual pattern, which has been observed in several industries. The classical technology diffusion framework divides the product life cycle into different groups comprised by the innovators, the early adopters, the early majority, the late majority and the laggards (Mohr *et al.*, 2010; Kiparsky *et al.*, 2013).

Innovators, early adopters and the early majority adopt an innovation prior to the average time of adoption. Conversely, the late majority and laggards adopt an innovation after the average time of adoption (Mohr *et al.*, 2010). Geoffrey Moore adapted the adoption and diffusion of innovation model to high-technology markets. One of his key findings was that there is a large gap, the so-called *chasm*, between the early market (the innovators and early adopters) and the mainstream market (the early majority, the late majority and the laggards). One reason for this chasm derives from critical differences between these two groups with visionaries seeing pragmatists as pedestrian, whereas pragmatists believe visionaries to be dangerous. Visionaries will think and spend big and want to be first to bring in new ideas to the market. Pragmatists, by contrast, are prudent and want to stay within the confines of reasonable expectations and budgets, and therefore want to progress slowly and steadily. The chasm results from the fact that the early market is saturated, but the mainstream market is not yet ready to adopt. As a consequence, there is no one to sell to (Mohr *et al.*, 2010).

Several strategies are employed to cross the innovation chasm, which are described in the book *Crossing the Chasm* by Geoffrey A. Moore (Moore, 1995). Two major points are (1) the identification of a single target market from which the mainstream market can be pursued and (2) the finding of a partner to develop a complete product solution as an integrated, end-to-end solution, that when the product is purchased, provides the customer with a seamless experience (Mohr *et al.*, 2010).

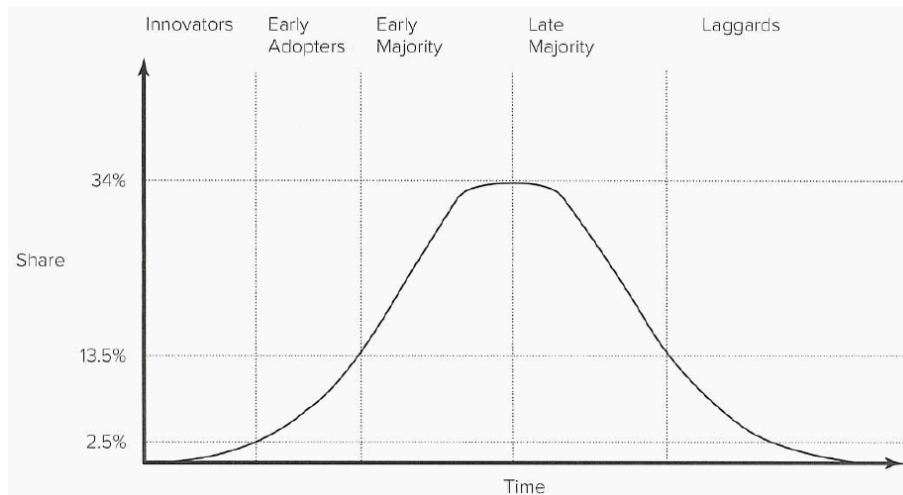


Fig. 5: Normal (Bell-Shaped) curve of market share (Source: Schilling, 2017, p. 59).

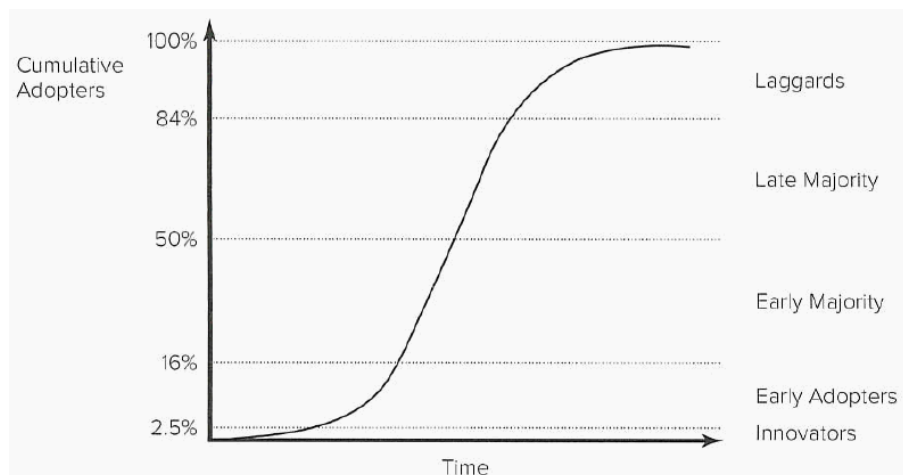


Fig. 6: S-curve of cumulative adopters (Source: Schilling, 2017, p. 59).

Water security includes a combination of physical, chemical, biological, social and economic factors, all acting on different scales and changing over time (Science for Environment Policy, 2015; Grey *et al.*, 2013). The complexity of these challenges in a rapidly changing world requires new, locally adapted and innovative solutions. Consequently, water innovation can not only apply to new technologies, but also to partnerships extending across public administration, research and industry, which lead to new business models and forms of water governance that are not only innovative themselves, but can also stimulate and support technological innovation (Science for Environment Policy, 2015). Innovation in urban water systems takes differing key forms including (1) new technologies (for example desalination or energy recovery from wastewater), (2) new approaches in management (regional coordination, rate structures, new business models, etc.) and (3) techniques and processes that increase the efficiency of existing systems (ITC, sensors and controls, the application of more precise models) (Kiparsky *et al.*, 2013; Li, 2015). Jacobsson & Bergek (2011)

formulated the *technological innovation system* approach, which is intended to enable the identification of the conditions necessary for innovations to succeed by overcoming the barriers derived from company capabilities or a mismatch in institutional structures between the new technologies and the existing systems. A technological innovation system can be defined as “a network of agents interacting in the economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology” (Carlsson & Stankiewicz, 1991, pp. 93). The important aspect of this definition is that the emphasis is on players, networks and institutions that enable innovation and not on the technical details of a new technology. This highlights the importance of these non-technical elements in the generation of innovation (Kiparsky *et al.*, 2013).

In order to be able to address global water challenges, both current and future water solutions demand scientific, technological and practical innovations within the water sector and beyond. However, the water industry is widely characterized as less innovative than other economic sectors (Markard, 2011). Possible reasons for this are the structural characteristics of water and wastewater infrastructure comprised by asset durability, capital and regulatory intensity, systemization, public organizations, competition intensity and environmental impacts (Markard, 2011). Conservatism can also be justified by the fact that the water industry and water utilities protect public health (Daigger, 2016). All these characteristics hamper innovation and lead to in slow, incremental change and path dependency (Kiparsky *et al.*, 2016).

It is evident that the world is more uncertain than ever before and that for many companies the competitive environment has changed greatly. But not all industries face the same uncertainties with regard to demand and technology. Dyer *et al.* (2014) define two primary types of uncertainty – *demand uncertainty* (will customers buy your product?) and *technological uncertainty* (make a desirable solution). The interaction of these two types defines how much uncertainty faces a specific industry.

Water supply and used water treatment facilities and installations are often managed and operated by public utilities. Although in the water industry private-public-partnership business models are also on the increase, the majority of installations are still managed by governmental institutions. In the logarithmic 2x2 matrix shown in Fig. 7, the horizontal axis plots each industry based on technological uncertainty, measured using average R&D expenditure as a percentage of sales over the past ten years. The vertical axis displays the demand uncertainty and is measured as an equal weighting of industry revenue volatility

(change) over the past 10 years and the percentage of firms that entered or exited the industry during the same period (Dyer *et al.*, 2014).

DEMAND AND TECHNOLOGICAL UNCERTAINTY BY INDUSTRY, 2002-2011

DEMAND UNCERTAINTY

Index of industry revenue volatility and firm turnover (logarithmic scale)



SOURCE COMPUSTAT, 2013

HBR.ORG

Fig. 7: Demand and Technological Uncertainty by Industry, 2002-2011. (Source: Dyer *et al.*, 2014, p. 3).

Utilities are located in the lower left quadrant, which indicates both a low demand uncertainty and technology uncertainty. According to Dyer *et al.* (2014), these types of industry require lower innovation management skills than the industries located in the other quadrants.

As already mentioned, water and used water management often resides in the public sector. There are significant differences in the incentives for innovation between the public and the private sector. Whereas in the private sector incentives from innovation emanate from competition, the profit motive and focused decision-making, innovation in the public sector is challenged by the absence of such factors (Tidd & Bessant, 2013; Kiparsky *et al.*, 2016).

The latest compilation of industrial data from the German water supply and sanitation industry sector for the years 2013-2015 supports the aforementioned arguments. Spending on innovation was € 0.49 bn in 2014 following € 0.42 bn in 2013. On the basis of the total business volume of the water and recycling industry, spending on innovation amounted to only 1 % (see Fig. 8). In 2014, only 3% of the total sales volume of the water and recycling industry was generated with products less than 3-years-old (following 5.9% in 2013 and 2.2% in 2012, see Fig. 9). If the R&D activities in the water and recycling industry are analyzed, only 2% of the companies studied carry out R&D and innovation projects on a regular basis,

while another 6% state that they pursue R&D activities occasionally and 93% of the companies say that they are not completing any R&D or innovation projects (Rammer, & Schubert, 2016).

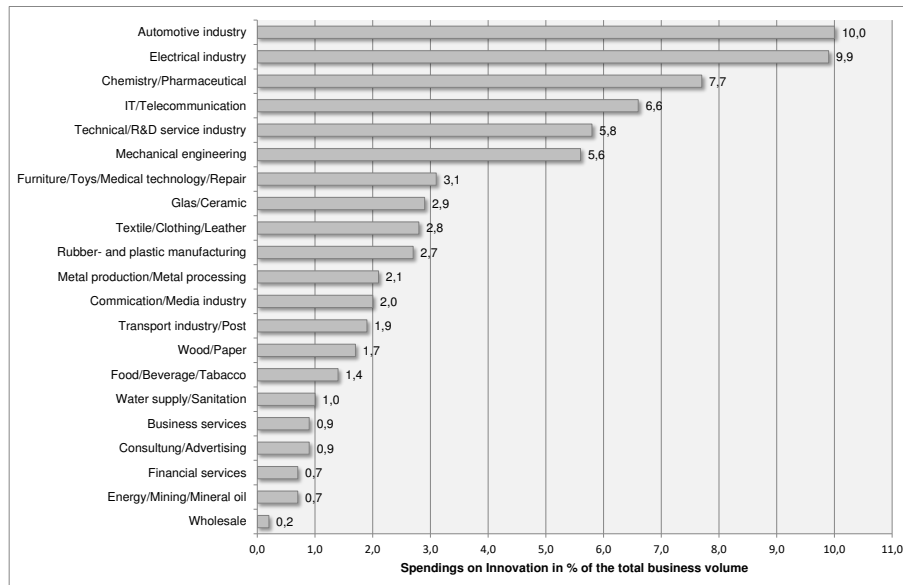


Fig. 8: Intensity on innovation divided according to different industry sectors of the year 2014 (Source: Rammer & Schubert, 2016, p. 1; own arrangement).

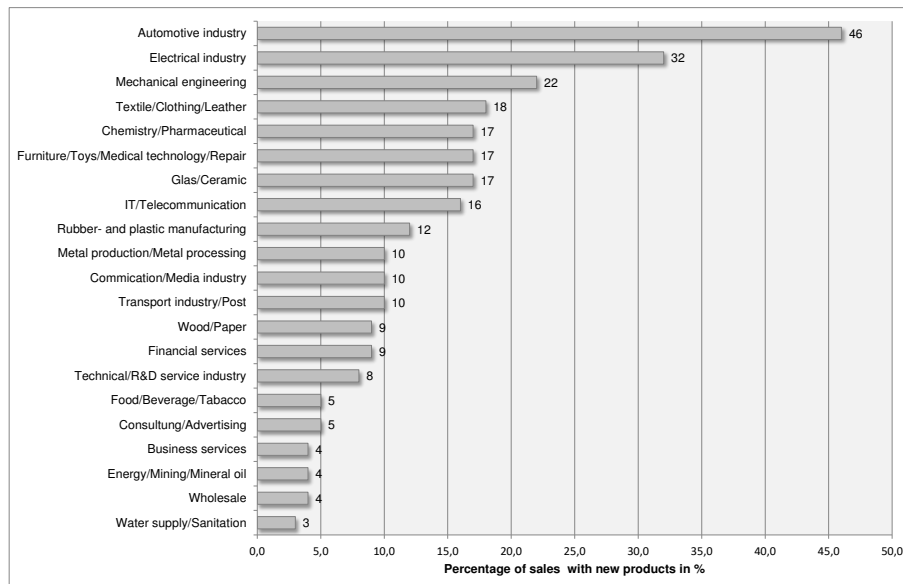


Fig. 9: Percentage of sales generated with new products in % of the year 2014 (Source: Rammer & Schubert 2016, p. 1; own arrangement).

2.2.1 European Innovation Partnership on Water (EIP Water)

One strategic program for addressing the lack of innovation in the water sector is the European Innovation Partnership on Water (EIP Water). EIP Water aims, “To stimulate

creative and innovative solutions that contribute significantly to tackling water challenges at the European and global level, while stimulating sustainable economic growth and job creation” (European Commission, 2012, p. 4). It also intends to promote collaboration in the water sector across the public and private sectors, non-governmental organizations and the general public (Science for Environment Policy, 2015). Another goal of this program is the identification of barriers and bottlenecks with respect to innovation in the water sector and the highlighting of measures that can overcome these hindrances.

The European Innovation Partnership on Water (EIP Water) is an initiative within the EU 2020 Innovation Union. The Innovation Union was launched in 2010 as a part of the Europe 2020 strategy with the goal of pushing Europe’s strengths and addressing its weaknesses with respect to innovation. The initiative should make Europe more competitive with regard to budgetary constraints, demographic change and increased global competition by tackling both the supply and demand side elements within the innovation eco-system, which consist of the public sector, businesses, academia and finance. The goal is to shape a framework conditions for innovation that extends from the European Commission to member states and regional governments, as well as other relevant stakeholders (European Commission, 2015).

In particular, EIP Water should facilitate the development of water solutions, which cannot be solved with current or business-as-usual approaches and technologies on either a European or a global level. EIP Water also supports the identification of market opportunities for new innovations, which include new products, approaches, processes, services, technologies and ideas. EIP Water focuses on an integrated view of water management and therefore the goal is to promote collaborative approaches and processes for water innovation across the public and private sectors, non-governmental organizations and the general public. EIP Water is targeted on eight priority areas: (1) water reuse and recycling, (2) water and used water treatment, including resource recovery, (3) water-energy nexus, (4) flood and drought risk management and (5) ecosystem services. In addition, three cross-cutting priorities are defined: (6) water governance, (7) decision support system and monitoring and (8) financing for innovation (EIP Water, 2017).

2.3 Innovation barriers

Successful innovation depends on firms combining a range of capabilities. These include the ability to access finance, understand market needs, recruit highly skilled staff and establish effective interactions with other stakeholders. Innovative firms have to cope with most, if not all, of these challenges. Some firms are deterred from involvement in innovation because of the related difficulties and thus adhere to their old, established routines. Other firms try to

innovate and invest in formal and informal research and development, but fail to bring new products or processes to market because they are unable to overcome these barriers (D'Este *et al.*, 2012). Until now, research has focused on successful examples of the implementation of innovation within organizations and firms. Barriers to innovation are frequently mentioned, but rarely investigated in detail (Mirow *et al.*, 2007). Amongst others, Hall & Martin (2005) argue that, "The key to innovative success is to minimize the disruption within the innovation value-added chain" (Hall & Martin, 2005, p. 274). Although their focus is only on the innovation value-added chain and does not consider secondary stakeholders, it still indicates the importance to the innovation process of taking into consideration all stakeholders with their individual needs and preferences.

Innovation barriers are considered as factors that impede, delay or completely block innovation (Mirow *et al.*, 2007; Hueske & Guenther, 2015). Innovation barriers research tries to reveal and understand barriers and determine their nature, origin and importance. Consequently, it aims to identify their point of impact in the innovation process and to measure their effects and consequences (Hadjimanolis, 1999).

Innovation is a multi-level process, which is influenced by factors on an environmental, organizational and individual level. Consequently, a consideration of the innovation barriers must also take into account these three levels of analysis (Hueske & Guenther, 2015). Innovation barriers are often expressed as rational arguments. Hauschildt (2004) distinguishes between the technological, marketing, financial and ecological arguments against innovations. The fact that in many cases, innovation barriers are obvious has to be considered, but nevertheless there are also tacit innovation barriers or "hidden rules", which may hamper innovation (Mirow *et al.*, 2007).

Innovation barriers can be classified in various ways. Hueske & Guenther (2015) employ a multilevel model to identify the barriers on three levels of analysis comprised by the external environment, the organization and the individual. This model is used for the analysis in this thesis. By contrast, Mirow *et al.* (2007) classify innovation barriers in four dimensions (i) What is the nature of the innovation barriers? (ii) Who is confronted by innovation barriers, (iii) Where do the innovation barriers come from? and (iv) At which point in time in the innovation process do the barriers appear? In particular, point (iv), the temporal perspective of innovation barriers, is missing in the Hueske & Guenther (2015) model. Mirow *et al.* (2007) define four innovation process phases, which consist of idea generation, idea selection, implementation and bringing the product onto the market. Hauschildt (2004) divides the innovation process into a decision-making and an implementation process, whereby specific

innovation barriers may arise for each process. Barriers related to the complexity of the innovation are more prominent during the decision process, while interaction barriers are more important during the implementation phase. The more advanced the innovation in the innovation process, the more important are the forces on the organizational level. Consequently, the type of innovation barriers may change during the various phases of the development.

A large amount of literature regarding innovation barriers exists. Nevertheless, the research on innovation barriers in the water industry is still fragmented. Consequently, this thesis should contribute to answering the following research questions: (1) What in particular are important innovation barriers within the water industry? (2) Are there differences between the innovation barriers perceived by SMEs and by larger organizations? (3) How are the companies interviewed dealing with innovation barriers and trying to overcome them?

2.3.1 Barriers at the external environment level

External barriers relate to the marketplace and the regulatory environment of the company (Mirow et al., 2007). According to the innovation value-added chain, suppliers, customers and complimentary innovators (e.g. competitors) are key stakeholders, who can influence innovations, or are influenced by them (Afuah & Bahram, 1995). Suppliers are defined as providers of basic resources for the organization. These are not limited to suppliers of materials, but also of human resources and investors as suppliers of financial resources (Hueske & Guenther, 2015). Furthermore, the state as the regulator responsible for political and legal framework conditions, and society (e.g. local communities or environmental activists) are stakeholders in the Hueske & Guenther (2015) model at the external environment level. The role of the state is ambiguous, as it may restrict innovation activities, but regulatory schemes can also trigger innovations, e.g. by upgrading certain quality standards for water, which have to be fulfilled.

2.3.2 Barriers on the organizational level

On the organizational level, the innovative company forms the center of the innovation value-added chain (Afuah & Bahram, 1995). Hueske & Guenther (2015) define five different factors that influence innovation at an organizational level: (i) strategy, (ii) structure, (iii) resources, (iv) organizational learning and (v) organizational culture.

The innovation strategy should be aligned with the company's overall strategy, otherwise resources are not used efficiently and the innovation competes with different priorities. Company strategy influences the behavior of the staff and top management. According to the

literature, company strategies that focus on the exploitation of a narrow market segment and do not allow internal change processes can hamper innovation significantly (Teece *et al.*, 1997, Blumentritt & Danis, 2006).

Moreover, the organizational (macro) structure is shaped by the organization's strategy (Wolf & Egelhoff, 2000). Damanpour (1991) identifies three main innovation barriers, which are related to an organization's structure and consist of formalization, centralization and vertical and horizontal differentiation. Formalization hampers the openness and flexibility of an organization, which are both important factors in the promotion of an innovation culture. The centralization of decision-making can result in the resistance of employees at lower hierarchical levels because they are not involved in the decision-making process. Owing to the fact that senior management is confronted with a large number of decisions in centralized organizations, it may be assumed that the quality of such decisions is decreasing. Vertical differentiation means numerous hierarchical levels, which hamper the permeability of new ideas and result in the disconnection of the idea from the innovator. Horizontal differentiation creates strong boundaries between the different departments of a company, which can impede communication and coordination between the different knowledge centers (Damanpour, 1991).

Resources are essential for innovation. Both human and financial resources are two elements, which are mandatory for innovation. Organizational learning and culture are linked to one other and refer to the resources on an organizational level and learning at the individual level. This is related to the abilities and attitudes of individuals in terms of their learning, use and sharing of knowledge (Hueske & Guenther, 2015). The organizational culture greatly influences the ability to innovate, as the behavior of the individuals within an organization is closely linked to the company's shared norms and values. Norms and values, which promote innovation, are based on a company culture that is open towards changes and tolerates failures. Little tolerance for failures may reduce the motivation of an innovator to share his ideas. As innovations are often related to conflicts, how an organization deals with diverging opinions and conflicts between the different employees and departments is also important. An open conflict culture, which tolerates a certain degree of conflict, can be favorable for innovations (Mirow *et al.*, 2007).

2.3.3 Barriers on the individual level

Organizations consist of individuals and therefore innovation depends upon their abilities and attitudes. This means that both the abilities and the attitudes of individuals can promote or obstruct innovation. Moreover, the lack of management commitment or support for innovation

can be a significant barrier (Hueske & Guenther, 2015). Mirow et al. (2007) argue that individual human characteristics constitute one of the main reasons for resistance against innovation. For example, barriers at an individual level can consist of a lack of willingness or motivational problems with regard to innovation development. Insufficient technical skills and knowledge can also be a barrier at this level. Other important aspects are the communication skills of an innovator and his/her social position within an organization. A central position within an organization’s network facilitates access to important resources and therefore it may be easier for an innovator with a good network to solve and overcome the problems, arising during the innovation process (Mirow et al., 2007).

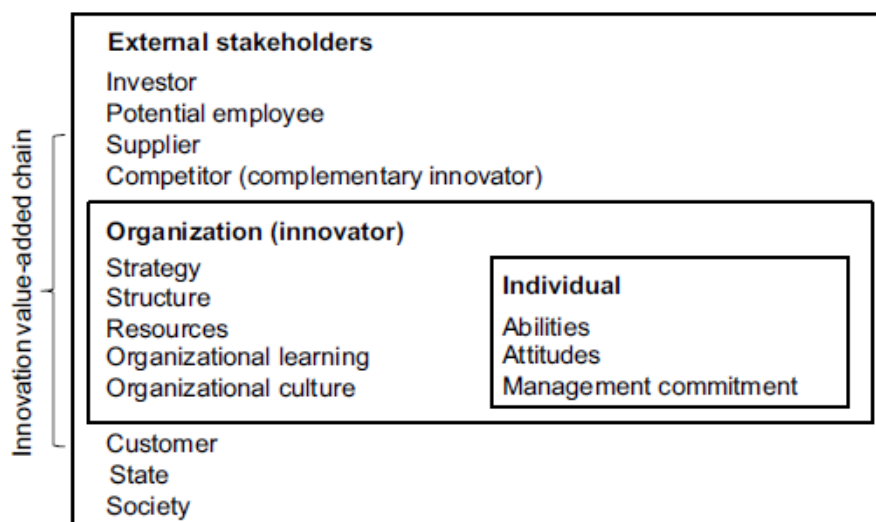


Fig. 10: Overview of the integrated and structured model of the three levels of analysis and the respective sub-categories (source: Hueske & Guenther, 2015, p. 51).

In order to overcome innovation barriers, it is essential that a holistic approach be followed. On the one hand, the overall strategy of a company must be aligned in a way that enables innovations to be absorbed and executed (“strategic fit of the company”). This then allows the implementation and creation of appropriate structures and processes within the company, and the allocation of sufficient human and financial resources. On the individual level it is important to encourage and increase the motivation of the innovators and single employees. Every employee should possess the certainty that new ideas and innovations are appreciated and promoted by the company (Mirow et al., 2007).

It is important to note that innovation barriers are not a negative fact per se. Innovation barriers can help to select and reject ideas and innovations of low quality or with a bad strategic fit. A certain resistance against innovation may prevent the company from

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expending resources, which are needed elsewhere and thus maintain the quality of those innovations, which are introduced successfully, on a high level (Mirow et *al.*, 2007).

3 Materials and Methods

There are a number of qualitative research methods, which are linked to differing opinions regarding what there is to know about the social world and how to discover it. One typical method consists of in-depth or unstructured interviews, which can be described as “a conversation with a purpose” (Webb & Webb, 1932, pp. 130 cited by Ritchie & Lewis, 2003). An in-depth interview has four key features: (1) the interview is intended to combine structure with flexibility, (2) the interview is interactive in nature and (3) the researcher uses a range of probes and other techniques to achieve in-depth answers in terms of penetration, exploration and exploitation and (4) the interview is generative in the sense that new knowledge is to be created. An in-depth interview involves several stages during which the researcher endeavors to take the interview from the everyday, social level to a deeper level and a focus on a specific issue or set of topics. At the end of such an interview, it is important to return to the everyday level (Ritchie & Lewis, 2003).

3.1 Data collection

Data for this thesis was collected using in-depth interviews with managers and employees from five innovative companies operating in the water industry. The selected companies vary in size, whereas the focus is on small and medium scale enterprises and start-ups. The data represents the perspectives of the managers and employees at these companies. Therefore, the data highlights perceived barriers from an insider perspective.

3.1.1 Interview structure

3.1.1.1 General information about the company

First, the interviewee is provided with background information on the study's objectives in order to understand the focus of the research. Subsequently, the first questions are concerned with the interviewee, his/her responsibilities and the company:

- Name of the interviewed person
- What is the interviewed person's position within the company?
- What is the number of employees?
- When was the company founded?
- What are the origins of the company (spin-off, start-up, etc.)?

- In which countries is the company active?

The next part relates to the products or services, which the company provides. The interviewee gives a short overview of the portfolio, typical applications and some customer groups:

- Description of the products/technology/service provided
- What are typical applications?
- Who are the most important customers, customer/market segments (private/public/industry?)
- What role does innovation play?

3.1.1.2 Identification of innovation barriers

The main part of the interview concerns the identification of innovation barriers. In order to inquire about open issues, the interview is started with very general questions:

- On the basis of your industrial experience, what do you regard as the relevant innovation barriers?
- Can you think of any other innovation barriers?

Having discussed the first innovation barriers; the interview is directed towards the different levels of innovation barriers:

External environment level

- What role do the state and other governmental institutions play?
- What role do investors play (shareholders, venture capitalists and banks)?
- What roles do competitors and customers play?
- What role do employees play (lack of skilled staff, etc.)?
- What role do suppliers play?
- Are there any further innovation barriers at this level that you can think of?

Organizational level

- How does strategy (long-term vs. short-term) influence innovation?
- What is the role of the available resources and the organizational structure within the company?

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- How do you ensure organizational learning (how to keep pace with the state of the art?)?
- How does organizational culture influence or hamper innovation within your organization?
- Are there further innovation barriers on this analytical level?

Individual level

- How do employee abilities and the company's attitudes influence innovation?
- What role does management commitment play?
- Are there further innovation barriers on this analytical level?

General

- Of the points discussed, which do you think is the most important innovation barrier specifically for your company?

3.1.2 Selected companies

Five companies, all of them working in the water industry, have been selected for the in-depth interviews. The selected companies are characterized by a high degree of innovativeness as they have developed their own, new products and processes and/or give high priority to R&D and innovation.

3.1.2.1 Company 1

Company 1 was founded in 2013 and is an Austrian SME in the field of online measurement systems. It is supported by the Austrian business incubator INiTS, the Austrian Research Promotion Agency FFG and the Austrian Federal Promotional Bank "Austria Wirtschaftsservice GmbH" (AWS) (Internet 1).

The main products are fully automated, microbiological online monitoring systems, which are capable of measuring the microbiological contamination level of water for different target organisms. The measurements are executed fully automatically within 15 minutes, while conventional microbiological laboratory analyses require 18 or 72 hours. The company's flagship product is the first measurement device, which is able to provide microbiological water quality as a real-time parameter. This can be used for real-time process control, process optimization, or early warning applications. It is also able to measure the following

parameters: Total Bacteria, E. coli and Coliforms Bacteria. This can be helpful in several applications (Internet 1):

- Membrane filtration process monitoring
- Disinfection process monitoring
- Flocculation process monitoring
- Drinking water quality monitoring
- Surface-, bathing-, irrigation water monitoring
- Fruit and vegetables washing water monitoring
- Used water treatment plant discharge monitoring
- Cooling water monitoring

The company has been awarded several prizes and awards, e.g. for the “Most Innovative New Technology” at the Channels for Innovation Summit at the WaterSmart Innovation Conference 2016 in Las Vegas or the “First Place Innovator” Award at the International Water Summit 2016 held in Abu Dhabi, United Arab Emirates (Internet 1).

The interview was conducted with the founder and general manager of the company on Friday, 14 April 2017.

3.1.2.2 Company 2

Company 2 is an SME based in Singapore and Germany that provides solutions for thermal separation. The applications for this technology include the treatment of highly saline process waters, the recovery of valuable materials in close to zero-liquid-discharge processing, the generation of highly purified water for pharmaceutical applications and power plant steam generation, and the energy-efficient, low temperature concentration of sugar solutions (Internet 2).

The technology is based on a process called vacuum-multi-effect membrane distillation, which is an efficient process for thermal separation using a modular concept. The modules consist of flat sheet membranes combined with an innovative plate and frame design, which are protected by a number of patents. The membrane distillation modules are produced in-house in the company’s own automated production facility. The focus thus far has been on the development of the basic process but now, the company is gathering experience in the differing applications in cooperation with partners from various industries and areas of application (Internet 2).

In October 2016, New Concepts Holdings Limited (NCHL) acquired all the company's assets and IP. NCHL is an investment holding company operating in the environmental protection and construction business area in Mainland China and Hong Kong, and is listed on the Main Board of The Stock Exchange of Hong Kong Limited (Internet 2).

The interview was conducted with the sales manager of the company on 12 May 2017.

3.1.2.3 Company 3

Company 3 is a world technology leader in the field of online, optical water quality monitoring. Its products include submersible, online spectrometer probes, water protection systems and event detection software. These systems can be used for measuring a wide range of parameters in numerous applications by providing a real-time water quality overview. All products are intelligent, robust, require little or no maintenance and can be integrated into both the company's internal systems and those of third parties. At present, some 7,000 monitoring systems are in use worldwide for various water applications (Internet 3).

The company was founded in 1999 as a university spin-off and is based in Vienna, Austria. Currently, it has four subsidiaries in USA, China, Spain and France and an export share of more than 95%. Its products are distributed in over 40 countries and applied in the private and municipal water and wastewater industry (Internet 3).

Innovation is one of the company's core values. All of its measuring systems are equipped with intelligence from in-house development laboratories. Their intelligent mix of software, hardware and algorithms forms the basis for the secure and expansion of the company's leading global market position in this field. More than 15% of the company expenditure is spent on R&D with the goal of developing new technologies and remaining on the industry's cutting edge (Internet 3).

The interview was conducted with the CEO and founder of the company on 25 April 2017 at its premises in Vienna.

3.1.2.4 Company 4

Company 4 is a water industry MNE with extensive knowledge in the design, construction and operational management of water and wastewater treatment plants. It has a workforce of around 2,000 employees and is represented via companies and offices in 25 countries. The service range provided is based on the complete life cycle of a water treatment plant, from project development to long-term plant operation. The focus is on emerging markets in

Europe, Africa, Latin America, the Middle East, India and South-East Asia, and the company has access to more than 100 in-house patents and three R&D centers in Chennai (IN), Vienna (AT) and Winterthur (CH). (Internet 4).

The interview was conducted with the Director of Technology, Research & Development, on 11 May 2017 in Vienna.

3.1.2.5 Company 5

Company 5 is a social enterprise, which develops innovative solutions with the goal of providing simple technological solutions for the benefits of poor families. The aim is to improve both the quality of the families' daily lives and the health care systems in their respective countries. The company uses green technology in order to create products suitable for sustainable applications in developing and industrialized countries (Internet 5).

Its main product is a solar-powered device that visualizes the process of solar water disinfection (SODIS) in PET bottles. Solar water disinfection is a natural process in which UV-radiation from the sun is used to eliminate pathogens in water such as viruses, bacteria and protozoa. Water is filled into PET bottles, which are exposed to sunlight. Over time the sun's UV radiation then makes the contaminated water safe for drinking purposes. The method has been investigated and scientifically proven by the Swiss water research institute Eawag and is approved by the WHO and UNICEF (Internet 6).

The company was founded in 2010. Since then, a large number of distribution partners around the world have been contracted with the objective of spreading the technology and the company's products to regions where they are urgently needed (Internet 7).

This interview took place with the CTO and founder of the company on 26 June 2017 in Vienna.

4 Results

The statements and barriers identified in the interviews have been clustered and grouped into external stakeholder, organizational and individual dimensions in line with Hueske & Guenther (2015). Each barrier is further illustrated by exemplary quotations.

4.1 External stakeholder dimension

The innovation barriers identified in the interviews that fall into the external stakeholder dimension are related to the five dimensions comprised by investors, potential employees, customers, the state and the society.

In the investor dimension, raising sufficient funds represents a significant innovation barrier for all the companies interviewed. Four of the five companies studied are SMEs and these often face resource gaps in terms of time, staff and money (Garsombke & Garsombke, 1989 cited by Hadjimanolis, 2003). However, it is of interest that the point in time at which funding problems occurred varied between the companies. For two interviewees, raising initial capital when starting the company was the most challenging barrier to be overcome. Two other interviewees identified the period during which the company grew from being a small into a medium-sized enterprise, as very challenging with regard to the accessing of sufficient funds. This means that when discussing the funding and financing of water innovation it is important to consider the time line. Financial instruments, supports and grants have to tackle both the initial funding stage and the subsequent phase when the company is expanding.

Another aspect mentioned was the financial capacity needed by the company for the application of new business models. PPP (Public-Private-Partnerships) constitute an effective method of convincing a customer of the merits of a new technology because they shift the risk related to the functional capability of a new technology from the end-customer to the contractor. Nonetheless, such business models can require significant financial resources from a company, which may be a problem for smaller organizations. Another point raised was the fact that the long-term perspective of water investments may not be interesting for investors, who have a focus on short-term ROIs.

Attracting highly skilled, potential future employees is an important aspect for all the companies interviewed. However, interestingly enough the interviewees perceived the barrier formed by the recruiting of skilled staff differently. Two companies identified finding and employing skilled staff as an innovation barrier because it is hard to discover experts with the right specific knowledge. The company must also have the resources to be able to attract the

experts and to keep them within the organization. Another interviewee stated that finding employees was not a problem and that some of the current staff even accept lower salaries than they could obtain elsewhere. The differing statements in the interviews indicate that the innovation barrier of finding potential future employees has to be evaluated subject to differing perspectives and that the social aspect has to be taken into consideration (working with a high-tech water start-up vs. working with a social enterprise).

All the companies interviewed identified customer characteristics as one of the most important innovation barriers in the water industry. The water sector is often exposed to the public sector, which is characterized as conservative and risk averse. The manner in which the companies are dealing with this problem varies. Some are focusing on niche markets and specific application fields where the acceptance of new products is higher, while others are concentrating on countries and markets that are more open to innovation. Other aspects relating to the customer dimension consist of the specific procedures in large organizations, which can be a barrier for small companies. One example from the interviews is ERP software, which requires data that small companies sometimes do not have available (product insurances, etc.). Furthermore, customer payment conditions (extended payment periods) were identified as a challenge for SMEs because they result in cash flow problems.

In the external stakeholder dimension, legal framework conditions, as well as specific norms and industrial standards can represent innovation barriers. One example raised in an interview was the approval of new methods of water analysis. Although the new measurement methods might have significant advantages as compared to conventional systems, some customers refuse to apply them because they are not approved officially. On the other hand, one interviewee mentioned that the state could also be a promoter of new technology when defining stricter regulations, which require new technologies in order that new targets are met.

Three aspects related to the dimension of society are brand reputation, innovation culture and product fit within the social environment. Two interviewees stated that brand reputation is essential in the water industry in order to obtain acceptance and create trust in the technology. The innovation culture in the DACH region was seen as a significant innovation barrier. Another important aspect is the product's fit in the social environment (social fit, e.g. taking into consideration the user's procedures, traditions, social norms, etc.). As water innovations are always embedded within a larger social and cultural context, it is important to consider this argument. Consequently, should a product lack a social fit this can prove to be an innovation barrier.

In the interviews, suppliers are perceived as an innovation barrier when they exploit their stronger position in possible conflicts with the start-up. This is especially true when the supplier is a larger enterprise, or an MNE. In such cases, the small start-up or SME is more or less helpless against the bigger company because it often lacks the financial resources needed to sue the company and the coverage of a legal dispute. The same applies to competitors in patent disputes. If the competitor is a well-known institution, or a large organization, it is difficult for the small start-up to initiate legal action against such a competitor. Based on the findings of the thesis, one important issue for the future will be an improvement in the legal certainty for start-ups, or the installation of an institution that specifically supports start-ups when they need legal advice.

Tab. 1: Overview of the innovation barriers mentioned in the interviews with regard to the external stakeholder dimension.

Innovation barrier dimension	Evidence from the interviews	Illustrative quote
Investor	Funding difficulties	<p>“It’s always been a kind of fight for survival. But finding sufficient funding and the lack of financial resources are definitely the biggest challenges.”</p> <p>“To sum up, raising money and finding sufficient funding are the main barriers because they require significant resources and effort.”</p> <p>“Financing our company in the beginning was not a big problem. Conversely, it was very challenging during the growth phase of the company in 2004-2005, when we had to cross the innovation chasm.”</p> <p>“What I miss is financial support during the subsequent phase when the company is growing.”</p> <p>“But what is really problematical is funding. I spend at least half of my time searching for and meeting new investors. I would</p>

		need this time for taking care of the business.”
	Financial capacity of the company	“Another issue, which is very important, relates to funding and financial aspects. For example, without the provision of the financing within a BOOT model, it would have been very difficult to realize and implement the [...] project.”
	Short term perspective of investors	“Along with return on investment (ROI), I consider the short-term perspective with regard to financial returns and parameters as one of the most important innovation barriers in our industry. [...] Water is such a fundamental asset that decisions are often taken with a long-term perspective.”
Potential employees	Finding skilled staff and having the resources to employ them	<p>“However, although my former ten or so employees have new jobs, I get their support in the production process whenever I need it. This again relates to the financial background and the funding of the company, but finding skilled staff is very important.”</p> <p>“One significant aspect that I forgot to mention is finding well-educated future employees, who are willing and able to work internationally. This is also an important factor.”</p> <p>“Therefore, it’s very important to have a skilled team. However, in the meantime I am so deeply involved in the subject that it is difficult for new employees to make up the knowledge gap.”</p>
Customer	Complicated	“Sometimes barriers relate to the

<p>procurement procedures</p>	<p>organizational procedures within the customer’s organization. It’s very straight-forward at, e.g. universities, but when working with big, multinational companies, their internal procedures can be quite a hurdle.”</p>
<p>Customer characteristics</p>	<p>“Introducing new innovative products in the water sector is especially difficult in Germany, Austria and Switzerland. I think that emerging economies are currently overtaking our countries, especially in the DACH region. China for example has very innovative data analysis systems in the water industry and in view of the many “friction losses” we have here in Central Europe, the emerging economies will be the technology leaders in the near future.”</p> <p>“The risks for a small engineering-procurement-construction (EPC) company are rather high and the customers are conservative. This is a problem and implementing innovative products and processes is rather difficult.”</p> <p>“But what also has to be taken into consideration when talking about innovative technologies [...] is the lack of knowledge on the customer side. This is especially valid with regard to developing and emerging countries.”</p> <p>“Therefore, the question as to whether industries are more open or closed with regard to innovation is greatly on type and of course, if it has a problem or not. For example, if companies realize that they</p>

		<p>have a cost issue, they are more open towards innovation as a means of staying competitive.”</p> <p>“Another barrier that I have experienced especially here in Austria is that the well-established players are simply not interested in our new technology. There are established paths and patterns and it seems that many organizations are unwilling to try out new things and prefer to continue with old, established and well-known procedures and products. [...] In other countries we do not face such problems and there we are testing our products with a number of NGOs and other partners.”</p>
	Payment conditions of the customer	“In addition, the payment conditions (e.g. 60 after delivery) that are standard for many big companies can be challenging for us.”
	Bureaucracy of the customer	“Another innovation barrier is bureaucracy. But this is different for municipal and industrial clients.”
	Customer acceptance, installation of demonstration sites	“If we could have carried out the trials together with the client and split the costs we might have had a full-scale reference plant.”
State	Legal framework conditions	“It may even take ten years until our method is considered as an approved procedure according to the related laws. The legal frameworks within the water sector are definitely a challenge for our product with regard to creating acceptance amongst clients. I’m quite sure that it will

		<p>require some time until our procedure is approved.”</p> <p>“The second main problem was that the method was not approved under the specific regulations and legal guidelines, and this is still the main barrier.”</p> <p>“Definitely legislation. [...] The legislative authorities are definitely a preventive factor. However, they can also be promoters and I am thinking for example of the Swiss legislation on micropollutants.”</p> <p>“During the next step, there is often a lack of legal security for start-ups when bringing investors on board the company.”</p>
	Norms and standards	<p>“We have currently a point at which we are asking ourselves if it makes sense to sell the products in countries which have such strong norms and regulations. Norms and standards are a huge innovation barrier.”</p>
Society	Brand reputation within the community	<p>“What we have learned over the years is that the most important aspect in our industry is product branding. Without a brand it is very difficult to position an innovative product.”</p> <p>“The third problem in the beginning was that we were a new player in the field and had no brand reputation.”</p>
	Innovation culture	<p>“In our Central European region the thinking that everything is running perfectly hampers and blocks innovation. It’s impossible to talk about drinking water monitoring in the DACH region.”</p>

	Fit to the social environment	“The acceptance of the local communities and end customers can be challenging. [...] But the important question is whether or not the new product fits into the daily existence of the end-users, or do they have to change their habits and their way of life?”
Supplier	Duration of the product development	“Yes, this was a problem because things were taking too long. But now I know that this is the normal way that things happen because development from the first prototype to a product, which is ready for serial production, needs at least a year.”
	Utilizing their stronger position	“I wanted to have a signed warranty form, but [...] they refused to sign it. At that point in time I could do nothing. If I had sued them, they would have immediately stopped production. So they utilized their stronger position against our company.”
Competitor	Utilizing their stronger position	“We had a chance to sue them because they had obviously copied our technology and we have the patent but each lawyer advised us not to do so because suing US companies and especially MIT is very difficult and not to be recommended.”

4.2 Organizational dimension

Innovation barriers in the organizational dimension relate to internal resources, organizational learning and culture. One interviewee mentioned a lack of human and financial resources as an innovation barrier, as it was not possible to hire new staff for the R&D department.

Both organizational learning and organizational culture are mentioned within the context of scaling up the organization from a small to a medium-sized enterprise. It can be seen that the scaling up of a company involves a number of critical moves such as hiring the right staff and entering the next rounds of financing. Maintaining the entrepreneurial spirit and creating

a culture that promotes innovations are two challenges, which were mentioned in the interviews and are currently important for many organizations.

Tab. 2: Overview of the innovation barriers mentioned in the interviews with regard to the organizational dimension.

Innovation barrier dimension	Evidence from the interviews	Illustrative quote
Internal resources	Sufficient funding	<p>“At that time, Mr. Sch. was the CEO [...] He was opposed to spending on this training course and he was very unhappy that we spend a week visiting innovative membrane bioreactors in Germany together with the possible customer. Sometimes you really have to fight against resistance within your own management team, which is an internal innovation barrier.”</p> <p>“However, the client was unwilling to pay for the trials, so it selected another process and company. This is again related to management and the resources released for a specific project.”</p> <p>“But internal resources are a limiting factor. This relates to knowledgeable staff leaving the company and a lack of sufficient employees in the unit to execute R&D projects.”</p> <p>“When developing a product it is important to have sufficient resources for each of the interfaces in the product development [...] This can be compared to a formula or a multiplication in which several variables represent the different players involved in the development cycle. If one of the variables is zero, the whole equation turns out to be zero.”</p>

Organizational learning	Maintaining the entrepreneurial spirit in a growing organization	“I think this is an advantage of a small company and for me personally as a CEO, it’s a huge challenge to retain the entrepreneurial spirit within the company. This is very difficult. If you are unable to make this happen, then the company has a problem.”
Organizational culture	Create a culture that promotes innovation	“As compared to the beginnings of our company, we now need ten times longer for new developments. This is naturally related to the organizational set-up, but it’s also a puzzle for me and I do not know the real reasons for this situation.”

4.3 Individual dimension

Individual abilities and management commitment constitute innovation barriers within the individual dimension.

Examples of abilities include specific expertise and the know-how or the individual characteristics of the entrepreneur. In several interviews, specific knowledge in this field was identified as one of the key drivers for innovation. Consequently, a lack of skilled staff can be an important innovation barrier. Small companies are specifically shaped by the individual characteristics of the entrepreneur, or founder of the company. Strong communication skills and the ability to convince people are important aspects along with the technical knowledge and expertise. If an entrepreneur lacks these personal characteristics and abilities, this can be considered as an innovation barrier. Selecting promising ideas and future products is an essential step in the innovation process. Formulating the innovation problem in the correct manner and taking into consideration not just technical, but also other information from sales or customer services is very important. The formulation of problems from standpoint of an inventor and a sales manager can be quite different and must be coordinated between the different departments. Stage gate processes can support the review of an innovation from different perspectives.

The aspect of management commitment is related to sufficient funding for R&D and innovation. A lack of managerial attention can result in a shortage of funds for the R&D department and human resources. One interesting aspect, which was raised during the

interviews, was that the strong personality of the CEO can itself be an innovation barrier because the other members of the organization trust that he/she will take the lead.

Tab. 3: Overview of the innovation barriers mentioned in the interviews with regard to the individual dimension.

Innovation barrier dimension	Evidence from the interviews	Illustrative quote
Abilities	Specific expertise and know-how	<p>“The R&D department should develop technical innovations and the marketing department should find product and service innovations. In reality, innovation is currently mainly driven by sales and customer service. But there is a general problem because if I merely follow the feedback from customers and clients, I only innovate in the direction of the client’s wishes. But I understand innovation as something which you can offer to the client that they did not wish for or expect and is a surprise for them.”</p> <p>“We then asked ourselves why we had not applied our patented process thus far and I think one reason why we did not apply this patent in full-scale projects was that several experts with critical knowledge related to this technology left the company.”</p> <p>“Once again it is important to have employees who have technical skills and experience in the field with customers, and who are able to come up with innovative solutions.”</p>
	Characteristics of the entrepreneur	<p>“When I develop a product I must be fully convinced that the system works. I’m not a person just standing out in front and telling</p>

		<p>stories, which are not true. I must be sure that my products are functional and [...] certain that my system is working.”</p> <p>“Innovation also depends on the personality of the entrepreneur. [...] He fully identified himself with his product from the first day of development until the exit, when he sold his company [...].”</p>
	Individual problem definition	<p>“Well, one important issue that has to be considered is the question: “Is the product really innovative?” The inventor and an experienced sales manager often answer this question differently.”</p>
Management commitment	Role of the CEO	<p>“I may even be an innovation barrier personally because I give clear directions as to how innovation has to take place. When you are a strong and innovative person it can happen that you are also a problem.”</p> <p>“What comes to mind is the management attention factor. [...] if there is a new process development, or a new product the management team is very interested and supports it massively. Conversely, insufficient management attention can be a barrier for innovation. Managerial attention and support are both very important.”</p>

The results gained from the in-depth interviews highlight the fact that the vast majority of innovation barriers relate to the external stakeholder dimension (7 innovation barriers with 17 items of evidence from the interviews overall). On the one hand, this might be specific to the water industry, as there is a major exposure to the public sector. On the other, the results match the literary findings, which highlight that barriers may vary according to the size of the

firm. It is widely believed that for small companies external barriers are more important than internal barriers. This is because they do not have the know-how or the resources to overcome any external barriers that may exist. The main innovation barriers in large firms are mostly internal ones, which arise from their organizational complexity (hierarchies, etc.) and often consist of problems with communications and coordination, and possibly a lack of incentives (Hadjimanolis, 2003).

The results showed also that in order to deal with external innovation barriers, many SMEs are selling their products and services in countries and markets, which are more open to water innovation. All of the companies interviewed are generating significant parts of their sales in other countries by exporting their goods and services, and are characterized by pronounced internationalization.

5 Discussion

5.1 Innovation barriers

Based on the findings gained in the in-depth interviews with the five water companies, the results are discussed in the context of existing literature data and results from other studies. The report “Barriers and bottlenecks for Innovation in the Water Sector” (EIP Water, 2014) summarizes and highlights barriers and bottlenecks, which are hampering the achievement of the goals in each of the eight EIP water priority areas. The different barriers which occurred in the various priority areas of the EIP study are matching with the results from the interviews held within this study (EIP Water, 2014).

- *Lack of funds for small and medium-sized enterprises (SMEs)*

Within the external investor’s dimension, funding difficulties, the financial ability of the company and the short-term perspective of investors were identified as the most important innovation barriers. The development of a new technological product often requires financial resources for the development of a prototype, other assets such as a laboratory or production facilities, and for human resources. It was mentioned in the interviews that there are a number of agencies available in Austria, which provide grants and funds for start-ups. But contacting these agencies requires a lot of time and effort, especially for a single entrepreneur, and receiving the requested funds can be difficult for technological start-ups.

Small and medium-sized enterprises represent the majority of all businesses in the European Union. In terms of workforce size alone, enterprises with fewer than 250 employees are estimated to constitute >99% of the total number of enterprises across Europe (CSES, 2012). Many SMEs are innovative and develop new products and services, but are often confronted by a lack of financial resources for the further commercialization of their products. Development often stops due to very little or no access to funds, R&D or other financial resources (EIP Water, 2014).

When considering the development of innovative, closed-loop industrial treatments, the installation of new technologies can be a particular problem for SMEs because of the high costs. For example, the uptake of the on-site treatment and re-use of water has been particularly slow in the textile industry, largely because many European textile businesses are SMEs (Science for Environment Policy, 2015; Vajnhandl & Valh, 2014). D’Este *et al.* (2012) also argue in their study that the main obstacles faced by small firms relate to the lack of both resources and the market structure. The missing resources include knowledge,

organizational skills and a lack of finance. Market structure can impose severe constraints in the form of competition, firm size and other conditions. Large established firms are often confronted with barriers to innovation because of path dependency and locks such as organizational inertia, or resistance to engaging in innovation in order to avoid the cannibalizing existing products or core competencies (D'Este *et al.*, 2012).

Within a survey carried out amongst used water utility managers in California, Kiparsky *et al.* (2016) also identify cost or financing as the most important barrier to innovation. Utility managers have to meet increasingly stringent regulatory requirements and at the same time are unable to raise per capita or per household revenues because of political and legal pressures. A differentiation must be made between short-term costs (e.g. investment and capital) and life-cycle costs for a given technology. Whereas access to capital is a key hurdle for a local utility, infrastructure investment can be challenging even when long-term rate reductions may result for the clients. Conversely, there are examples of innovations that reduce service costs, as for example when framing wastewater as a resource for energy recovery (biogas utilization, etc.) (Kiparsky *et al.*, 2016).

- *Customer characteristics, risk aversion in the water sector*

Customer characteristics and antiquated structures within customer lobbies form another important innovation barrier and were mentioned several times in the interviews. The bureaucracy at large business customers with their organizational procedures was also identified in the interviews as a barrier, especially with regard to SMEs selling their products.

As already mentioned, a certain risk aversion and resistance against innovations can be observed in the water sector (Daigger, 2016). This is especially true of with regard to drinking water applications, as this sector protects public health and therefore trusts more in traditional technologies. On the other hand, the water industry sector is characterized by high capital intensity. Because of the scaling problem, it is possible that deficiencies only occur in full-scale plant projects, which have high financial impacts. Therefore, municipalities and other water technology customers want to reduce their project risks and avoid innovative solutions (EIP Water, 2014). Instead of applying new technologies, water utilities also often prefer to invest in existing, long-lasting technologies, with the maintenance or renovation of this equipment claiming a large portion of current budgets (Science for Environment Policy, 2015).

Kaparsky *et al.* (2016) also identify risk and risk aversion among decision-makers as one of the key effects, which influence innovation. These results to some extent from the incentive structures in place in public organizations where decision-makers generally face a set of

incentives that encourage risk aversion. Lieberherr & Truffer (2015) argue that little competence in innovation management has been built up in most water utilities and that private and mixed governance modes have an increased degree of innovativeness. Understanding the perceptions of risk and the incentives for risk aversion is an important step towards the development of institutional changes to speed up the evolution of urban water services.

- *Lack of demonstration sites, brand reputation*

Another point raised in the interviews was brand reputation within the water community, which is related to the number of references and full-scale plant installations that a company possesses. The more demonstration sites are available, the easier it is to gain acceptance and to create a brand awareness of a new product or process.

Alternative business models such as public private partnerships might facilitate the use of innovative solutions and the implementation of demonstration sites because the risk is partly shifted to the contractor. However, when employing such business models the organization has to have sufficient financial capacity and funds available. This argument was also raised in the interviews.

In their paper, Dolnicar *et al.* (2010) highlight the relationship between the information about water from alternative sources and public acceptance. Their results clearly indicate that acceptance increases significantly when people are provided with information about the water production process. This also applies to new processes, as customers are easier to convince when they are able to see the benefits of a new technology “for real” and are provided with first-hand information. However building representative, large-scale demonstration sites is again capital intensive (EIP Water, 2014). Kiparsky *et al.* (2016) report in their study that as many as 65% of the interviewed utility managers require at least a demonstration project to even consider the technology and almost 25% will only consider technology that is standard to the industry.

Identification of Innovation Barriers in the Water Industry

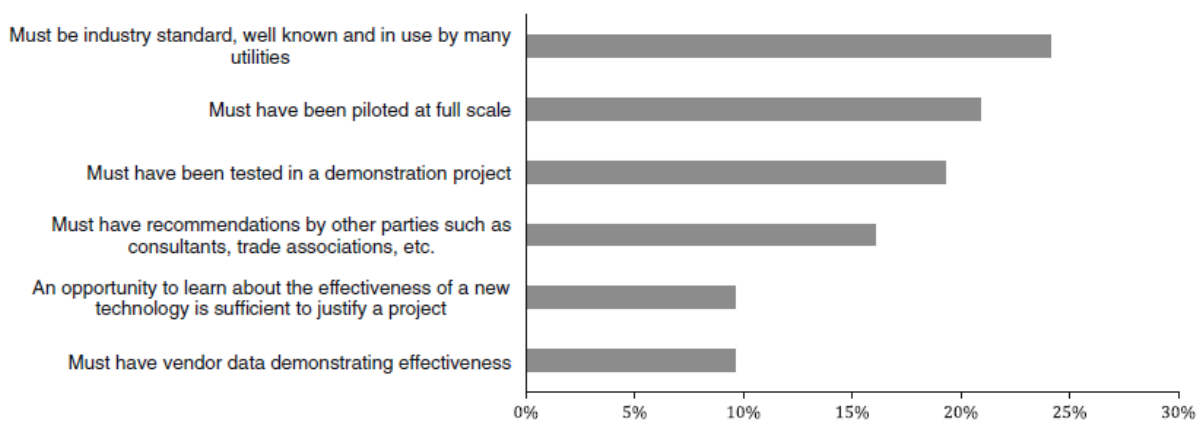


Fig. 11: Statements of wastewater utility managers when asked what is required for them to consider an innovative technology (Source: Kiparsky *et al.*, 2016, pp. 1214).

The installation and operation of demonstration sites in order to convince the client regarding a new technology was highlighted in the interviews. An interviewee stated that the required financial resources were not approved and therefore the client opted for another technology. This clearly shows that pilot trials are a powerful tool for increasing customer acceptance.

- *Legal regulations, industry standards, inconsistency and fragmentation of policies and regulations*

The argument that legal regulations and industry standards are a significant barrier for innovation in companies was also mentioned in the interviews. When for example the official institutions have not approved a new measuring approach, it can be used for internal monitoring, but the client must continue to operate with the procedure certified by the public authorities. This is one reason why the companies are trying to sell their products abroad in other markets where the legal hurdles are not as high as in the DACH region.

The regulatory environment in the water sector is very complex, as there are different regulations along/across the various political levels (e.g. different regulations and standards per region). This high fragmentation of the legal frameworks and division of responsibilities along the different levels of governance can be an influential factor in hindering innovation (EIP Water, 2014). Innovation is not hampered in general by regulation, but it is somewhat negatively influenced through its implementation or enforcement in a specific environment. Besides other factors, this is because regulations are a function within another set of drivers and barriers. Examples of fragmentation are provided by the non-harmonized regulations across the EU, because these are certified at national levels and there are several countries with specific and different requirements (EIP Water, 2014).

With respect to one very important regulation within the European water sector, the Water Framework Directive (WFD, 2000), it was found to have positive effects on innovation both directly and indirectly. The WFD establishes rules to halt deterioration in the status of EU water bodies and to achieve a “good ecological and chemical status” for Europe’s rivers, lakes and groundwater by 2015. Within this framework the legislation places clear responsibilities on the national authorities throughout the EU with regard to the integral assessment and management of their water bodies (WFD, 2000). The implementation of the WFD has encouraged the demand for water-related goods and services and as the WFD is a stringent regulation, many European companies in the water sector have witnessed a growing demand for innovative goods and services (Technopolis Group, 2013).

- *Water authorities and water sector fragmentation*

A direct consequence of the high fragmentation of policies and regulations is that at different levels the utilities responsible for water supply, used water, storm water, waste and energy are independent of each other. There is only low-intensity cooperation between the different sectors and the fragmented nature of small water utilities and SMEs can also slow down the diffusion of innovation (Science for Environment Policy, 2015). This results in potential synergies and advantages remaining unrecognized or unrealized. Utilities are often quite small and lack the strategic, technological, planning competences and necessary funds to implement innovative water system solutions. In addition, the various stakeholders (e.g. drinking water and wastewater from urban areas; irrigation for agriculture; process water and wastewater from industries) have divergent interests and perspectives regarding water innovation and will therefore favor it differently (EIP Water, 2014).

- *Conservative procurement*

Current procurement approaches still focus on low/lowest costs and insufficiently consider longer-term operational or lifecycle costs. There is also a preference for conventional, proven technologies, which additionally hampers the innovation process (EIP Water, 2014). Within their Europe 2020 strategy, the EU is trying to push forward the development of a forward-looking, innovation procurement strategy in such a way that public procurers can drive innovation from the demand side. This should enable the public sector to modernize public services faster, while also creating opportunities for innovative companies in Europe (EC, 2016b).

Procurement procedures were also mentioned in the interview as an innovation barrier, not only in the public, but also in the private sector where different ERP software is used, which requires data that is sometimes unavailable to small companies.

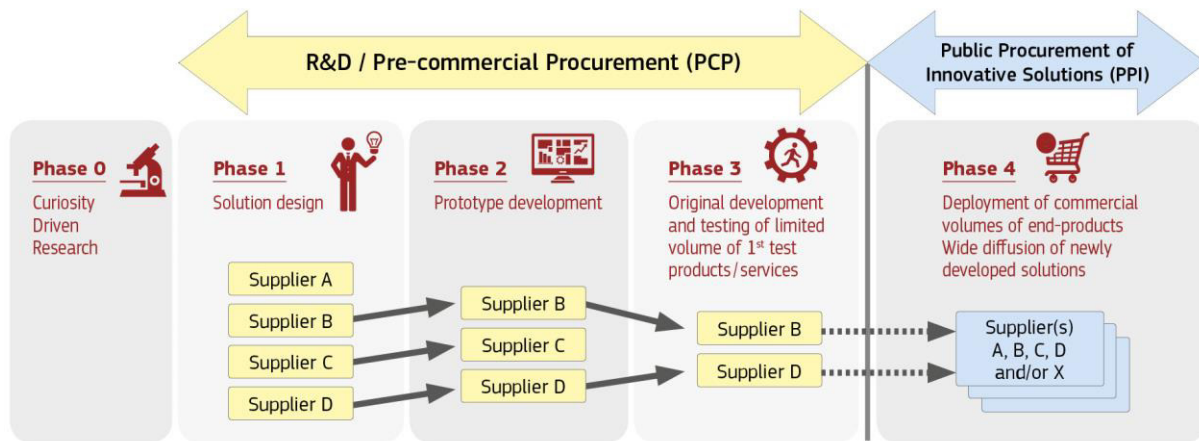


Fig. 12: Overview of the European Commission's Public Procurement of Innovative solutions (PPI) framework (Source: EC, 2016b, <https://ec.europa.eu/digital-single-market/en/innovation-procurement>).

5.2 Approaches to overcoming innovation barriers

There are several approaches to overcoming innovation barriers in the water industry. One objective is to develop adequate financial instruments. As highlighted in the literature on innovation barriers and in the interviews, financial instruments and funding play an important role in the application of innovations in the water sector. The financial risk influences various stakeholders: water users/launching customers, equipment providers, contractors, developers/demonstrators, funders/banks and SMEs (EIP Water, 2014). Currently, there are discussions and policy initiatives ongoing as to how to combine private and public funding in order to push investments and innovation forwards. One prominent example in this connection is the European Fund for Strategic Investments (EFSI). Its major goal is to help finance infrastructure and innovation projects, as well as small and medium-sized enterprises (SMEs) and mid-cap companies. Another approach is to create revolving funds, which cover part of the financial risk for customers employing innovative technologies.

Harmonizing the legal frameworks and regulations (including standards, joint targets, etc.) is another approach to overcoming innovation barriers. Water regulations should address and facilitate innovation and therefore EU regulations should be reviewed with regard to their positive and negative impacts upon the placing of innovations in the global water market (EIP Water, 2014).

Innovative organizational and regulatory models are also needed (Tove *et al.*, 2016). The cooperation between the different stakeholders within the water-related value chain should be promoted through the recognition of possible synergies. Public water utilities are often relatively small because water management is organized on a regional and local level. This

fragmentation and consequently the lack of a critical mass for investments and insufficient market size, hamper the implementation of innovative solutions. One approach to overcoming this barrier could be to explore and develop partnership approaches in order to ensure cooperation and finance. These partnerships could take the form of public-private-partnerships or inter-sectorial frameworks. Groups could thus exchange information on best practices and be able to make larger orders, thereby not only possibly reducing costs, but also creating more viable propositions for suppliers (EIP Water, 2014; Science for Environment Policy, 2015). The collaboration with universities can also be a powerful tool for testing new technologies and creating synergies. Universities have different possibilities for raising funds and can also help in creating acceptance of the functionality of a new product, or measuring method amongst different water sector stakeholders.

There are a number of examples of technology and innovation platforms, which try to enhance knowledge diffusion between the stakeholders through social and business networks. Trade organizations such as the International Water Association provide forums where representatives from industry and public utilities can engage in order to build knowledge and practice networks (Kiparsky *et al.*, 2013). Another example is the Technology Approval Group (TAG), which was initiated by Isle Utilities in 2005, as a global innovation forum for the world's leading water utilities. It acts as a bridge for connecting innovators with people, who are looking for new technologies on behalf of large public and private sector organizations. It would be very difficult for start-ups to get in contact with all the stakeholders individually, but within the TAG forum they are brought together in one place. The main goal of the TAG is to accelerate the market uptake of innovative technologies by involving the industry during the pre-commercial stages of development. There are regular TAG meetings in Europe, the US, Australia and the Philippines, and the topics covered include municipal water/used water, industrial water, and clean tech in the building environment (Isle Utilities, 2017). One of the interviewees also used this platform for leveraging the publicity of his company and increasing his network.

Demonstration sites have to be established in order to create acceptance and confidence for innovative technologies. Examples of good cooperation between different areas should be identified and consequently one or more regional showcases implemented. The lessons learned from other innovation initiatives can then be drawn upon (EIP Water, 2014). The implementation of demonstration sites and innovative technology trials can also be supported through grants. One example is the "Preparatory action on development of prevention activities to halt desertification in Europe" (European Commission, 2013), which supplies grants for pilot initiatives for new technologies, while also disseminating best practices to

improve water savings. Grants can also be used to combat risk aversion. There are approaches in the Netherlands, which have been used for providing financial support to cover any unexpected additional costs or adaptations that might arise (EIP Water, 2014).

Effective water pricing could be another method of stimulating the application of new innovations. For example, the European Commission recommends that water and wastewater charges should be based not only on financial costs, but also on environmental and resource expenses (Hrovatin & Bailey, 2002). Separate charges for water use and effluent might drive industry towards increased efficiency, investment in water treatment innovation and the closing of local water cycles (Partzsch, 2009). Many water-pricing policies are still not targeting on a defined and restricted user group, and equitable utilization that does not harm the environment. Consequently, any pricing must be supported by clear and appropriate regulations (Science for Environment Policy, 2015.)

6 Summary and Outlook

Water systems all over the world are facing immense sustainability challenges such as water scarcity, climate change and population growth (Sousa-Zomer & Cauchick Miguel, 2016). At the same time, increasing awareness of the environmental impacts of water use is creating additional pressure to do more with less. Until now, there has been an innovation deficit in urban water management. Water management in general has tended to evolve slowly, particularly in the absence of dramatic regulatory pressure and public funding. Addressing the current stressors and challenges will require faster innovation and major changes within the industry (Kiparsky *et al.*, 2013).

The goal of the thesis is to identify and highlight innovation barriers in the water industry by interviewing executives and non-executives from five innovative companies, which are working in this field. Three interviews were carried out with executives from start-ups, one with an executive from a SME and one with an R&D Director from a MNE. The in-depth interviews were carried out using open questions and a structured interview guideline.

According to literary guidelines, the innovation barriers identified were clustered in the following three dimensions: (1) external stakeholder dimension, (2) organizational dimension and (3) individual dimension. For each dimension, several sub-categories were identified and are illustrated by exemplary quotes from the interviews. The interview results were compared with data from other studies and public policies such as the European Innovation Partnership on Water.

With reference to the external stakeholder dimension, the interview results highlighted the fact that the investor dimension, i.e. the funding and raising of sufficient money for expanding the company, or applying new technologies is seen as one of the most important barriers. This applies to both start-ups in their initial phase and larger SMEs when growing and trying to cross the innovation chasm. Conservative customers are perceived as a major barrier to innovation in the field of water. This is due to the fact that water utilities are often public organizations and are managed by decision-makers, who face a set of incentives that encourage risk aversion. Furthermore, water systems are capital-intensive and public budgets are often constrained (Kiparsky *et al.*, 2016). Due to the exposure of the water industry to the public sector legal regulations, as well as norms and standards, play a crucial role and were defined as a major innovation barrier in the interviews. In particular, this applies to new procedures or technologies, which are not approved by the legal authorities, or specific norms and laws. In order to gain approval for a new technology, companies have

to do a great deal to convince a number of stakeholders and organizations, especially in the DACH region. As this process takes a long time and has an uncertain outcome, two of the interviewed small companies are looking for other markets, and are selling their products abroad where legal regulations are more flexible.

Barriers on the organizational level relate to the allocation of sufficient resources for R&D and innovation. However, innovation barriers at this level are also connected to the cultural aspect of a company and the goal of keeping the entrepreneurial spirit alive when the organization is growing and the creation of a culture that promotes innovation. Innovation barriers on the individual level relate to the specific abilities of the staff (particular knowledge, staff fluctuations) and factors appertaining to the CEO (lack of managerial attention).

The results from the interviews match the literary data closely (amongst others: EIP Water 2014; Kiparsky *et al.*, 2013; Kiparsky *et al.*, 2016; Science for Environment Policy, 2015; etc.) and it would seem that companies and professionals in the water industry are experiencing comparable innovation barriers. In the following section, suggestions for overcoming the innovation barriers are discussed on the basis of literature research and the conclusions deduced from the interviews. These include the provision of adequate financial instruments and funds, the harmonization of legal frameworks within the water sector and the installation of demonstration sites, which would increase the trust of water professionals in new technologies and processes.

Innovations in the water industry not only involve the technological inventions that generate greater efficiency and the physical transformation of water treatment and delivery systems, but also the political, cultural, social and economic factors that can both hamper and facilitate such changes. Existing practices will need to be altered in ways that are not yet anticipated because simply doing more of the same will not be economically efficient or socially acceptable. This is why new ways of doing things, or innovations, will be essential to the future of urban water systems (Kiparsky *et al.*, 2013).

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8 Appendix

8.1 Transcription of the interviews

8.1.1 Company 1

The interview was conducted with the founder and CEO of the company. The interview was carried out personally on 15 April 2017 in Vienna. The interview language was German.

I have already found some information about your company and your products on your homepage. How many employees do you have currently?

At present, I have two employees. Until six months ago, I had ten.

The company was founded in 2013, is that correct? And what were the “origins” of your company?

I started in 2010 with the development of the product and in 2013 founded the firm as a limited liability company (GmbH). Initially, I had the idea for an instrument for measuring colorimetry. Then this idea developed towards fluorescence measurement. Theoretically, many different parameters could be measured with this method, but I decided to focus on the measurement of microbiological parameters in water. Measuring real-time microbial parameters in water has to date been unavailable and this is the reason why I focused on this field of application.

In which countries or regions of the world are you doing business? Is there a focus region?

Three of our products are in Canada, one in New Zealand, one in Denmark, one in Sweden, one in the UK, one in Austria, one in Germany and one in Spain. We are thus working worldwide. I am also in contact with the main sewage treatment plant in Hong Kong and with PUB in Singapore and NEA in Singapore.

Are your main clients from the public or the private sector?

Our clients come from both the public and the private sector. The clients that contact us are really interested in the technology and are pushing ahead with new technologies and innovations. They either have a real technology need, or are truly innovative. Universities were among our first clients because ensuring that our technology is scientifically proven is one of our strategic goals.

I would now like to focus our discussion on innovation barriers. To dive straight into the topic, what in your experience do you consider as the most important innovation barriers? To date, which innovation barrier proved the biggest challenge for you?

It's always been a kind of fight for survival. But finding sufficient funding and the lack of financial resources are definitely the biggest challenges. For an innovative product there is at least a minimum amount of money required, e.g. for producing a prototype, for installing a lab, or for human resources. Without this minimum amount, it's impossible to start a business.

One problem for an individual entrepreneur like me is that lots of time and effort are needed to acquire the required financial backing and money. Especially in my case because mine is a very new technology in the field and not an app or something, it is very difficult to raise the money, which is necessary in the beginning.

In Austria there is a relatively well-developed subsidy environment with several agencies that provide grants and funds for start-ups. However, it seems that their focus is sometimes more on companies that provide new apps than on companies with a new technology. When contacting a funding agency, the discussion about an exit starts immediately.

To sum up, raising money and finding sufficient funding are the main barriers because they require significant resources and effort.

When thinking about other barriers, which others spring to your mind?

Other barriers include the legal framework conditions. Our method of analyzing and determining bacteria in water will not be legally approved within the coming years. It may even take ten years until our method is considered as an approved procedure according to the related laws. The legal frameworks within the water sector are definitely a challenge for our product with regard to creating acceptance amongst clients. I'm quite sure that it will require some time until our procedure is approved.

The situation is totally different in other geographic regions, for example in the Asia-Pacific region and especially China. The water stress and the urgent need for action in the field of water supply and sanitation favor the application of innovative products and processes and even generate pressure for new solutions. This is why I'm pretty sure that we can enter these markets earlier than our central European markets. Here in Europe, we focus on specific, targeted applications.

I'm currently in contact with the EPA (Environmental Protection Agency, USA) and I'm a member of the Austrian standards committee.

What other innovation barriers can you think of? Are you subject to any organizational innovation barriers?

Due to the specific situation that I'm facing at present, I only have two employees. However, although my former ten or so employees have new jobs, I get their support in the production process whenever I need it. This again relates to the financial background and the funding of the company, but finding skilled staff is very important. Nevertheless, the sales forecasts for the current year are very promising, so I think that I can increase the number of staff again during the year.

Do competitors play a role as an innovation barrier?

Not really in our current situation. Although I have to admit that some competitors would be great for raising awareness with regard to our product and the possibility for product comparisons. Being the first mover can occasionally be very challenging.

Can you think of other innovation barriers?

Sometimes barriers relate to the organizational procedures within the customer's organization. It's very straight-forward at, e.g. universities, but when working with big, multinational companies, their internal procedures can be quite a hurdle. They have specific hierarchies and systems, which are mandatory for, e.g. placing an order. For example, I just delivered a product to a large multinational company in the UK. Naturally, it has R&D departments, who want to test our device and take their own measurements. But in order to buy one of our units, they naturally have to place an order. For placing the order, the SAP system has to be fed with numerical data and if we are unable to provide one of these numbers (e.g. insurances which we do not even have), then it's impossible to continue with the purchase order in their system. This is one hurdle for selling the product to huge MNEs because they have their specific programs, which have to fit.

In addition, the payment conditions (e.g. 60 after delivery) that are standard for many big companies can be challenging for us.

Cooperation with bigger companies is sometimes carried out via universities. The companies fund and financially support a project at a university and the university then buys a product from us. This is a procedure that can overcome the "structural hurdles" at big companies.

Are there other barriers you can think of?

When I develop a product I must be fully convinced that the system works. I'm not a person just standing out in front and telling stories, which are not true. I must be sure that my products are functional and since the beginning of last year; I'm 100% certain that my system

is working. Only then, did I start to contact international clients such as international water supply companies and participate at international conferences where I promoted and presented our system.

Are there any institutions, which were helpful for you?

One institution, which has been very helpful for us, is the UK-based Isle Utility Group. This company was founded by an ex-Thames Water executive and has the goal of acting as a bridging platform between established water companies, utilities and new, innovative water companies and start-ups. For this purpose, they have installed a so-called Technology Approval Group (TAG), which reviews and evaluates new water products and technologies and presents them to a bigger audience.

Thank you for the interesting conversation!

8.1.2 Company 2

This interview was conducted with the Sales Manager of the company on 12 May 2017 via Skype.

When you think about innovation barriers, which barrier do you see as the most significant?

Along with return on investment (ROI), I consider the short-term perspective with regard to financial returns and parameters as one of the most important innovation barriers in our industry. There are examples of people who became millionaires within a very short period of time, but I think this is hardly possible in the water industry. Water is such a fundamental asset that decisions are often taken with a long-term perspective.

I take your point regarding the long-term perspective in the water industry, but when thinking of innovation barriers does this mean that it is difficult to raise sufficient funds in order to get started because of the long-term perspectives in the water industry, which discourage investors and venture capitalists?

That is not that easy to answer, because it relates to the issue of how an investor thinks. There are several investors, who have a long-term investment perspective.

But raising sufficient money was never a problem for you or the companies that you worked with up to now?

No, not really. When our company was bankrupt we had offers from several investors who were interested and were willing to invest several million euros. Therefore, the resources and the capital are available. This is of course also relating to the fact that loans are extremely

cheap at the moment and there are negative interest rates on German bonds. Investors are looking for opportunities to maximize their rate of returns. Putting money in a bank is no alternative at the moment and as a consequence, they are seeking alternative investments.

We were talking about short-term strategies and the role of investors. Are there any other innovation barriers, which spring to your mind?

Well, one important issue that has to be considered is the question: “Is the product really innovative?” The inventor and an experienced sales manager often answer this question differently. Of course, the inventor is excited about his invention, but the sales manager is asking himself if he can sell the product to customers in the market. In many cases, the inventor does not have a marketing or sales background therefore, many companies have stage gate processes in which each of seven or eight gates have to be passed before a product is finally launched. The background to such processes is provided by the fact that it cannot be assumed that the person who invented a new product has a complete knowledge of the facts required for placing a successful product on the market. The new product has to be evaluated by different departments, technically and marketing-wise, in order to ensure a full view of the advantages and disadvantages. These organizational processes such as stage gates, or whatever they are called, should act as a quality barrier to make certain that the new product has enough benefits for the sales department to be able to convince the clients and customers of its advantages.

We have discussed the different individual roles, which are involved in the development of a new product and the fact that it is essential to have a full picture. We also spoke about organizational setups such as stage gate processes, which should ensure a focus on innovations with the greatest potential. Are there any other innovation barriers, which come to mind?

What I have experienced in my professional career to date is that innovation has the greatest success when it comes from sales, customer service and from those people who are out on site for three to five days per week. These people have the information from the field, start the process from bottom-up and define from the beginning what the new product has to look like and what features it should have. Such innovation processes are much quicker than for example top-down developments that involve the definition of the research question and the scale-up of the product, which take significant time and effort.

Apart from this feedback-oriented type of innovation, it is vital that companies come up with ideas and innovations that the customer has not thought of. Once again it is important to

have employees who have technical skills and experience in the field with customers, and who are able to come up with innovative solutions.

May we return to your company and the factors that hampered the successful application of the product? The water industry is characterized as being conservative, especially the municipal water market. Does this also apply to industrial customers and have you experienced this as an innovation barrier?

No, this totally depends on the type of industry. This might be true for companies who have a very new, innovative product, as these are very open with regard to innovation. This is also due to the fact that they have to develop their own industrial production processes and do not have a given technological status.

However, this is not true for conservative industries such as breweries. They have been producing beer for centuries without, e.g. a new water treatment process and consequently it is much more difficult to sell a new product to them than to other, newly formed companies. Moreover, the paper industry is even more conservative than the breweries. They have extremely expensive production machines and manufacture paper at speeds of 2,000 m/min according to detailed specifications. Naturally, this industry is conservative because it knows exactly, that if there is one small problem at any stage of the production process this has massive financial consequences.

Therefore, the question as to whether industries are more open or closed with regard to innovation is greatly on type and of course, if it has a problem or not. For example, if companies realize that they have a cost issue, they are more open towards innovation as a means of staying competitive.

Are there any other innovation barriers that you can think of?

When developing a product it is important to have sufficient resources for each of the interfaces in the product development cycle, starting from R&D, the person writing the software program and the service technician, who assists the client with a specific problem. This can be compared to a formula or a multiplication in which several variables represent the different players involved in the development cycle. If one of the variables is zero, the whole equation turns out to be zero. All the steps that should result in a specific product, or a process have to be considered and executed accordingly. Otherwise some parts will be missing and this can have a significant negative influence on the entire product innovation.

Thank you for the interesting conversation!

8.1.3 Company 3

The interview was conducted on 14 April 2017 with the CEO and founder of the company at its premises in Vienna.

Your company was founded in 1999, is that correct?

We started the development of our sensors 18 years ago and we finally entered the market by founding the company in 1999. According to the definition of SMEs we are not an “S” any more, but an “M” because we have more than 50 employees and a turnover of over € 10 million.

How many employees do you have currently?

There are 53 employees in the Vienna office and together with the colleagues in our international offices and subsidiaries we are 68 people.

May I suggest that we dive straight into the topic? When thinking about innovation barriers in the water industry, what is the first and maybe most important barrier that comes to mind? Also considering the date when you founded the company?

What we have learned over the years is that the most important aspect in our industry is product branding. Without a brand it is very difficult to position an innovative product. We only found this out later.

When we entered the market in 1999, as a young company we had three main problems. Firstly, we had a very new and innovative product, which was a huge challenge technology-wise. At that time we did not have the know-how needed to develop a finished product. Therefore, the first problem was technological. The second main problem was that the method was not approved under the specific regulations and legal guidelines, and this is still the main barrier.

What does you mean when you say the method is not approved? Is it not approved within the legal framework conditions, or within the norms and engineering standards?

Well, both. In the EU, USA and China the method is not approved subject to the standard methods contained in the specific regulations and legal guidelines. However meanwhile, slowly but surely, the method is winning recognition, but this is a slow process, which takes a long time.

The third problem in the beginning was that we were a new player in the field and had no brand reputation. As a new and innovative company there was strong support, especially

from those people interested in innovation. More or less every company department or water supply company has one person, and often only one, who is fulfills this position. It is easy to cooperate with such people and reaching a kind of product “test phase” is quite straightforward. At this stage we were quite successful, but this does not mean that a product has arrived on the “real market”. This is only the stage of the early adopters. But then, when trying to cross the chasm, things became very difficult. I know of many innovative firms that did not make it across the chasm and disappeared from the market. But from a customer perspective it is clear that it’s not enough for a product to be innovative. There must of course be a proven customer value. Crossing the chasm might be easier for very innovative developments than it is for items, which are silhouetted against other competing products.

To sum up, I think the three main barriers for us were (1) controlling the technology, (2) the fact that our method is not approved by the legal frameworks and guidelines and (3) gaining recognition as a company so that the customers would believe in our innovation.

A big company would have been much faster in developing and launching this product, as it would have had far more resources. But we established our method and only 10 years later a competitor tried something similar. It had been waiting until we cleared the way for this new technology (“first mover”) and it is following (“first follower”). At the beginning, it is not a pull market, but a push market.

One advantage of our product is that we are able to measure valuable parameters, which when analyzed in the conventional manner in the laboratory were normally quite expensive and required a lot of time. Owing to this fact, our products were quite profitable and we were able to sell them with high margins. As a result, we had sufficient funds and cash in order to be able to proceed. We entered a high-price niche market with our products, which was definitely an advantage and a good decision. Currently the market is changing from a product to a service market and we also want to enter this new area.

Introducing new innovative products in the water sector is especially difficult in Germany, Austria and Switzerland. I think that emerging economies are currently overtaking our countries, especially in the DACH region. China for example has very innovative data analysis systems in the water industry and in view of the many “friction losses” we have here in Central Europe, the emerging economies will be the technology leaders in the near future.

What other innovation barriers can you think of?

When thinking about the structures in the water industry, for example in Austria, gaining acceptance is complicated and such a long and painful process, that in the end domestic market business is for us of little interest. Bypassing all the hierarchical structures, all the

unions and organizations is virtually impossible for a new and innovative product. As a result, the status quo remains and there is no real development within our industry, at least not in the DACH region.

When looking, e.g. at Iran, the extent to which people there are interested in new technologies is amazing. In Europe, we have huge problems to obtain approval under food legislation for one of our products in the drinking water sector. We have currently a point at which we are asking ourselves if it makes sense to sell the products in countries which have such strong norms and regulations. Norms and standards are a huge innovation barrier.

When considering other external barriers, did financial aspects play a role for your company? Was it difficult to receive sufficient funds, especially at the beginning when you started your company?

Financing our company in the beginning was not a big problem. Conversely, it was very challenging during the growth phase of the company in 2004-2005, when we had to cross the innovation chasm. At that time, I did not want to undertake another financing round, so I decided to sell some company shares to a partner. Since 2005, we have been making profits therefore personally, I do not regard the financial aspect as such a critical factor.

When thinking about innovation barriers, the literature suggests concepts, which classify barriers on different levels, starting from the external level, organizational and individual levels. Can you think of any barriers on the organizational or the individual level?

There is definitely an important point. When several products are launched successfully onto the market the focus of the company shifts from exploration to exploitation. This means that the emphasis moves from innovation to operations such as the production of an increased number of items, or marketing. This means that the innovation promoters are busy with their day-to-day work such as problem solving, etc. and are unable to focus on innovation. I think that it's essential to separate the innovation department from the rest of the company otherwise it becomes bogged down in daily tasks. This relates to the organizational setup of the company, which is essential for innovation. We have created a new department, which has the function of selling services on the one hand, but the development of new products and ideas on the other. It is located separately on the other side of the street.

As compared to the beginnings of our company, we now need ten times longer for new developments. This is naturally related to the organizational set-up, but it's also a puzzle for me and I do not know the real reasons for this situation. We are not as innovative as we used

to be and that's a fact. Currently, we are in a phase where we are trying to understand the reasons why, but currently we need a long time for very small, incremental innovations.

Do you think that this is related to the organizational structure of the firm?

Yes, maybe. However, although we are not so inventive any more, our product is still ten times more innovative than the comparable product from a competitor. I think another influential factor is the proximity of the innovator and the customer, the product and the application. The more you split a task in different sub-tasks, the more difficult it is for the innovator to keep in mind the full, holistic product.

Is that why it is important to be out in the field and to gain experience and feedback directly from the client?

This also relates to the size of the company. In the early days, I developed the products and tested them together with our clients in the field. I therefore had an holistic view of the problem from different perspectives.

Obtaining feedback directly from the customer and the field is very important?

Yes, extremely important. In our industry it takes several years until you have a product, which is really working without any major problems. We had our first prototype in 2000, but the spectrometer first only really worked well in 2004. In those early days, one had a high number of iterations requiring that improve the product. Those iterations are typical for the water industry and are not so important in other industries.

Another challenge in the water industry is that the environmental conditions are changing. It is impossible to carry out all the developments and tests solely in the laboratory. Our sensors for example have to deal with different types of water, including drinking water, river water and used water, under different climatic conditions ranging from hot to cold. This is very hard to simulate in the lab. For this you need to go into the field and this requires iterations and learning loops. I think that it is specifically difficult to develop new products in the water industry because of these factors.

It is also very important to keep the innovative spirit high within a growing company. This is the task of our "solutions department" and what I do is to dispatch our innovators into the field. The head of the innovation department also has to send his staff out into the field to the clients in order that they experience their problems and the challenges that they face.

May we talk about the innovative spirit within your organization?

I think this is an advantage of a small company and for me personally as a CEO, it's a huge challenge to retain the entrepreneurial spirit within the company. This is very difficult. If you are unable to make this happen, then the company has a problem. At a certain point in time you are no longer able to innovate by yourself and then, as a consequence, you have to buy in innovation from external sources.

My ideal concept would be that innovation comes from all departments. I personally think that the marketing department should be a strong driver for innovation because it should know best about the latest market trends.

Is this related to the individual level of each employee?

I think that the marketing department should be the driver for innovation. The R&D department should develop technical innovations and the marketing department should find product and service innovations. In reality, innovation is currently mainly driven by sales and customer service. But there is a general problem because if I merely follow the feedback from customers and clients, I only innovate in the direction of the client's wishes. But I understand innovation as something which you can offer to the client that they did not wish for or expect and is a surprise for them. Then you have an advance. Unfortunately, this more radical type of innovation is still only coming from me and up to now, I have been unable to institutionalize innovation in our company.

We have tried several things in order to become more innovative, but the outcome was only middling. For example, we launched an innovation prize and monetary bonuses for innovative activities with the simple goal of pushing innovation. However, due possibly to of a lack of internal marketing and consistency with regard to implementation and execution, these initiatives failed. If you want to institutionalize innovation within the company, you have to integrate it into the organization's culture. A prize is not enough.

Generally, I'm not a big fan of institutionalizing innovation. I think innovation is more of a personal characteristic. Either you are innovative, or you are not.

Do you think that the reasons why you are not able to create this innovative spirit within your company lie in the structure of the company, the organizational setup or the individual employee?

With fifty employees, you always have a mix between those who are interested in innovation and those who are not. With only ten employees, everyone is highly motivated and

innovative and pulls in one direction. It is part of the responsibility of the management to cultivate this spirit and be a role model within the organization.

Within our organization we have established a steering group, which is the core element in our innovation strategy. We meet four times per year and the committee is made up of the CEOs from our subsidiaries, which currently number four and in the near future will soon be five, as well as the departmental heads. During these meetings, we discuss different issues but in particular talk about what is going on in the market and the current trends are. Innovation happens within this group and in addition, we have monthly info meetings and product meetings. In our organization, the product champions are the main innovators. They are located in the development department and are responsible for a product group. At present, we have a very young development team and a product champion needs 2-3 years until he has the courage to be innovative. Courage is essential for innovation.

I also ask myself, if I should leave or sell the company and have I institutionalized innovation in such a way that innovations can occur within the company itself and without me? I may even be an innovation barrier personally because I give clear directions as to how innovation has to take place. When you are a strong and innovative person it can happen that you are also a problem. I would love to see innovations originate organically from inside the company. It would be a success for me, if the different departments had their own ideas and were themselves innovators.

I even took a six-month sabbatical during which some things went very well and other things did not work out at all. What I experienced was that the first thing that slowed down was innovation, but innovation is too strongly linked to my person. Other departments such as sales, etc. are developing wonderfully without me.

However, my input is important when discussing new markets and company strategy. This is because I am the company owner and therefore I can decide to take a greater risk than my employees. For example, my ownership allows me to opt for entry into a new market and this is also true with regard to innovation, where I can allow the company to take more risks if this might push innovation.

Is this related to the individual characteristics of the owner and the management style?

Yes. When travelling to conferences I meet very innovative persons. But our industry is so conservative, especially in the DACH region. I travel all year round and I do not see many countries in the water industry, which are more conservative than those in the DACH region. I think the most open country for innovation is Iran where I delivered a 6-hour presentation. In

our Central European region the thinking that everything is running perfectly hampers and blocks innovation. It's impossible to talk about drinking water monitoring in the DACH region. In the drinking water sector, innovation is even more difficult because it is controlled by a small number of organizations and institutions that are very conservative. However, we do not have severe problems and enjoy high quality drinking water, so there is no real need for innovation and action in our region.

We have now covered different levels of innovation barriers, from the external to the organizational and the individual. Are there any other remaining barriers you would like to discuss?

For me, the biggest question is how to institutionalize innovation and how to push the innovative spirit within my organization, or if it would be better to install a strict management system for innovation. The main question is how to transfer the innovative culture of a start-up to a growing company.

One significant aspect that I forgot to mention is finding well-educated future employees, who are willing and able to work internationally. This is also an important factor.

Thank you for the interesting conversation!

8.1.4 Company 4

This interview was conducted with the Director of Technology, Research & Development, on 11 May 2017 in Vienna.

When you consider innovation barriers, which would you regard as the most important?

Definitely legislation. As far as micro pollutants are concerned, we see that the European Union is reacting rather slowly, while Switzerland is quite fast. In Switzerland, a specific law has to be adhered to, which is not yet the case, in the European Union. In Germany I believe there is a voluntary basis. The legislative authorities are definitely a preventive factor. However, they can also be promoters and I am thinking for example of the Swiss legislation on micropollutants.

Is there another innovation barrier, which comes to mind?

Yes, customers. Customers in the water management field are rather conservative. The risks for a small engineering-procurement-construction (EPC) company are rather high and the customers are conservative. This is a problem and implementing innovative products and processes is rather difficult.

Another issue, which is very important, relates to funding and financial aspects. For example, without the provision of the financing within a BOOT model, it would have been very difficult to realize and implement the Ujams WRP project.

But what also has to be taken into consideration when talking about innovative technologies based on our Ujams WRP example is the lack of knowledge on the customer side. This is especially valid with regard to developing and emerging countries. Back in 2006 I already held a training course on membrane bioreactors in Germany with representatives from the City of Windhoek. The training included visits to demonstration sites and huge persuasive efforts. This was one of the crucial factors in their decision to opt for this technology. The Ujams Water Reclamation Plant is a very innovative project and now a flagship project in Southern Africa. Therefore, know-how transfer and persuasion are very important factors.

In this respect, for the example of Ujams WRP, another barrier was important. At that time, Mr. Sch. was the CEO of our company. He was opposed to spending on this training course and he was very unhappy that we spend a week visiting innovative membrane bioreactors in Germany together with the possible customer. Sometimes you really have to fight against resistance within your own management team, which is an internal innovation barrier.

That is very interesting, as the last statement covers the external, organizational and individual innovation barriers. What about other factors and barriers, e.g. company strategy?

We have a quite clear and simple strategy. In September 2016, I had a meeting with our global CEO and the CEO of the European Cluster during which we discussed our innovation strategy. Two topics emerged from this discussion, water reuse and sludge. Sludge is not directly a development project, but related to the establishing of our sludge guidelines and also innovative processes such as thermal and chemical sludge disintegration technologies, which we developed some years ago. We then asked ourselves why we had not applied our patented process thus far and I think one reason why we did not apply this patent in full-scale projects was that several experts with critical knowledge related to this technology left the company.

On one occasion when we had a possibility to apply this innovative process in a full-scale project, our global CEO decided that the client should pay for the trials. However, the client was unwilling to pay for the trials, so it selected another process and company. This is again related to management and the resources released for a specific project. If we could have carried out the trials together with the client and split the costs we might have had a full-scale reference plant. Therefore, the allocation of sufficient resources is another important factor.

Do you think that your available resources and the organizational setup is a limiting factor for innovation?

Yes, of course. We have sufficient resources and budget for external cooperation, for equipment and partnerships with universities. But internal resources are a limiting factor. This relates to knowledgeable staff leaving the company and a lack of sufficient employees in the unit to execute R&D projects.

Can you think of another innovation barrier?

What comes to mind is the management attention factor. Our Swiss office is a positive example in this respect because if there is a new process development, or a new product the management team is very interested and supports it massively. Conversely, insufficient management attention can be a barrier for innovation. Managerial attention and support are both very important.

It is also important to consider that barriers are changing for the different sectors and geographical regions. They are different for municipal and industrial clients and vary according to the local region (e.g. Europe vs. Asia) and the specific circumstances (water shortages due to droughts, etc.).

Another innovation barrier is bureaucracy. But this is different for municipal and industrial clients.

Can you think of any innovation barriers on the individual level?

As already discussed, the individual interest of the management in innovation and new technologies could be an example of a barrier on the individual level. Personal relationships with experts and clients are also important. Consequently, if someone is not a good networker, open-minded and a good communicator, this is an innovation barrier because it is essential to convince the clients.

Finally, is there an innovation barrier, which up to now we have not discussed.

It is also important that the R&D team is involved in daily operations, in order to obtain feedback regarding the requirements and needs of the market and the clients. In former times we had an organizational setup in which there was only one department for "R&D and process engineering". The longer the employees were with the company, the more they focused on process engineering, but all of the engineers were still involved in R&D. Using this setup it was possible to develop new R&D projects based on customer requests.

Innovation also depends on the personality of the entrepreneur. For example, Prof. Benedek invented the Zenon membrane system and then became the CEO of his own company. He fully identified himself with his product from the first day of development until the exit, when he sold his company to GE.

Thank you for the interesting conversation!

8.1.5 Company 5

This interview took place with the CTO and founder of the company on 26 June 2017 in Vienna.

What are your main clients? Do you work with NGOs, or do you work with end customer?

We always planned to work with the end customer and we moved in this direction. The business model for our product envisages that the end customer, who has problems with water quality, buys the product itself. We already have offers from a supermarket chain, which wants to add our product in their portfolio. But currently we have the problem that our product is still too expensive and many people cannot afford to buy it. Therefore, we have to focus on reducing prices. Consequently, only a small share of our products is currently sold directly to the end customer, but we wish to increase this percentage in future.

Our current customers and partners are mainly NGOs, most of which are located in Africa, Asia and India. The bulk of our sales is generated by local African NGOs. NGOs are important for us from two perspectives: (1) on the one hand, they are customers and (2) on the other, they train the people how to use our product. Applying our product requires some training. This is not technical training, but more coaching on how to change daily habits in order to apply our product in optimum fashion (“behavior change”). The NGOs also train the customers in product selling, which is an important asset. Using our product it is possible to disinfect a huge amount of water without major costs, which is one of its main advantages. We are working with schools, which are disinfecting 1,000-2,000 L water per day and then selling the water. They are thus earning real money.

Other customers consist of corporations and enterprises. For them, we offer a type of service package, which includes (1) CO₂ reduction certificates and (2) corporate social responsibility (CSR).

Our third important customer group includes local governments (ministry of water, etc.) and institutions such as the United Nations, the WHO, etc. Working with these customers is a

long-term target, but we have already the first purchase orders from the WHO for example. When working with governments and ministries, we seek to show them that our product is a preventive measure that prevents follow-up costs for the treatment of sick people. India for example is spending about 2% of GDP on the treatment of people with diarrhea, which adds up to USD 30 billion. Within this context, we want to show that our product can have a positive impact besides disinfecting water.

We are also selling our product via Amazon in Europe, mainly for the outdoor market. This is important for us because we want to show our customers in Africa that our product is not a typical poor-man's device. The people in Africa can also see that the product can be purchased via Amazon in Europe.

How many employees do you have currently?

We have eight employees at the moment.

Where are your production facilities?

We are producing here in Austria, in Upper Austria. We also started production in India, but this did not work out. For the beginning, I wanted to keep the knowledge here locally.

With regard to the financing of your company, are you working with an investor?

We have several investors, most of which are business angels and one is an impact fund from the Netherlands. The main funding still comes from Austrian and Swiss business angels.

When was the company been founded?

I founded the company in 2010. In 2012, I had to close down the company, but I reopened it one year later.

Turning to the topic of innovation barriers, can you think of some important innovation barriers, which to date have been relevant for you and your company?

When we applied for a patent in Austria this process took around three years, which is a very long period for a small company. In other countries, this procedure was much quicker. We needed our patent in order to receive money from the government (grants) and investors.

As far as universities are concerned, it sometimes seems that they are very far away from private companies and also from their needs. If the performance and facilities of universities in Switzerland, e.g. the ETH are compared with the universities here in Vienna, there are significant differences.

Another barrier that I have experienced especially here in Austria is that the well-established players are simply not interested in our new technology. There are established paths and patterns and it seems that many organizations are unwilling to try out new things and prefer to continue with old, established and well-known procedures and products. Many local NGOs here in Austria are simply not interested in innovation. In other countries we do not face such problems and there we are testing our products with a number of NGOs and other partners. They want to try out new products and are more open to innovation. We are focusing on other markets, but Austria remains a niche market for some small target applications such as CO₂ reduction.

When talking about innovation barriers, it is possible to cluster them on different levels ranging from the external to the organizational and individual dimensions. Are there any other innovation barriers you can think of?

As far as start-up financing is concerned, I think that there are a number of good options such as grants, awards and other financial instruments available here in Austria. One example is research funding. Without sufficient research funds it would not have been possible to found our company. We received significant funds for our initial microbiological tests, which were very expensive. However, without these, it would have been impossible to continue with company operations.

What I miss is financial support during the subsequent phase when the company is growing. I would prefer to establish a high-risk fund, which provides financing to start-ups for producing proof of a concept for example. I think working with loans and grants would be better than just providing financing through research funds.

During the next step, there is often a lack of legal security for start-ups when bringing investors on board the company. This can be a major innovation barrier and I experienced this myself when one investor signed for an investment in exchange for a 25% share of the company. But then he did not pay the agreed price, but kept the share of 25%. I talked with many lawyers, but finally the only thing I could do was to find another investor, who was willing to buy the equity share from the other company. In this matter I lacked legal security because I could not act against the investor. There are also no official institutions, which could support young companies and start-ups when they face such challenging situations. I definitely think this is an important innovation barrier and that it would make sense to establish a proper legal framework, or install an ombudsman, who can support the start-ups within this context.

Are there any other innovation barriers you can think of, suppliers for example?

Yes, this was a problem because things were taking too long. But now I know that this is the normal way that things happen because development from the first prototype to a product, which is ready for serial production, needs at least a year. I only learned this at a later point in time. I also talked to other hardware start-ups and all of them said that at a minimum development needs one year.

There was also an issue regarding the warranty of an injection die, which we provided to one of our suppliers. I wanted to have a signed warranty form, but even after half a year and following the start of the production, they refused to sign it. At that point in time I could do nothing. If I had sued them, they would have immediately stopped production. So they utilized their stronger position against our company.”

Any other innovation barriers you can think of, competitors for example?

We are in a sound position because we have a patent and the product is available only through us. There is one competitor, a MIT spin-off, which is using the same technology. They have even copied our technology and I clearly communicated this to the company. We had a chance to sue them because they had obviously copied our technology and we have the patent but each lawyer advised us not to do so because suing US companies and especially MIT is very difficult and not to be recommended. Currently there are no overlaps with this company, but we have decided that should this company enter our markets, we will take legal action.

Are there other innovation barriers you can think of?

In the initial stage, when I founded the company and developed the product it was important to bring specialists on board, who were able to handle the software and detailed hardware development. Therefore, it's very important to have a skilled team. However, in the meantime I am so deeply involved in the subject that it is difficult for new employees to make up the knowledge gap. I read papers, visit conferences and spend lots of time in the field. When working with technicians, they often do not think outside the box. They make interesting developments, which work perfectly here in Austria, but are not suitable for developing countries in Africa. Consequently, I have to monitor all the further developments of our products closely. I cannot send a technician into the field five times in order to gain experience because this is too expensive.

In general, we do not have significant problems in finding new employees. This is perhaps also related to our product and the fact that we are a social enterprise and wish to make a positive impact in the world. This positive spirit motivates our employees.

Are there any other innovation barriers you can think of, e.g. on the organizational dimension?

We adapted our strategy and changed our business model several times on the basis of our field experiences. And we learned from our own mistakes.

But what is really problematical is funding. I spend at least half of my time searching for and meeting new investors. I would need this time for taking care of the business. We would have developed our product much faster had I not had to constantly deal with investors. This is a problem and many investors and start-ups tell the same story because it takes up so much time.

Are there other innovation barriers you can think of?

The acceptance of the local communities and end customers can be challenging. We designed our product in order to create trust by using technical installations such as sensors and displays, which show the status of the treatment process. But the important question is whether or not the new product fits into the daily existence of the end-users, or do they have to change their habits and their way of life? We all have our daily routines and it is sometimes difficult to change our habits. There are also regional differences and in Asia people are far more skeptical than in Africa for example.

Are there any innovation barriers on the individual dimension?

No, not really. We have a motivated team and there is a kind of “drive” within the organization. I also had the same experience when I worked for other start-ups. There is a good spirit in such organizations and that motivates the employees.

Thank you for the interesting conversation.