MSc Program
Environmental Technology & International Affairs

Energy blackouts and water outages:

A risk management approach towards raising awareness and assuming responsibility

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Affidavit

I, **ISABEL MANK**, hereby declare

1. that I am the sole author of the present Master’s Thesis, "ENERGY BLACKOUTS AND WATER OUTAGES: A RISK MANAGEMENT APPROACH TOWARDS RAISING AWARENESS AND ASSUMING RESPONSIBILITY", 116 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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Abstract

Awareness of the risk of an energy blackout and its effects on the water sector are inadequate. It is undeniable that electricity is needed for water pumps and the mechanical treatment of wastewater. A gravitational water flow can avoid interdependency, which is regionally limited and should not be generalized. This work aims to raise awareness and assume responsibility in order to show that a risk for blackouts and water outages exist in industrialized countries and that planning and preparation are necessary. A risk management approach with five pillars is used as a guideline. The first pillar emphasizes the lack of examination of the effects of a power outage on the water sector. Today's critical infrastructure is more complex and vulnerable to power outages than ever before. The causes for outages as covered by the second pillar include natural, societal and technical causes. A blackout does not need to be the disaster itself, but can be the result of heat waves or mismanagement. The consequences of blackouts and water outages, as described in pillar three, reach from a halt of water supply and low water quality to disrupted communication and social upheaval. Suddenly common behavioral structures are questioned and communication channels are cut. Missing communication means emphasize the need for in advance preparation and exchange between all stakeholders. Technical mitigation measures such as backup generators can only sustain daily life temporarily, while self-sufficient energy systems and renewable energy sources could provide electricity as energy islands. Social resilience and public/ private partnerships are additional management mechanisms assuring safe drinking-water and hygiene throughout the blackout. Several possible response measures are shared, although their application depends on a variety of aspects, for example: duration of the power outage; the amount of regions or countries concerned; and the season of the year. A fixed plan cannot be applied given that blackouts and water outages are unpredictable. Stakeholder interviews conducted in Austria and international case examples help to define awareness, perceptions and responsibilities towards blackouts and water outages in industrialized countries.

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List of abbreviations

ACPA	Austrian Civil Protection Association
APG	Austrian Power Grid
ASCE	American Society of Civil Engineers
BGBI	Bundesgesetzblatt
BMI	Bundesministerium für Inneres
BMWFW	Bundesministerium für Wissenschaft, Forschung und Wirtschaft
BMVIT	Austrian Federal Ministry for Traffic, Innovation and Technology
BWZ	Bundeswarnzentrale
CDC	Center for Disease Control
DHS/OCIA	Department of Homeland Security Office of Cyber and Infrastructure Analysis
DWP	Drinking-water Provider
EFDRR	European Forum for Disaster Risk Reduction
EKC	Einsatz- und Koordinationscenter
EU	European Union
EVN Group	Energieversorgung Niederösterreich
FAG	Finanzausgleichsgesetz
GAC	Granular activated carbon
IFRC	International Federation of the Red Cross and Red Crescent
KIT	Karlsruhe Institute for Technology
LADWP	Los Angeles Department of Water and Power
LWZ	Landeswarnzentrale
MDGs	Millennium Development Goals
MOTI	Ministry of the Interior
Natechs	Natural-hazards triggering technological accidents

NBC Defence School	Nuclear, Biological and Chemical Defence School
OVGW	Austrian Association for Gas and Water
PAHO	Pan American Health Organization
RC	Red Cross
SCADA	Supervisory control and data
SKKM	Staatliches Krisen- und Katastrophenmanagement
SSC	Safety and Security Center
SWOT	Strengths, weaknesses, opportunities and threats
TCCC	The Coca-Cola company
THW	German Federal Agency for Technical Relief
UN/ISDR	United Nations/International Strategy for Disaster Reduction
UNISDR	United Nations Office for Disaster Risk Reduction
UK	United Kingdom
UV	Ultraviolet
WASH	Water, sanitation and hygiene promotion
WBGU	German Advisory Council on Global Change
WHO	World Health Organization
WTP	Wastewater Treatment Plant

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1. Introduction

Energy blackouts, defined as the complete breakdown of the electricity supply causing a cascade of failures within the critical infrastructure for a longer period of time, are complex, unpredictable and unimaginable caused by a cascade of events (Hohl et al., 2013). Perceptions of the risk of a blackout vary: it is a risk; it is a risk, but preparations are not possible or needed; or it is seen as not a risk at all. It is not seen as an event never to occur, but the perception rather is, when will it occur. "*Es behaupten ja viele, es ist keine Frage ob, sondern es ist eine Frage wann, dass es zu einem Stromausfall kommt, oder zum Blackout kommt*" (Interview Austrian RC, 2015). A demonstrative example occurred in August 2003, when Switzerland, whose electrical system is connected to Italy and France, faced a short circuit in one of its grids. A second grid replaced the demand of the first one. At the same time Northern Italy was experiencing a heat wave, which required a high electricity demand for cooling. The second Swiss grid was not able to cover that unusual high demand for the time it took to repair the short circuit, wherefore it shut down as well. Within a short period of time, a domino effect took place causing the whole electrical system in Italy, apart from the island Sardinia, to shut down leaving over 55 million people without power for several hours (Bundesheer, 2012; Hohl et al., 2013).

The example demonstrates the fact that our society became more and more interconnected over the last years in several ways. The energy transmission grid is one central aspect of it and is often considered to have a tremendous economic impact. It is essential for development, industrialization, and social and political stability (Reichl & Schmidthaler, 2011). Furthermore, in industrialized countries a lifestyle without electricity is not only impossible anymore, but also unimaginable. Most citizens of industrialized countries experience a strong interdependency between energy and daily life influenced by high energy security over the last decades, with only short power outages (Bundesheer, 2012; Petermann et al., 2011). Scattered small regions in Austria, for example, experience up to thousand short power outages of up to seventy minutes every year, but no long-term blackouts affecting a larger area (Bundesheer, 2012).

Blackouts are rarely a topic in public negotiations and among stakeholders due to a lack of personal experiences and a perception of security. This creates a vulnerability paradox contradicting the perception of risk and reality. Accordingly, while the energy supply gets less and less disruptive, once an interruption occurs the effects are more severe and long-lasting (Bundesheer, 2012; Petermann et al., 2011). As blackout happens rarely by itself, but is caused by natural, societal or technical causes such as flooding, human error or an energy overload from renewable energy sources.

One question of concern is “how the failure of one infrastructure system disrupts other infrastructures?” (Chang, 2009). A heat wave, for example, does not only affect the electricity demand, but indirectly also the water sector. Power is needed to pump water from the water sources to the consumers and further to the wastewater treatment plants, where it is treated by technical equipment (DHS/OCIA, 2014). Out of many critical infrastructures effected by a blackout, water supply and discharge were chosen because of daily and even hourly use, hence its essentiality for daily life. Safe drinking-water is essential for survival and health and is a basic human right in international law (Van Leuven, 2011; WHO, 2011).

In this regard, a blackout causing a water outage can cause disruption of daily life, when known cultural structures fall apart and order diminishes. Preparation on the side of the stakeholders and the public is, therefore, essential to counteract the effects of disasters. “*Die Ordnung und das System so wie es jetzt läuft, [wird] zu dem Zeitpunkt nach einem Monat Stromausfall nicht mehr bestehen […]. Also wichtig ist, Vorbereitung auf beiden Seiten. Natürlich darf man […] Infrastrukturbetreiber auch nicht außen vorlassen. Die müssen natürlich auch ausreichend vorbereiten, aber so kann jeder seine Schaufel dazu beitragen, um einfach gegen die Folgen oder die Auswirkungen von Katastrophen besser gegenwirken zu können oder besser damit umgehen zu können*“ (Interview Austrian RC, 2015). Communication and active planning at an early stage are inevitable to respond to a blackout since they are disconnected in case of a short circuit. Timely preparation and exchange between different stakeholders ranging from ministries, the Armed Forces and relief organizations to water providers, experts from wastewater treatment plants and the general public need to be emphasized and improved.

Public resilience and vulnerability are tightly connected to risks defined by risk awareness, a lack of preparation, coordination and response measures to assure safe drinking-water and hygiene on a daily basis. A risk assessment uncovers causes, hazards, effects and management mechanisms, while raising awareness on risks improve resilience and encourage the implementation of risk mitigation measures.

2. Methodology

Hazards linked to electricity blackouts have become a global concern and cannot be viewed in isolation from neighboring countries and regions. A concern in one sector impacts and requires action in another one and vice versa. This interdependency is related to increasing vulnerabilities, technological and socio-economic conditions, urbanization and climate variability to name just a few (UN/ISDR, 2007). The management of risk reduction continues to be a global challenge. Mitigation measures must be integrated into policies, plans and programs, while supporting regional, bilateral and international cooperation and collaboration. In order to encourage commitment at the individual, community and national level, awareness needs to be raised as it was done by the Third World Conference on Disaster Risk Reduction, which took place in Sendai, Miyagi, Japan, in March 2015 (UN/ISDR, 2007 & 2015).

A risk analysis in general provides an essential basis for prevention planning in the risk management process on all governmental levels and has been conducted over the last years only (Hohl et al., 2013). According to Hillson (2004), first major steps in risk management are the definition and analysis of risks, the distinction to uncertainties and the formulation of responsibilities of stakeholders, who are managing the risk. It includes the protection of people, their environment and assets from undesirable consequences while assuring a continuity of life (Castillo, 2014). In comparison, a risk analysis is based on the likelihood of impacts to occur (Castillo, 2014; Laugé et al., 2013). Risk analysis and risk management need to be combined because one or the other by itself would exclude correlations and insights (Castillo, 2014). For example, without informing and sharing information on risks with the population, they will not be prepared for possible consequences to make appropriate decisions. This results in ineffective mitigation and preparation measures (ASCE, 2009).

In order to make reasonable decisions on risk responses to mitigate negative effects on the water system that are addressed in this work, so called interdisciplinary risk estimations should be undertaken. These include scientific and concern assessments of risks to human health, the environment, and social and economic implications integrating knowledge of technical, social and natural sciences and economics (Renn & Klinke, 2015).

> "*Prevent new and reducing existing disaster risks through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience*" (UN/ISDR, 2015).

2.1. Objectives and problem statement

Power outages and a fear of lack of electricity are regularly discussed by the media either due to natural disasters such as earthquakes or due to a change of the energy mix towards renewable energy sources. However, the effects a blackout could have on the water system are rarely in the focus of attention. Awareness of a direct correlation between an energy blackout and a water outage and subsequent action are missing in industrialized countries. Therefore, the goal is to close the gap of awareness and knowledge and to enhance action by different stakeholders reaching from ministries, the Armed Forces, relief organizations, water industries, the private sector and the general public.

The objectives of this thesis therefore are

(1) to define and analyze the threat a blackout can have on the water system;

(2) to express the necessity of planning with and integrating of different stakeholders in decision-making process, trainings and workshops; and

(3) to show the necessity to communicate with different groups before a disaster may occur. Subsequently, the overall aim is to raise awareness and assume responsibility in order to show that a risk exists and that planning and preparation are necessary.

2.2. Definitions

First of all, awareness needs to be raised that water and power outages are hazards in industrialized countries. Hazards have the potential to cause harm and pose a threat (Renn & Klinke, 2015). A risk is defined as the probability or likelihood of an event to occur multiplied by the severity of consequences or impacts (ASCE, 2009; Renn & Klinke, 2015). In risk management for water supply e.g. the probability of a generator to fail or a well to be contaminated and the consequences such as waterborne diseases can be addressed. Despite several approaches in literature, the meaning and identification of a risk are complicated and controversial; and besides objective observations, risk perception strongly depends on individual mental constructions such as interpretations and responses influenced by social, political, economic and cultural contexts. According to Hohl et al. (2013) and Hunter et al. (2002), a risk is defined as an incident that has a negative outcome such as loss, harm or injury to the population and their life style, economic impacts, environmental damage, cultural loss or the loss of critical infrastructure.

Risk = probability of a hazard * severity of consequences

Risk perception is connected to uncertainties, tolerability, vulnerability, resilience as well as risk communication. A risk is not left without a certain amount of an “uncertainty that matters” assuming that it affects at least one object and that timing and magnitude of the hazard cannot be predicted. An uncertainty is often referred to as a threat, though it must not necessarily have a negative meaning, but can also provide an opportunity. In this regard, real risks are “uncertainties, which if they occur will have a positive or negative effect on one or more objectives” (Hillson, 2004). There is never a guarantee for zero risk or decisions based on full scientific knowledge, instead a certain amount of probability or severity of a consequence always exists. The tolerability of consequences always implies an accepted risk level and economic loss by a specific person or group (ASCE, 2009; Van Leuven, 2011). The severity of a disaster increases with the vulnerability of a person or area. McEntire (2013) defines vulnerability as "the proneness of people to disasters based on factors such as their geographical location, exposed property and level of income". A low vulnerability may also mean a high resilience. Originally the term resilience derives from ecological research and defines how natural ecosystems cope with stressors. In general, which also includes social systems, it can be said that it is the ability and capacity of systems to resist shocks, to cope with events and to recover from them appropriately (Renn & Klinke, 2015).

It is easier to cope with a short power outage or brownout than an energy blackout, referred to as a blackout, power outage or power cut interchangeably throughout this work. A power outage is defined by the number of days an individual stays without electricity supply despite of the existence of a transmission line (Chang et al., 2008). It should not be confused with a brownout, which is the provision of reduced voltage for several minutes (Bruch et al., 2011). A blackout is defined as the complete breakdown of the electricity supply causing a cascade of failures within the critical infrastructure for a longer period of time (Hohl et al., 2013). Water and energy, but also other resources are part of the critical infrastructure and are crucial for daily life.

2.3. Structure

This thesis on blackouts and water outages in industrialized countries aims to bridge literature and research gaps and shall provide first steps towards an interdisciplinary, international and interconnected approach. A risk management approach is used focusing on the effects of a blackout on the water sector, which both immensely affect the daily life in case of outages. Austria and Vienna (as the capital city) are taken as examples for industrialized countries assuming that they are more reliant on energy and face different concerns than developing countries. For this specific case possible causes and response measures are identified for the Austrian water sector.

According to Hillson, a well-known international risk management consultant, a risk analyses builds the foundation to analyze causes, hazards and effects (Hillson, 2004). The hazard is a blackout as well as a water outage, of which the latter may also be an effect of the power outage causing a halt of water transmission and wastewater disposal and treatment. Due to the reason that water is highly dependent on electricity and that the electricity system has become safer as well as more complex and vulnerable than ever before, emphasize is put on blackouts and water outages that may disrupt daily life (Figure 1). In many emergencies and disasters it is not the event itself that is dangerous, but the effects it has on the critical infrastructure, people and the environment (Levy & Bissell, 2013).

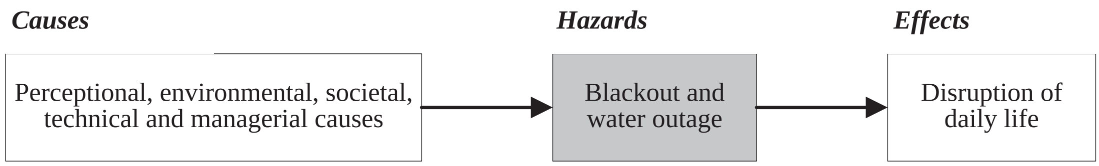

Figure 1: Causes-Hazards-Effects

Source: Own description

The present report is structured based on the core structure of a risk management approach with individual chapters representing the pillars (Figure 2). The particular organization is adapted to schemes of different experts ranging from risk management as published by the British Cabinet under Keegan (2004), the Hyogo Framework for Action as proposed by the WHO et al. (2013), project and risk management as shared by Cooper et al. (2004) and emergency plans from the WHO (2011). All approaches are similar in structure and in guidance on how to approach risks. The only difference is the subheading of each of the five pillars of the approach, which is adapted according to the aim as it has been done for this report.

The first pillar (Chapter 3) provides the necessary background knowledge on the topic. It includes reasoning, definitions of key elements and the state-of-the-art. The second pillar (Chapter 4) covers the identification of causes for water and power outages. Subsequently, the likelihood for a blackout is analyzed and causes and sources listed including environmental (earthquakes, flooding, heat), technological (power outage, accidents on the street, technical failure), societal (attacks, epidemics, refugees) and managerial causes as proposed by the Swiss ministry on how to divide risks and in order to show possible threats for a blackout in relation to water outages (Hohl et al., 2013). As discussed below there are three broad elements in a risk assessment that need to be considered:

(1) Hazard analysis that include the identification of the hazards and the assessment of the magnitude and probability of their occurrence;
(2) vulnerability analysis which contains the vulnerability of individuals, populations, infrastructure and other community elements to the hazard; and
(3) capacity analysis in order to manage risks by reducing hazards or vulnerabilities or responding to and recovering from a disaster (WHO et al., 2013).

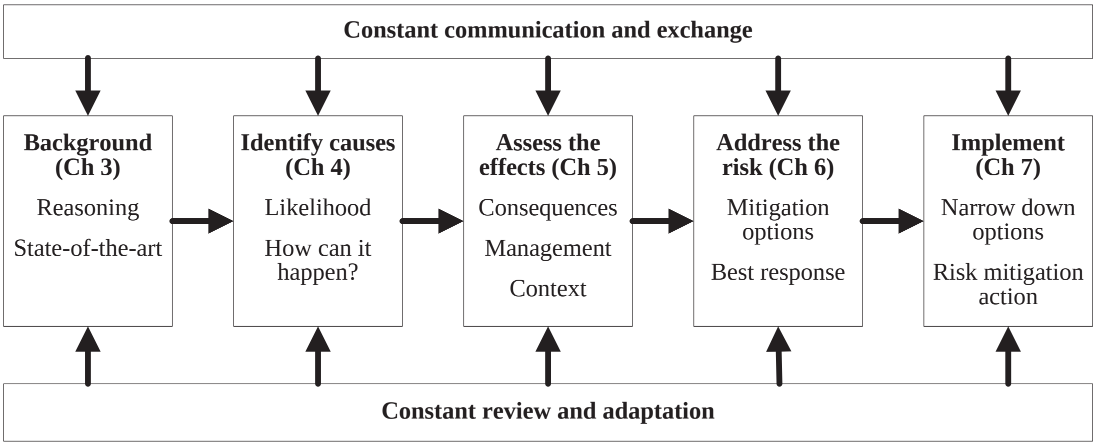

Figure 2: Risk management approach

Source: Own description according to Cooper et al. (2004)

The third pillar (Chapter 5) describes the effects of power and water outages and the consequences on the critical infrastructure, the organizations and the population. Priorities are set on drinking-water provision, information and communication exchange, knowledge management and societal behavior. This is followed by the fourth pillar (Chapter 6) with a discussion on risks including the most important responses in order to reduce the overall risk exposure, share the current mitigation measures in place, determine the possibilities on how to treat or even prevent the risk and its indirect effects with regard to the water sector. Based on the literature and the interviews this includes the identification of mitigation options and the best response possibilities.

The fifth pillar (Chapter 7) covers the implementation of the proposed solutions in Austria by sharing a timetable on the cascading effects on water, electricity and fuel, and communication. The provided mitigation options mentioned in Chapter 6 are narrowed down and include solely specific risk mitigation measures and their applicability. The conclusion summarizes the findings with the goal that in the end insights have been shared, ideas developed, awareness raised and further action enhanced.

The foundation of each chapter is stakeholder interviews that have been conducted in Vienna and in the near-by villages Laxenburg and Bad Fischau. Those complement the literature work, support assumptions, identify gaps on awareness and in existing knowledge of water outages caused by blackouts, current stakeholder perceptions and find regionally feasible commitments. Consequently, more relevant, valid and regionally applicable judgements about effects of a water outage can be incorporated into the report. Stakeholders from the following seven organizations have been interviewed:

- the Austrian Red Cross (Austrian RC),
- the Ministry of the Interior (MOTI),
- the NBC Defence School/ Armed Forces,
- drinking-water providers
  - in Vienna (DWP Vienna) and
  - in Bad Fischau (DWP Bad Fischau) and
- stakeholders from wastewater treatment plants
  - in Vienna (WTP Vienna) and
  - in Laxenburg (WTP Laxenburg).

With regard to the water sector, one big and one small drinking-water provider and wastewater treatment plant were chosen. The interviewees were identified according to their expertise and their special responsibilities in crisis management within their units. Additionally, the following stakeholders have been contacted and asked questions via email:

- the Ambassador of Japan in Austria,
- experts from the Kobe City Public Construction Projects Bureau,
- the Kobe City Water Works Bureau and
- Tokyo University.

The interviews have been conducted at the beginning of the research process, wherefore the questionnaires are based on brainstorming sessions and first investigations of literature. During the interviews the questionnaires have only been used as guidelines in order to ask additional questions. The content of the questions have been adapted according to the organizations and the background of the interviewees, who are either experts on water issues or are responsible for risk and disaster management within their unit or both. Interviews with Austrian stakeholders have been taken in German, recorded with a voice recorder and transcribed. Interview statements are directly integrated into the text. The transcriptions of all interviews can be asked for from the author.

Concluding, this work aims to draw attention to blackouts and water outages and offers possible response measures. The focus is on prevention, vulnerability reduction and strengthening the water sector and the communities. In the case of a blackout, it is not necessarily the power outage which causes a disaster as a direct cause. Moreover, vulnerability and a lack of preparation by the population and the stakeholders to cope with and to respond effectively to the disaster are of concern (WHO et al., 2013). The consequences are substantial and complex, wherefore approaches must go beyond normal or traditional crisis management principles and practices (Bissell, 2013).

3. Reasoning a focus on water outages

The following chapter aims to establish the context (Chapter 2.3, Pillar 1) by taking a look at the connection between water and electricity. The focus is on the importance of water in life; the economic damage of a blackout; and the availability of international and Austrian publications on water outages caused by a blackout and its effects on water quality and supply and wastewater treatment.

3.1. The water-electricity connection

The water and electricity sector are part of the critical infrastructure as both are essential for the functioning of society and economy. The critical infrastructure includes thousands of networks, pipelines, water reservoirs, roads, conduits and facilities. Moreover, it also comprises gas, telecommunication, financial services, governmental services, security services, public health, agriculture and transportation systems (Bruch et al., 2011; Castillo, 2014; Petermann et al., 2011). Most of them are connected and reliant on the functionality of another critical system in order to provide services to the public (Shi & O'Rourke, 2008; Van Leuven, 2011). For example, a power failure may cause a halt of the water transmission and wastewater treatment (Figure 3). Other problems affecting the water system are the contamination of open water sources with sewage, response interruptions due to missing telecommunication, and traffic jams causing a delay of the provision of water tanks. Hence, an outage or failure of any of these sectors can stop the functioning of another one (Bruch et al., 2011; Castillo, 2014; Petermann et al., 2011). Dependency is defined "as the reliance of a facility on an external utility or service to carry out its core operations including domestic use, operations or cooling" (DHS/OCIA, 2014).

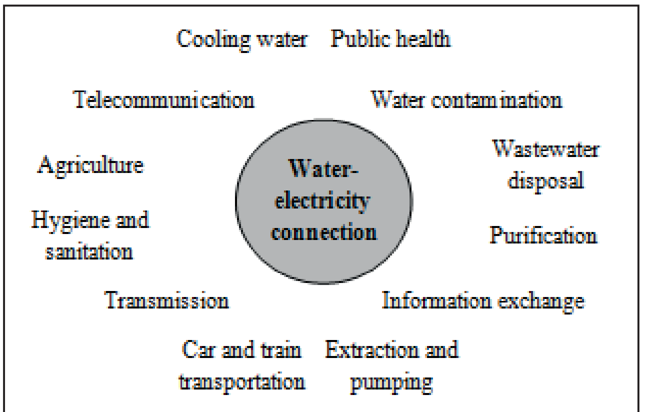

Figure 3: Water-electricity connection

Source: Own description

Supply sectors, for instance power and water systems, are circuit systems reaching from providers to consumers through transmission and distribution equipment (Castillo, 2014). The transmission sources for water are on the one hand natural critical resources such as lakes, rivers and streams, which are used for navigation, water supply and flood water storage. On the other hand water systems are influenced by virtual critical infrastructures including electronic and information systems (ASCE, 2009). Hence, the functioning of the water system is nowadays highly dependent on other infrastructures, but increasingly on a continuous provision of electricity. If power plants would come to a halt, refrigerators would stop cooling, hygienic behavior could not be followed, and sewage could not be removed and burned contaminating lakes and rivers (Beatty et al., 2006).

In order to respond to threats telecommunication is indispensable. Water, energy and telecommunication are indirectly connected to each other for operation and response to disasters, wherefore an outage in one of these sectors may quickly affect the whole society (Van Leuven, 2011).

3.2. Water outage as a hazard?

"*[…] Die Wasserversorgung, bewusst Wasserversorgung und nicht nur Trinkwasserversorgung, [ist] ganz was essentielles […]. Je länger die Wasserversorgung funktioniert, desto weniger Probleme gibt's summa sumarum in so einem Fall*" (Interview DWP Vienna, 2015).

In order to assure the well-being of the population, water transmission is the most essential infrastructure decreasing many problems in case of a disaster, as stated by the drinking-water provider in Vienna. Water is transported from raw water sources over water treatment plants into the supply lines to the houses and multistoried buildings and further as collected wastewater from the houses to the wastewater treatment plant. Without the electrical work of pumps, the water supply, but also the wastewater disposal would come to a halt (Bundesheer, 2012). Water extraction, provision and treatment rely on a functioning energy grid, which, in case of an outage, can have severe effects on the water system including a water outage or water contamination (Keegan, 2004; Petermann et al., 2011; World Bank, 2014).

In this regard, (1) safe drinking-water is on an individual level required for body functioning, hydration and the prevention of diseases such as diarrhea. In Austria, the daily per capita supply of drinking-water is about 135 liter, which is delivered to ninety percent by 5500 central water supply systems of different size. The other ten percent account for around one million Austrians, who have their own water supply, e.g. household wells (Ministry of Life, 2014). (2) The quality of life has immensely improved over the last decades with the promotion of daily hygienic practices. More than one-third of the private water use is for body hygiene (36%), while toilet flushing takes up 27 percent of water and drinking and eating account for six percent (Petermann et al., 2011). Table 1 provides an overview of the minimal amount of safe water needed per day for basic human survival.

Table 1: Minimum requirement of water needed for survival

Water use	Minimum requirement (l/day/person)	Notes
Water intake for food and drinking	2 - 3 liters	Depends on climate and individual physiology
Basic hygiene practices	2 – 6 liters	Depends on social and cultural norms
Basic cooking needs	3 – 6 liters	Depends on food type and social and cultural norms
Total	**7 – 15 liters/day**	

Source: Ray & Jain (2014)

Accordingly, two to three liters are needed for food intake and drinking, two to six liters for basic hygiene practices and three to six liters for basic cooking. This results in a total need of seven to fifteen liters of water per day and person (Ray & Jain, 2014). If the required daily intakes cannot be assured the risk for waterborne diseases increase quickly and may lead to a cholera outbreak especially threatening the life of children, handicapped people and the elderly (WHO, 2011).

A water outage may also contribute to the consumption of (3) low quality water retrieved from rivers, lakes or other open water sources. The loss of high-qualitative water due to a blackout or any other reason can have many cascading effects halting the operation of hospitals, restaurants and wastewater treatment plants. If the wastewater is not purified before it reaches the open water sources, contaminants may enter the food chain (Bruch et al., 2011; Petermann et al., 2011). So far 94.5 percent of the Austrian population is connected to municipal sewage systems including wastewater treatment plants larger than 50 population equivalent. The remaining percentages refer to people who own small wastewater treatment plants or cesspools (Ministry of Life, 2014). Yet, water is not only needed for drinking, but also for (4) cooking and to extinguish fires, especially during a blackout when people rely on candles and gas lamps for heating. In winter people would make open fires in order to stay warm inside the home increasing the chances for houses to catch fire. Fire fighters may not be able to extinct them if water is missing (Bruch et al., 2011; Petermann et al., 2011). A stable water infrastructure is also necessary for (5) industries and power generation plants. Water is used for cooling, steam generation, the processing of products and to remove and process manufacturing waste (DHS/OCIA, 2014).

The need of safe water in everyday life is unquestionable, while the perception that a water outage is a hazard and may be caused by a blackout is debatable. The DWP Vienna, for example, declared that for them “a power outage is luckily not a big topic“. “*Stromausfall ist Gott sei Dank bei uns net ein sehr großes Thema*“ (Interview DWP Vienna, 2015). On the contrary, power outages occur regularly as stated by the stakeholder of the WTP in Laxenburg: “*Ein Thema [der Stromausfall], ja genau. Kommt im Normalfall schon einmal im Jahr bis zweimal, oft sogar dreimal im Jahr vor*“ (Interview WTP Laxenburg, 2015). Subsequently, not all stakeholders may perceive a blackout as a hazard at the moment due to a low risk perception and a high tolerance level accepting a certain degree of risk. A hazard does not need to occur before a risk is perceived, but a risk assessment can increase risk awareness that a potential disaster may occur and decrease tolerance (Prisching, 2008).

Until today, Austria did neither have long-lasting power outages nor water outages unlike other countries in Europe. “*Man muss glücklicherweise sagen, bei all den großen Stromausfällen in Europa, ist Österreich ja verschont geblieben. Also wir haben bis jetzt in den letzten, also mit bekannten Zeiten keinen längerdauernden Stromausfall in dem Sinn gehabt, also keinen flächendeckenden*” (Interview Austrian RC, 2015). In this case, reference is made to a power outage lasting for a few hours to days and was caused by a disruption of electrical flow (Hohl et al, 2013). A blackout, however, is likely to be an indirect cause of the actual disaster and hardly the disaster itself (Bruch et al., 2011).

For the duration of a blackout, a lack of water is not considered a problem in Austria because the Danube and several smaller rivers and lakes are spread throughout the country. Austria has water in abundance as stated by the Austrian Ministry of the Interior, "*Wir haben ja in Österreich einen hohen Wasserreichtum. Also sobald ich da jetzt über Wien hinausgehe, also Richtung Klosterneuburg, und so weiter, dort ist das jetzt natürlich ein städtischer Bereich, aber dadurch, dass die Donau so nah ist, dadurch, dass es dort eine Vielzahl an Bächen gibt, die finden sich*" (Interview MOTI, 2015).

3.3. Financial investments in a blackout

"*Jede Vorhersage oder jeder Plan. Ich sage auch mal so […], da kommen übergelagert so viele Probleme auf Österreich [zu]. Ich sag mal, das ist alles nicht mehr. Die Logistik ist dann total zusammengebrochen. […], aber ich sag mal so das sind Millionen Menschen… Da irgendwo… Alles… Finanzmarkt. Alles ist weg. Also ich denk mal, Konkurse ohne und Ende und und und. Also irgendwo daraus was zu Papier zu bringen, für ein Unternehmen, für einen Betrieb, da kann man voraussagen das ist schade für die Arbeit*" (Interview WTP Vienna, 2015).

A blackout affects the financial market, people and many more sectors difficult to define, according to the WTP Vienna. For the interviewee, these unpredictable effects make any planning impossible and take up too much time and resources (Interview WTP Vienna, 2015). This leads to the assumption that there is awareness, which is yet based on individual perception and unstructured knowledge on the causes and effects of a water outage in an industrialized country. The problem is that risk awareness and interest cannot be increased by success outcomes or financial benefits due to losses and damages provoked by a disaster. A risk interest is necessary to conduct effective risk management, because otherwise ideas on how to address a risk are difficult to develop (Keegan, 2004).

A finance plan including a cost-benefit analysis is essential for the implementation of disaster risk reduction measures, can raise awareness on the need to prevent water outages and may help to find the most cost-effective response measure depending on the region and its individual characteristics (Renn & Klinke, 2015). A financial plan includes costs for preventive measures in order to decrease the severity of the effects of water and power outages, backup systems, educational programs and information material (Staudinger, 2015). Early on investment can in the end prevent direct and indirect costs in the short- and in the long-term. Direct costs in case of a water and power outage include lost production, standstill of workers and technology, damage to electronic data and technologies, spoiled food, and damaged products and equipment. Indirect costs are, for example, looting, accidental injuries, human suffering, rubbery, loss of water supply and cracked reputation of and trust in governments and industries. Indirect costs are likely to exceed direct ones by up to five times, which proves that also not so obvious costs and effects need to be integrated in the analysis (Bruch et al., 2011; Petermann et al., 2011).

In case of a blackout, the Technical University of Vienna calculated in 2003 that the costs for Austria would reach up to forty million Euros per hour, which increased with economic development by 2010 to sixty million Euros per hour (APG, 2011). According to Reichl & Schmidthalter (2011), the economic damage to industries, public institutions and households in Vienna ranged in January, 2008, at 10:00 in the morning between 62 million Euros for a power outage of one hour to 200 million Euros for fifteen hours.

According to Table 2, the costs for losses are the highest after the first hour of a blackout and increase only slightly with every following hour considering location, season of the year, time of the day and duration. The Armed Forces, who constructed a comprehensive mathematical model that estimates the probable economic damage based on current knowledge and insights, estimate the economic damage to reach 180 million Euros for a blackout that takes about one hour. When it takes around 24 hours, costs of 890 million Euros have already been assumed. In the above mentioned estimations, indirect costs due to the disaster are not include and would increase economic costs substantially (Bundesheer, 2012).

Table 2: Economic damage to industries, public institutions and households as a result of power outages in 2008 depending on location, season, duration and energy

Power outage location	Date, start	Duration	Missing energy	Damage costs (in 1 000 EUR)
Vienna	January, 10:00	1h	1300 MWh	62500
Vienna	January, 10:00	15h	18000 MWh	200000
Austria	August, 10:00	1h	8700 MWh	150000
Austria	January, 10:00	10h	90000 MWh	540000
Austria	January, 10:00	24h	220000 MWh	990000
Austria	January, 10:00	48h	420000 MWh	1700000

Source: Adapted according to Reichl & Schmidthaler (2011)

The difference in costs shows, that, on the one hand, the economic damage depends on the kind of assessment conducted such as whether they are based on assumptions or include community assessments such as on the will to finance the prevention of water outages (Petermann et al., 2011). On the other hand, damages also depend on the affected region including the population density, climate and industries. In Germany, for example, a one hour blackout during the winter season would cost between 0.6 to 1.3 billion Euros (Petermann et al., 2011). In India a blackout occurred in 2001 due to technical failure and failure of substitution. The power continued to be missing for around twelve hours, affecting around 230 million people and causing a loss of approximately US$ 110 million (Bruch et al., 2011).

In Austria, the municipalities have to carry the financial costs for damages on the critical infrastructure and for prevention measures (Interview MOTI, 2015). Both costs need to be balanced to see when, where and how investment does make sense. In Laxenburg three stakeholders have a cooperation to share the high costs of almost one million Euros for a backup generator. "*Sie müssen sich vorstellen, dass*

Notstromaggregat das kostet, weiß ich nicht, fast eine Millionen Euro. Das ist Wahnsinn“ (Interview WTP Laxenburg, 2015). On the contrary, Bad Fischau considers disaster risk reduction measures such as the installation of a photovoltaic system to create an energy island and to become less reliant on the central energy grid as a means to reduce costs. “*Der Hauptgrund war sicher die Sparmaßnahme. Ja klar, die Investition zu machen kostet sicher viel Geld*“ (Interview DWP Bad Fischau, 2015).

Such prevention measures are regulated by law according to which municipalities have legal responsibility to provide a regular budget for disaster risk response (FAG 2008, BGBl. I Nr. 103/2007). Whenever needed, the government of the provinces and the federal government have to support the municipalities through the budget of the “catastrophe fund” (Katastrophenfondsgesetz 1996) (Staudinger, 2015). The Austrian Disaster Fund guarantees that a certain amount of tax revenues are available for disaster risk reduction measures. Unfortunately, no detailed information was found on the kind of risks included besides a fund for flooding and avalanche reduction. Furthermore, the report seems to have a mistake in the labeling of the table since it is not clear if fifteen percent of the national budget is spent on disaster relief and 45 percent on risk reduction or vice versa. The only certainty is that for both twenty percent are provided by the decentralized budget given by local bodies (Staudinger, 2015).

3.4. Existing literature on water outages caused by blackouts

Several reports and scientific papers exist on risk analyses and disaster risk responses, yet they vary in focus on infrastructure and targeted region. Most importantly, they often exclude blackouts as causes for a water outage.

On March 17, 2015, Austria submitted its “National Progress Report on the Implementation of the Hyogo Framework for Action (2013-2015)” as mentioned earlier reflecting on its new security strategy called “Security in a new Decade - Shaping Security”. Inside the report the ministry states that “natural hazards are well documented, while technical or multi-hazard situation need to be investigated in more detail”. Subsequently, this statement correlates with the assumptions made above that awareness exists for some areas such as floods, but it is missing for others such as power outages. The report states furthermore that exposure to hazards needs to be reduced and resilience of the people improved by providing training and education, ensuring better cooperation between relevant stakeholders and conducting further risk assessments in the upcoming years (Staudinger, 2015).

Another report published following the initiative of the Austrian security research program “Kiras” and financed by the Austrian Federal Ministry for Traffic, Innovation and Technology (BMVIT) in 2011 is called “Blackouts in Österreich – Teil I” (“Blackouts in Austria – Part I”). Also here, the water sector is not included, while focusing on the financial investments and the economic profitability of prevention measures against blackouts (Reichl & Schmidthalter, 2011).

On the international level the availability of publications on blackouts and water outages has been more successful. In 2012, Switzerland published a risk analysis on several hazards including the risk of a power outage for their country (Hillson, 2004). This report is cited several times in a project report on the effects of a blackout conducted by the German Bundestag and the Karlsruhe Institute for Technology (KIT) and published in 2011 by Petermann et al. Both reports share many insights on the vulnerability of the critical infrastructure following a blackout, on awareness and behavior of the population, and on the likelihood and costs of a long-lasting and far-reaching power outage.

A practical report referring to real-life experiences has been published by the City of Kobe in 2010 in report named “Comprehensive strategy for recovery” following the Kobe earthquake in 1995. Though the main focus is on seismic mitigation measures, useful information is shared on experiences of stakeholders, lessons learned on effective disaster response for a long-lasting emergency, reaction of the population and mitigation measures applied to prevent another water outage (City of Kobe, 2010).

Overall, information on water outages caused by blackouts had to be searched intensively because of the variety of key words that can indirectly describe blackouts, water outages, disasters and risk management. For instance, power and water outages are discussed in the same publication, but independently from each other. Subsequently, a connection had to be created with the help of additional literature and the interviews. Undoubtedly, outages of the critical infrastructure are discussed in the literature confirming that awareness in industrialized countries exists, but publications are limited to specific regions and organizations. To them, prevention is profitable and can reduce overall costs. Investment in mitigation measures is considered effective for reducing and preventing high costs and economic losses. Even if a blackout may not be considered cost intensive, indirect costs such as human suffering need to be included in calculations. Though they are difficult to quantify, indirect costs tend to be five times higher than direct costs making any mitigation measure financially profitable even if the target group may never be hit (Levy & Bissell, 2013). Active commitments assure public safety in an interconnected system that is influenced by geographic, political, cultural and organizational environments.

4. Identifying causes for hazards and their likelihood

"*Wir müssen eigentlich feststellen wir haben keine Erfahrung aus der Vergangenheit, weil nichts passiert ist. Also kann sie nicht so groß sein, die Gefahr, also rein rational betrachtet. Nur wenn halt was passiert, dann ist es halt ein riesen Problem, net so wie bei einer Lawine*" (Interview MOTI, 2015).

Experiences are essential for well-grounded risk analyses and the examination of human and environmental vulnerabilities and exposures, and the classification of risks (UN/ISDR, 2015). Wake up calls and first hand experiences for the USA were the terrorist attack of September 11, 2001, and Hurricane Katrina in Georgia in 2005. Both disasters intensely affected the critical infrastructure and raised questions on emergency management and security (Van Leuven, 2011).

A risk is not a simple, unchanging threat, but has to be taken apart according to causes of risk, the risk itself and effects of risks (Chapter 2.3, Figure 2, Pillar 2) (Hillson, 2004). Risks are limited in comprehension and generalization because not all people perceive the consequences equally threatening differing between developed and developing countries. People become selective in which hazards to consider as risky and which ones to ignore. This is often related to the vulnerability and resilience of people, two important components in a risk assessment (Renn & Klinke, 2015). This chapter identifies hazards that may cause a power and water outage with regard to a halt of the water supply or a decrease of drinking-water quality below acceptable levels. The goal is to provide a general approach taking possible causes for a water outage into consideration (Keegan, 2004).

In general, the effects of a blackout are affected by political, legal, economic, social, technological and environmental decisions, which may cause direct or indirect effects on water providers and consumers (Castillo, 2014). Knowledge and experience on water outages caused by blackouts are limited to nonexistent, but derive from other events such as the earthquake in Nepal (2015) or the flooding on the Philippines (2014) that affect several parts of the critical infrastructure. Hence, water or power outages are rarely the actual disaster, but are more likely to be effects of a disaster. For example, the natural disaster has a direct effect on the power supply and an indirect effect on the water system. Indirect effects are difficult to predict, seem unimaginable at the current point in time and yet can cause long lasting consequences to the population (Bissell, 2013). Several authors provide comprehensive overviews on possible causes for a water outage and a blackout, which can be grouped into three categories: environmental, social and technical causes.

Figure 4 provides a visual overview on causes that may directly or indirectly affect the water sector. The focus is on the indirect effect on the water system caused by a blackout. Both, power and water outages, are hazards that as a consequence disrupt daily life, which is, for example, expressed in societal unrest, lack of hygiene and communication disruption. Due to today’s high dependency of the water sector on electricity, the focus of this chapter is on events that may directly affect the power supply and indirectly the water supply or wastewater treatment.

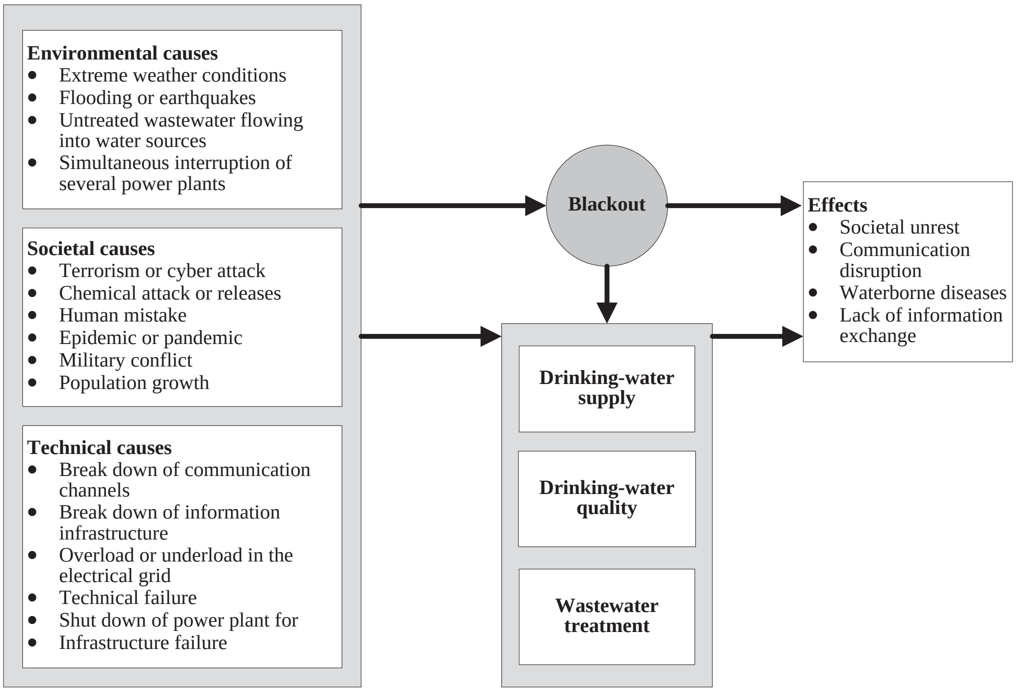

Figure 4: Causes, hazard and effects

Source: Own description according to Bruch et al. (2011); Bundesheer (2012); Hohl et al. (2013)

4.1. The likelihood of hazards and the perception to causes for water outages

Risks are perceived in different ways by stakeholders and the population. Hazards have the potential to cause harm such as earthquakes or contaminated water (Renn & Klinke, 2015). A risk analysis should be an unbiased assessment considering the perspectives of all stakeholders affected by the risk. A risk assessment is part of risk management and defines the likelihood of a risk and its impacts, has no standard approach and is adapted according to risk perceptions (Keegan, 2004).

A risk is calculated by the probability of a hazard times the severity of the consequences and always has a likelihood to occur above zero. There is always a minimal risk even if it would mean to consider a worst case scenario (Government of Canada, 2003). A worst case would be, for example, if not a single drop of water would flow, according to the Ministry of the Interior. Though this may be perceived as unlikely, the interviewee agrees that a small probability should never be excluded.

"*Dementsprechend kann man sich ausrechnen wie viel dann durchkommt, wenn wirklich nichts durchfließt. Aber dann sind wir schon wieder bei der Steigerung vom Bösen. Das gar nichts zufließt ist auch schon wieder nahezu unwahrscheinlich. Aber ein bisschen Wahrscheinlichkeit muss man bei den ganzen Dingen ja auch mit berücksichtigen*" (Interview MOTI, 2015).

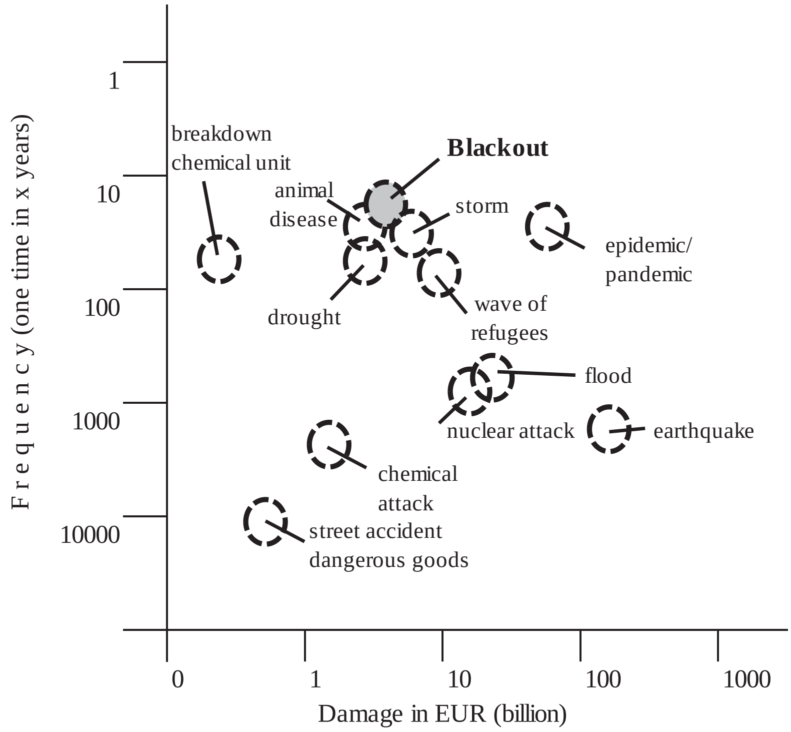

Figure 5: Risk diagram

Source: Adapted according to Hohl et al. (2013)

The Swiss ministry published a risk diagram contrasting each risk potential within the environmental, societal and technical causes (Figure 5). According to the experts a power outage has one of the highest probabilities and frequencies compared to other risks including heat, flooding and terrorist attacks, though the economic damage of a power outage is on average low compared, for example, to earthquakes or epidemics (Hohl et al., 2013).

The result of a risk equation can be visualized in a 3x3 or 5x5 matrix. The matrix is labeled according to the probability of loss, harm or injury and the severity of the consequences (Hunter et al., 2002). The categories of the matrix on the horizontal scale are “high, medium and low” or “rare, unlikely, possible, likely and almost certain” with respect to the probability of an event and on the vertical scale they are “insignificant, minor, moderate, major and catastrophic” referring to the severity of consequences (Figure 6) (Keegan, 2004).

Severity of harm

Low probability and catastrophic harm	Rare probability and catastrophic harm	Medium probability and catastrophic harm	Often and catastrophic harm	High probability and catastrophic harm
Low probability and critical harm	Rare probability and critical harm	Medium probability and critical harm	Often and critical harm	High probability and critical harm
Low probability and serious harm	Rare probability and serious harm	Medium probability and serious harm	Often and serious harm	High probability and serious harm
Low probability and minor harm	Rare probability and minor harm	Medium probability and minor harm	Often and minor harm	High probability and minor harm
Low probability and unlikely harm	Rare probability and unlikely harm	Medium probability and unlikely harm	Often and unlikely harm	High probability and unlikely harm

Probability of occurance

Figure 6: Five-dimensional classification of risk (light grey: acceptable risk, medium grey: tolerable risk and dark grey: intolerable risk)

Source: Own description according to Hunter et al. (2002)

The light grey area in Figure 6 describes a tolerable risk with a low or rare probability of occurrence and a negligible impact. If the likelihood of occurrence is slightly higher (medium grey area), the impact can still be negligible and further action is not required. At the same time, when the harm is critical, but the probability of occurrence is low, the risk tolerability is high also leading to no action or intervention to prevent the disaster from occurring. The dark grey part illuminates a worst-case scenario with a high probability of occurrence and catastrophic impacts requiring action since the effects are considered as not tolerable (Renn & Klinke, 2015).

Though this grouping seems straight forward, the classification is not as simple. The identification and characterization of risks are complicated and controversial and depend on individual mental constructions such as perceptions, interpretations and responses influenced by social, political, economic and cultural contexts (Hunter et al., 2002). For example, a backup generator can, on the one hand, assure a constant flow of electricity, but, on the other hand, may cause envy and anger if the organizations and people around you do not have one. In this case being prepared is perceived as a risk. "*Wobei so ein Notstromaggregat dann auch irgendwo wieder diese gegenteilige Folgen hat. Du musst dir vorstellen, es ist dann rundherum alles finster und du hast ein Notstromaggregat und du hast Licht. Das kann, sag ich mal, nachteilige Folgen auch haben, dass du jetzt plötzlich von einer Masse an Bevölkerung gestürmt wirst*" (Interview WTP Vienna, 2015).

Tolerability

It is not easy to draw a line between acceptable, tolerable and intolerable hazards and effects as also stated by Renn & Klinke (2015), because not one hazard is equal to another one or perceived in the same way by everybody or even by the same group of people. Risk tolerability highly depends on moral judgment and individual experiences influenced by the valuation of the infrastructure or resources that may be lost in case of an event, the weighing of costs for prevention and costs for response, and the foresight of the stakeholders (ASCE, 2009; Hillson, 2004; Keegan, 2009; Renn & Klinke, 2015). Furthermore, there are different options to calculate the risk probability as mentioned in Castillo (2014) of which not a single method has been identified yet.

For Austria, the highest risk identified by the Ministry of the Interior is a heat wave as it has been expressed as the most probable risk with the most severe outcomes. Just in 2012, a heat wave occurred in Europe causing thousands of deaths. "*Wir haben da gemeinsam die Risiken, die wir für Österreich erkannt haben, aufgelistet und bewertet. Und das größte Risiko, das wir haben, also jetzt im Sinne von*

Eintrittswahrscheinlichkeit und Auswirkung ist in Wahrheit die Hitze. Das ist das was viele nicht so jetzt im Vordergrund sehen“ (Interview MOTI, 2015). Each cause is likely to occur depending on varies factors and cascade of events. A heat wave, for example, may be the least tolerated, whilst the increased consumption of electricity for cooling, the augmented flow of water for pools and gardening, and the higher consumption of drinking-water equally threaten the stability of the power grid and the quantity stored in water tanks.

Uncertainties

“*Also wenn wir jetzt […] über einen Stromausfall sprechen, in ganz Österreich, dann ist das natürlich ein worst-case Szenario mit dem man sich beschäftigen kann. Die Frage ist, kann das wirklich realistisch eintreten?*” (Interview MOTI, 2015). A comprehensible question asked by the ministry is “whether a blackout all over Austria is actually realistic?” Laugé et al. (2013) would answer this question with “yes”, because they state that the likelihood of cascaded events tends to be underestimated. Though there are uncertainties in defining risks, long-term impacts such an event can have on the quality of life, the economy and the environment are also often more severe than expected (Laugé et al., 2013). It is important to expect the worst as long as it is still reasonable to do so. Uncertainties on the probability of water and power outages and on the severity of harm it may cause have been contradictive within the stakeholder interviews. Once defining a blackout as a risk for Austria, a few sentences later it is relativized.

The DWP Vienna, for example, provides two sides. On the one hand, the interviewee states that the possibility of a blackout has not been part of their risk analysis over the last years, since they have never experienced difficulties with their water supply. Vienna receives water by gravitational flow, wherefore motorized pumps are not needed. Only once it happens, they will figure out where action should be taken. “*Stromausfall ist Gott sei Dank bei uns net ein sehr großes Thema. Jetzt in der Vorausschau. Wenn’s wirklich dann mal ist, werden wir wissen, wo wir wirklich hängen werden. Aber derzeit sehen wir das eigentlich nicht als sonderlich großes Problem*“

(Interview DWP Vienna, 2015). On the other hand, measures to be prepared for a blackout are taken already since 2000, following the millennium change. Since then backup generators are installed in higher regions, where five percent of the Viennese population lives and relies on water pumps to receive water. “*Wir sind aber jetzt schon seit einigen Jahren dabei, dass wir an zentralen Stellen, wo wir Pumpwerke haben, mit Notstromaggregaten Einspeisestellen schaffen*“ (Interview DWP Vienna, 2015).

The small wastewater treatment plant in Laxenburg is prepared for a power outage for the longest period of time compared to the other three water units. Accordingly, a backup generator already exists since 1995. However, the risk perception is also here controversial, when the question was raised whether a blackout is a topic. A quick first denial was followed by an equally quick confession that several power cuts have already occurred due to an open wire. “*Nein, eigentlich nicht. Ja, es ist schon ein Thema aus dem Grund, weil wir leider Gottes von unserer Freileitung her noch sehr schlecht bedient werden sozusagen [und es ist] schon öfters vorgekommen, dass wir unseren Stromausfall gehabt haben*“ (Interview WTP Laxenburg, 2015).

A last example from the interviews on uncertainties and controversies of risk perceptions is stated by the Ministry of the Interior. “*Und wenn ich die tausend Leute zusammenfasse und das ist relativ leicht überschaubar und nur schau, was die alle zu Hause haben, dann leben die alle eine Woche ohne dass irgendwer wohin einkaufen fährt*“ (Interview MOTI, 2015). Accordingly, a water outage should neither be of concern for the ministry nor for the population. Independently if a risk exists or not, everybody has so much food and water stored due to over-consumption and supermarkets have extensive supplies stockpiled, that there are enough resources available to live without external support for several days. An uncertainty though lies in the duration of a power outage for which preparatory action should be undertaken. “*Ja, schon, also das [ein Stromausfall] ist nicht unrealistisch. Das ist schon möglich. Die Frage ist nur für welchen Zeitraum?*” (Interview MOTI, 2015). Subsequently, the previously stated denial of a possible power outage is relativized. A risk depends on the location and size of the area hit, the duration of the blackout and the reaction of the population. All of these factors contribute to the disaster perception, outcome and response (Interview MOTI, 2015). The severity of an effect on life can often not be known. It may actually never occur, wherefore it is difficult to integrate possible risks and outcomes into a risk management approach (Hillson, 2004).

Positive and negative experiences drawn from former events can help answering uncertainties and finding solutions. Discussions on climate change prove that uncertainties always exist. Information on duration, affected location ranging from an area to a country-wide or even continent-wide blackout and on economic costs of damage cannot be known in advance (Government of Canada, 2003). Most risk assessments lack examples and experiences on possible outcomes and undesirable effects (Government of Canada, 2003; Renn & Klinke, 2015).

Risk perception

Differences in global risk perception are influenced by the location and duration of the hazard to occur. In the case of a heat wave, the risk in a city is higher than in a village due to a lack of natural ventilation, the increased density of people per square meter, and the lack of storage space for food, water and tools. This makes a disaster in a city more complex (Menoni, 2001). In addition, people living on the countryside feel less exposed in case of a water outage because they live in reach of tools and water sources to help themselves. "*Dort [auf dem Land] hat er Werkzeug, dort hat er eine Grünfläche, dort hat er vielleicht die ein oder andere Möglichkeit zu heizen ohne, dass er auf Strom angewiesen ist. Im städtischen Bereich haben sie halt all diese Möglichkeiten nicht, im Ballungszentrum*" (Interview MOTI, 2015).

The risk perception also changes with the season of the year. With regard to a power outage, the affected population will not be threatened to freeze in summer (Interview MOTI, 2015). On the contrary, a water outage is more likely to cause harm since the water availability is already stressed increasing the threat of infectious diseases due to a lack of hygiene (City of Kobe, 2010).

Vulnerability

Certain countries and population groups have a higher vulnerability for water outages, blackouts and other disasters that may harm the critical infrastructure and are often equally less resilient to catastrophic events. People with certain needs or from certain areas such as the elderly, the poor or handicapped people, perceive an event more dangerous due to their reliance on other people and their need for specific infrastructure (McEntire, 2013). "*Neben anderen vulnerablen Gruppen, sind das eben Gruppen, die spezielle Betreuung und eine Notunterkunft brauchen und auch dafür muss man dann eben schaun, dass man geeignete Maßnahmen setzt und eine geeignete Infrastruktur herstellt*" (Interview Austrian RC, 2015). Vulnerabilities are not only socially constructed through perceptions, religious beliefs, reliance on technologies, insufficient education and so on (the holistic theoretical school), but also institutionally by governmental policies, economic institutions and political structures, which create social relationships, law and class diversion (social vulnerability school of thought) (McEntire, 2013). The later can, nevertheless, also help to actively decrease the vulnerability of the population by improving education, raising awareness, setting up help centers for people in need and providing policies that increase the overall resilience.

Resilience

Liability and capability are strongly connected to vulnerability and influence each other. Both can enhance the cooperation and acceptance for certain policies or recommendations by the population (McEntire, 2013). For example, vulnerability exists when a house is connected to the water system. If the water system would be connected to a high-level water storage tank from which the water flows down by gravitational force, resilience would be improved (Bissell, 2013). A distinction is made between objective resilience, the withstanding of stress by the system, and subjective resilience, mastering crisis situations by the respective actors. Resilience includes adaptive management capability, coping capability and participative capability that allow a person to resist stress and to deal with disasters (Renn & Klinke, 2015). In general, crisis management does not begin with the crisis itself, but with awareness of vulnerabilities and an assessment of potential disasters that may occur (Prisching, 2008).

4.2. Direct and indirect causes for water outages: Nature and society

"*[…] Wir hier in Österreich [gehen] eigentlich hauptsächlich von den Naturkatastrophen im klassischen aus[…]. Terrorgefahr, ja, wir sind jetzt nicht anders wie viele andere, aber nicht exponiert. Und technische Gefahr, dass man da einfach mal das Thema Stromausfall mit einer aber nicht extrem hohen Wahrscheinlichkeit beleuchtet. Wenn wir so zurückschauen, was waren denn unsere letzten großen oder die größten Katastrophen? Da haben wir Lawine, da haben wir Kaprun als technische Katastrophe. Aber in Wahrheit…, dann haben wir die Gefahr des Atomunfalls*." According to the Ministry of the Interior, Austria has not a high probability of a blackout, though it certainly may occur. More dangerous threats mentioned are natural disasters such as avalanches, accidents with an aerial railway and atomic disasters (Interview MOTI, 2015)

Environmental causes

The first cause for power and water outages to be looked at are environmental causes, for instance extreme weather events including strong winds and lightning, flooding and earthquakes, snow and ice storms, untreated wastewater flowing into open water sources and simultaneous interruption of several power plants (Bissell, 2013; Bundesheer, 2012; Hohl et al., 2013; Van Leuven, 2011). Previous disasters in the USA (Hurricane Sandy 2012) and Haiti (earthquake 2010) have shown the high vulnerability of infrastructure systems to natural disasters including water, electricity, security, transportation and communication (Bissell, 2013; Chang, 2009). In the case of Hurricane Katrina (2005), USA, over 170 drinking-water facilities and 200 wastewater treatment facilities were destroyed (DHS/OCIA, 2014; Van Leuven, 2011). In Haiti, the 2010 earthquake destroyed electricity units and other infrastructures causing a delay and a complication of response measures (Levy & Bissell, 2013). Simultaneous events such as a car accident hitting electrical poles or a balloon accident may already cause a cascade of events leading to a wide reaching power outage or even a long-lasting blackout (Bruch et al., 2011; Bundesheer, 2012; Hohl et al., 2013).

An earthquake may affect the water system due to the tremble of the earth and thus, the destruction of the water distribution pipes and the subsequent contamination by sewage or chemicals (Nakashima et al., 2014). Natural events indirectly cause water outages, because water may still be flowing, but the transportation through the pipes might not be possible anymore and water consumption could be harmful. Subsequently, natural disasters can help to understand the effects a water outage can have on the population and industries, the response measures in place and the resilience of the critical infrastructure as such.

Japan, as an example, is regularly affected by natural disasters causing water and power outages. It can look back at many experiences with regard to effective mitigation management, disaster response and reconstruction measures in a modern metropolitan area in an industrialized country (Menoni, 2001). Due to the earthquake in Kobe in 1995, several population groups stayed without water and natural gas for two to three months. The problem was that four reservoirs were damaged, many conducts and pipelines were ruptured and overhead cables were hit by collapsing buildings in and around Kobe city (City of Kobe, 2010; Menoni, 2001). The earthquake caused a total to near to total destruction of more than thirty percent of buildings and housings, the death of over 6000 people and injuries of around 44000 people in the whole earthquake region. In Kobe, the electricity was off for around seven days and telephones did not function for fifteen days affecting around 25 percent of the city. For eighty percent of the population gas was cut for 85 days. Subsequently, the entire urban infrastructure, civic life and economic activities were affected (City of Kobe, 2010).

A lack of water and food were the main concerns of 2.6 million customers following week one after the earthquake. Local authorities were not able to meet those needs as they were not prepared to keep certain strategic traffic lines free for supply cars and because precise maps that located the defected areas of the water system were not accessible since stored copies were buried underneath buildings and not electronically accessible due to the power outage, which further delayed emergency response and damage reduction measures (Menoni, 2001).

A second example for an earthquake severely affecting the population is the Northridge earthquake from 1994 that hit Los Angeles. This has been the first time that the entire city of 2.5 million people sat in the dark (Shinozuka & Chang, 2004). Due to the trembling of the earth not only the Los Angeles Department of Water and Power (LADWP) was damaged, but the population had to live without water for a range of one to seven days (Chang et al., 2008; Shi & O'Rourke, 2008).

Both, the USA and Japan, have experienced power and water outages as developed countries. Their insights can help to understand risks for industrialized countries such as Austria. The effects of environmental influences should not be underestimated. A flood, for example compared to an earthquake, may not need to destroy the pipelines, but can cause biological or chemical water contamination. In order to prevent an outbreak of diseases, the consumption of water would be forbidden to protect people from diseases that may break out sooner or later in time. "*Wobei beim Erdbeben sind vielleicht die Leitungen beschädigt und da gibt es viele Aspekte. Also grundsätzlich bei einer Überschwemmung, zum Beispiel, werden die Leitungen nicht beschädigt, aber möglicherweise die Brunnen. Die Brunnen werden kontaminiert oder Brunnenfelder verändern sich, Wasserströme unter Wasser, alles mögliche und so weiter. Das wäre, zum Beispiel, so ein Punkt und die Wasserversorgung geht dann trotzdem weiter und es wird dann die Meldung rausgegeben „Wasser nicht trinken", abkochen, wenn's nur eine biologische Geschichte ist oder gar nicht trinken, wenn's auch eine chemische Geschichte ist. Dann muss man sich anders versorgen*" (Interview NBC Defence School, 2015).

The Austrian RC referred to another natural disaster that affected the critical infrastructure. They provided support following the typhoon on the Philippines in 2014. The critical infrastructure was partly not usable and the supply of electricity was interrupted, wherefore diesel tanks were used to assure the continuous provision of drinking-water by purifying water with drinking-water treatment units. In case of an international operation, the supply with diesel for backup generators is in the responsibility of the logistics in the respective country or needs to be ordered and delivered from abroad (Interview Austrian RC, 2015).

Societal causes

Secondly, societal or human-caused incidents are equally hazardous for the water system. Those include physical threats such as vandals, chemical threats and cyber-attacks; military conflicts causing the destruction of the electronic units; epidemics or pandemics affecting workers of the power grid; and even human failure due to distraction or as simple as switching off the wrong button (Bissell, 2013; Bundesheer, 2012; Hohl et al., 2013). These causes represent an increased vulnerability due to enhanced reliance on technology.

In the case of the Northeast blackout in the USA the power outage was caused by human error and the failure of utility companies to upgrade their equipment over the last years (Valcik & Tracy, 2013). Although disasters caused by humans had never catastrophic outcomes so far, attempts to do so prove that potential means, motive and opportunity exist. Throughout history, biological and chemical agents have been used to contaminate drinking-water (Van Leuven, 2011). In 2005, an attempted attack with the chemical Atrazin was planned at the Bodensee in Germany. An anonymous person threatened to use the chemical to contaminate the drinking-water. Fortunately, he was not successful (Hohl et al., 2013). Terrorism plays an important part nowadays since our society highly depends on the critical infrastructure and would be a target of high profile. The destruction of electrical supply, the sabotage of water and wastewater treatment systems or the dispersion of toxic chemicals in water would not only quickly hit important stakeholders, but also all parts of society including industries and healthcare facilities. Chemical attacks could affect a whole region, nation and even continent while the base would be located thousands of kilometers away (DHS/OCIA, 2014; Levy & Bissell, 2013). This would spread fear and anxiety for a long period of time causing panic throughout the society. Hence, human-caused attacks can be internationally or nationally caused by insiders or outsiders (Van Leuven, 2011).

Cyber-attacks “include the intent of individuals or groups to electronically corrupt or seize control of data or information essential to system operations”. This takes into account the manipulation or retrieval of information from a system or the acquisition of supervisory control and data (SCADA) over the network comprising computers and applications. SCADA systems are increasingly used for the control of water pumps and valves from remote locations, focusing on the improvement of the functionality but not on the security of the system. Cyber-attacks also include the retrieval or manipulation of maps, security plans, financial documents and all other documents that are stored electronically (Van Leuven, 2011). They can be accessed either by a hacker or through access within the organization as it was described in Mark Elsberg’s novel “Blackout” (2012). Especially terrorism and cyber-attacks cannot be predicted or easily controlled wherefore a certain risk always exists. It may be enough already to attack a single power plant, which could cause difficulties on the side of the power providers to hold the voltage of the grid leading to a domino effect. “*Je Vernetzter das wird, Smart home, Smart grids, Smart meter, desto höher sind natürlich auch die Chancen, dass es irgendwann einen Angriff gibt, einen Cyberangriff und dieser Cyberangriff das System lahm legt*“ (Interview Austrian RC, 2015).

A third societal cause for water and power outages is the unavailability of the workforce during a disaster due to own losses and damages; family responsibilities; many being affected by an epidemic; the availability of too many helpers hindering the response experts; or due to retirement taking knowledge on mitigation and response measures with them (Van Leuven, 2011). Subsequently, the question is how to make a work place (more) attractive in case of a blackout. “*Personal, wie komme ich zur Kläranlage. Kommen sie überhaupt die Mitarbeiter, weil sie, sag ich mal, zu Hause verhaftet werden zu recht von ihren Familien? Wenn es um Nahrungsmittel geht, die knapp werden, keine Heizung. Ein geordneter Arbeitsprozess in dem Sinn ist dann auch nicht mehr gegeben von den Rahmenbedingungen. Also sie müssen sich aufstellen, wer könnte verfügbar sein, wie kann man den Arbeitsplatz attraktiv machen, also, dass die, die vielleicht keine Familie haben, Bereitschaft zeigen, her kommen, weil es hier doch noch warm ist, oder da oder dort noch Essensvorräte gibt*“ (Interview WTP Vienna, 2015). Uncertainties in work force availability require a lot of flexibility on the side of the management. Compared to the Armed Forces, many organizations do not and cannot force the employees to arrive at the office in case of a disaster (Interview MOTI, 2015). Incentives such as the availability of backup generators, heating, food and water are needed in order to give the employees a motivation to come to work and to help out whenever needed. This could improve reliability of employees and the overall response (Interview WTP Vienna, 2015).

During the Kobe earthquake only 41 percent of the stakeholders needed were present. The highest mobilization rate had the fire fighters with 95 percent, the Board of Education Secretariat with 92 percent and the Waterworks Bureau with seventy percent (City of Kobe, 2010). Although almost all of the fire fighters as a group of volunteers came to help, not all volunteer organizations should rely on it. "*Wir haben zwar jetzt 60000 Freiwillige. Die Frage ist aber, wie viele erreichen wir erstens noch, wenn die Kommunikation ausfällt. Und zweitens, wie viele davon stehen uns auch zur Verfügung, weil die natürlich selbst, also wir haben, zum Beispiel oft, selbst viele Freiwillige in der Landwirtschaft. […] Und ich glaub, ein Landwirt, der sonst für uns freiwillig tätig ist, der wird zu dem Zeitpunkt andere Probleme haben*". The Austrian RC has over 60000 volunteers, of which many work in the agricultural sector. They have to take care of their animals and cannot leave their responsibility. Additionally, telecommunication does not work anymore, wherefore there is not an easy possibility to reach out to the volunteers asking for help, wherefore the available workforce would decrease immensely (Interview Austrian RC, 2015).

4.3. Technical cause: Blackout as a cause and risk

"*Ja wir sind verwöhnt. Es war kein Thema. So wie der einzelne Bürger oder Bürgerin verwöhnt ist. Sicherheit…. Jetzt haben wir aber gehört, dass das europäische Stromnetz Schwachstellen hat. Und in gewissen Phasen, besonders im Winter, immer wieder regulierend eingegriffen werde muss. Das erhöht sich sukzessiv*" (Interview WTP Vienna, 2015).

Technical causes for blackouts include an overload and underload of the energy transmission grid and technical failures of power plants causing the breakdown of communication channels and information infrastructures. Many reasons have been found in the literature that may harm a constant power supply and that should be known as risks to the water sector. A primer threat on both systems is the interconnectedness of the energy grid. Austria is surrounded by and connected with seven neighboring countries either through the import or export of electricity, e.g. the import of wind energy from Germany (APG, 2011; Reichl & Schmidthaler, 2011). Consequently, the electricity supply does not only need to be regulated internally, but also in cooperation with external providers.

Nationally, the Austrian Power Grid (APG), the biggest Austrian electricity provider, regularly implements new safety measures to its power grid. The APG is responsible for the transmission of electricity to consumers and to prevent power cuts in Austria (OVGW, 2015b). The Safety and Security Center (SSC) of the APG monitors the electric power transformation sub-stations inside the country. It also integrated a backup station to the system, uses modern and secure multi-site architecture and plans to construct a high-voltage ring connecting several Austrian cities to overcome transmission interruptions (APG, 2011; OVGW, 2015b).

Technical precautionary preparations gained weight with the change in energy production from coal and natural gas to renewable energies, which is boosted by the 20-20-20 European emission goals (APG, 2011; Reichl & Schmidthaler, 2011). The European Member States have to decrease their CO_2 emissions, improve energy efficiency, meet increasing energy demands, become more independent from energy imports and increase the share of renewable energies in order to combat climate change. Austria receives an increased share of energy from Germany through renewable sources for a cheap price especially when there is an overload of electricity. Furthermore, Austria increased its electricity exports by 39 percent over the last years and expects to increase its share in renewables, especially hydropower and biomass, by 2020 both equally putting pressure on transmission grids in other countries as well as within Austria itself (APG, 2011; Reichl & Schmidthalter, 2011). Such extensions of the renewable energy sector cause volatility in the transmission grid and make an overload even more likely. APG already found out that its grid is nowadays not only more often strained, but also over longer periods of time (APG, 2011; BMWFW, 2014). Feeding the energy grid by wind parks causes changing peaks of supply depending on the amount and strength of the wind, whilst the power plants continue running on regular supply. This results in further stress on the grid (BMWFW, 2014; Reichl & Schmidthalter, 2011).

Another threat to the Austrian and European power grid is not only a market change, but also market unbundling and liberalization contributing to increased electricity demand. According to the EU Directive 2003/54/EG, the European energy market is open to electricity suppliers and consumers assuming a decrease in electrical prices (Reichl & Schmidthalter, 2011). The subsequent higher energy demand causes the energy limits to be reached even quicker and affects the security of the energy grid (APG, 2011; Bundesheer, 2012). Austria experienced an increased use of electricity from 1970 to 2008 by 2.9 percent (APG, 2011; Reichl & Schmidthaler, 2011). Within the private households more people use decentralized, renewable and intermittent energy sources, which increases the need for storing and moving energy (Reichl & Schmidthalter, 2011). Consequently, the Austrian grid is not threatened by an underload as previously expected, but by an overload during peak hours due to a high influx of electricity from different sources (Reichl & Schmidthalter, 2011).

In general, the grid is filled by only seventy percent of the total capacity in order to easily increase the influx in case more energy is needed or provided (Bundesheer, 2012). In Austria and other countries, this security rule is more and more pushed towards its limits possibly causing an overload (APG, 2011). Extended energy grids, increased demand and augmented influx do not necessarily lead to a more secure electricity supply, but increase the vulnerability of the grid and the probability of a blackout (Reichl & Schmidthalter, 2011).

Reichl and Schmidthalter (2011) state that the electrical transmission is less reliable on the countryside than in the city, while the latter faces longer lasting power cuts. In a city, energy transmission lines are usually buried, which takes more time and effort to find the flaw (Reichl & Schmidthalter, 2011). However, Laxenburg, as an example for a small village, still has open wires hanging in the air, which makes them more violable towards wind and storms. After almost forty years the open wire will finally be put underground. “*Und jetzt ist man hergegangen und hat man sich entschlossen, dass man heuer bis in den September endlich diese gesamte Leitung in den Boden verlegt. Das hat um die dreißig, ja vierzig Jahr gedauert*“ (Interview WTP Laxenburg, 2015).

In spite of well-connected power grids, one single power cut leading to a supply interruption can cause severe damages. If the capacity load of the grid is too high for too long, if the electricity flow cannot be kept constant or if several events occur at the same time, the result might be a domino effect increasing the risk for a far reaching blackout for a wide area of households (Bundesheer, 2012; Interview MOTI, 2015). Within the interconnected European Union separated energy grids exist, namely Central Europe, Scandinavia and Great Britain. These energy islands aim to function as backups in case a power outage occurs in one or the other area (Bundesheer, 2011).

4.4. Cooperation and responsibilities in times of crisis exemplified for Austria

An underling hazard to the water sector is a lack of knowledge on stakeholder responsibilities. Subsequently, the following chapter gives an overview on the structure of coordination exemplified for the Austrian disaster response system. Figure 7 shows who is connected to whom within the Austrian crisis team in a simplified way.

In Austria, risk management and disaster response are part of civil protection and are, previously in the responsibility of the military, nowadays controlled by the governments. Since the mid-1980s the government has the task to inform the population about self-protection measures; protect people against daily threats and natural, technical and civil disasters; and support them thereafter (BMI, nn). Austria has no national civil protection law that regulates all state and non-state actors. Disaster preparedness and response is in the responsibility of the government of the respective Federal Province. "*In Österreich ist Katastrophenwesen als Behörde Zuständigkeit der Bundesländer. Es gibt also eine Hierarchie, auch der Behörden. Die Bundesländer, dann die*

Bezirkshauptmannschaften beziehungsweise die Magistrate und in unterster, letzter Instanz die Gemeinden. Und die Gemeinden sind auch Zuständig für die Wasserversorgung und –entsorgung“ (Interview MOTI, 2015). Austria’s risk reduction runs under the principle of subsidiary. This means that all levels of governments reaching from municipalities to district administrations, the nine federal provinces and the national government, are responsible for disaster preparation and response, and the implementation of respective legislations (Staudinger, 2015). That way, preventive measures are applied according to the local and individual need.

“*Ja, und dann gibt es halt das Innenministerium, das im Falle solcher derartiger, großartiger Krisen, hat eine Koordinationsfunktion inne hat. Das heißt es geht darum alle staatlichen Maßnahmen, alle Verantwortlichen, obersten Behörden an einen Tisch zu bringen und das Gesamte zu koordinieren. So dass man zur selben Zeit in dieselbe Richtung zieht*“ (Interview MOTI, 2015). Since 2006, the umbrella organization in crisis and disaster management is the Austrian Federal Ministry of the Interior and here their department for operational, crises and disaster coordination. It is responsible for the operation and coordination of action (Einsatz- und Koordinationscenter, EKC), the governmental crisis and disaster protection management (Staatliches Krisen- und Katastrophenmanagement, SKKM) and international crisis and disaster protection (BMI, nn). This entails organizing and mobilizing stakeholders, conducting response plans, assuring human capacity and

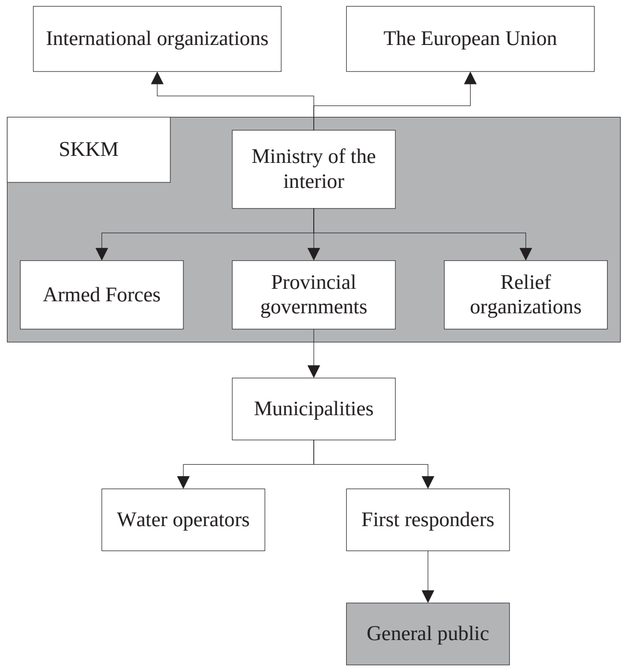

Figure 7: Coordination of Austrian crisis management

Source: BMI (nn)

capability, organizing adequate resources including transportation means, and decreasing the work load for other organizations (Ruback et al., 2013). However, the ministry does not have access to information of relief organizations, but can only demand it if required. This seems unlikely since the organizations work in trust and believe that one or the other is prepared in case a water outage occurs. "*[…] Man hat sich irgendwann einmal, jetzt nicht ausgesprochen, aber doch offenbar, so gesagt, im praktischen Katastrophenorganisationsmanagementleben dazu durchgerungen zu akzeptieren, dass alle in ihrem jeweiligen Bereich die Aufgaben einigermaßen vernünftig machen. Und dann hat das Rote Kreuz für den Bereich, wo sie halt Aufgaben entfalten die entsprechenden Reserven. […] Und so kümmert sich ein jeder um seinen Bereich und wir werden nicht sozusagen von der Zentralstelle aus das ganze Leben in Österreich mit den entsprechenden Versorgungen regulieren können. Das wird nie der Fall sein können. […] Wenn's notwendig wäre [könnten wir] sagen ‚ok, wir brauchen jetzt einen Überblick und jeder soll einmelden*"" (Interview MOTI, 2015).

The SKKM, which was newly established in 2004, is the communication platform for the respective organizations. It is a single coordination committee that organizes the collaboration of relief organizations and media with the Provincial ministries and governments and acts in case of a state wide disaster as the coordinator of different levels (BMI, nn; Interview MOTI, 2015). The Federal Warning Center (Bundeswarnzentrale, BWZ) acts as the operational coordination and information center since 2006 and has a common warning and alarm system, which is tested once a year to familiarize the public with the meaning of the signal (BMI, nn; Staudinger, 2015). It is in constant contact with the Provincial Warning Center (Landeswarnzentrale, LWZ), the federal states, neighboring countries, the EU and multinational and international organizations. It is a 24/7 contact and information point for the SKKM and a coordinator for an effective crisis and disaster relief operation (BMI, nn).

First responders

The backbone of the Austrian civil protection mechanisms and for the emergency water provisions are several voluntary aid and relief organizations. Those include the

Austrian RC, the Austrian mountain rescue team, Samariter, Johanniter, Malteser and the Austrian water rescue team. So far, Austria has approximately 4800 fire brigades, 900 rescue points, 250000 active members within the fire brigade, which is also the biggest voluntary organization, and 40000 trained paramedics. It can rely on a consistent and extensive pool of voluntary workers and first responders applying first aid whenever needed. The Austrian RC is the biggest rescue and disaster provider with about 60000 volunteers, approx. 8000 employees and around 5000 people doing community service (“Zivildienstleistende”) all over Austria working under the umbrella of the humanitarian international law. It covers eighty percent of all rescuers and acts in all regions. Volunteers, employees and social workers are trained in special trainings centers and fulfil during the day regular health tasks (Interview Austrian RC, 2015).

„*Und die sind first responder und arbeiten auf freiwilliger Basis. Das heißt die laufen einfach, wenn eine langfristige Katastrophe kommt und langfristig meine ich jetzt ab mehreren Tagen bis einer Woche, laufen die an ihre Kapazitätsgrenzen. Weil einfach die Leute kommen aus dem Arbeitsleben, gehen direkt in ihre freiwillige Tätigkeit. […] Dann kann eben das Bundesheer, nicht schnell, also wir sind keine first responder, wir sind nicht die ersten […], aber wir können lang bleiben. Wir sind durchhaltefähig, schichtfähig […]. Wir können das über Wochen und Monate sicherstellen. Das ist sozusagen diese Schnittstelle wie es in Österreich eben gut funktioniert*“ (Interview NBC Defence School, 2015). As important as the first responders are, they can only help out for a few days up to one week before they reach their physical limits as they are volunteers coming from work or other main obligations.

Consequently, after a few days the Armed Forces step in assuring supply for weeks and months. In order to act though, the Armed Forces need to be requested by the responsible authority of the Provincial government or the municipalities in case of disaster with unexpected dimensions. Though the Armed Forces primarily have a military responsibility, follow the military law and wear the military clothing and weapons at all times even during disaster operations, disaster response is for them obligatory. In Germany, for example, the Armed Forces follow mainly a military purpose while the German Federal Agency for Technical Relief (THW) provides the disaster response measures on a voluntary basis. "*Die haben quasi dieselbe Ausrüstung wie wir, nur halt nicht grün angemalt und keine Bewaffnung und keine militärischen Vorgaben und sind ein reines technisches Hilfswerk eben; eine Katastrophenhilfseinheit, sowohl national als auch international*" (Interview NBC Defence School, 2015).

With regard to water treatment, the NBC Defence School shares water treatment units, tests water quality and educates new personnel in case of a disaster. In order to become a water and hygiene specialist, higher academic education in natural sciences, medicine or technological sciences is necessary, in addition to the fulfillment of several courses and trainings in which further insights on water analysis and the Austrian legal system are taught (Interview NBC Defence School, 2015). The RC requires a similar background knowledge and training as the Armed Forces, while a distinction between national and international water experts is made (Interview Austrian RC, 2015).

Responsibilities

The coordination of the different groups and levels within the groups such as in and between volunteer organizations is a difficult task, but essential during disasters. Differences in culture, policies and response procedures complicate responses and can cause loss of time. This may, for example, be the case if there are not enough volunteers or equally if there are too many. In order to be aware of organizational differences and rules regular events, joint policy developments, trainings and exercises should be organized that can help bridging the knowledge gaps and enhance understanding and cooperation when it is needed without delay. Furthermore, a plan defining different tasks of the volunteers and organizations can help during the response later on. A detailed structure with defined responsibilities can prevent confusion and blame, and can close knowledge gaps in the response process (Ruback et al., 2013).

If no one feels responsible or no tasks have been assigned, areas or population groups may not be looked after. Gaps in knowledge on responsibilities also became slightly visible during the interviews. Two stakeholders confirmed that they are not sure who is responsible and how the issue is usually solved. In case of the wastewater disposal, neither the Austrian RC nor the Armed Forces feel responsible to assure a safe disposal or even an alternative solution in case the canal cannot be used or the pumps are not working. "*[…] Von uns wird man natürlich nichts finden, weil wir auch nicht verantwortlich sind, für die Wasserentsorgung eigentlich. Also wir können eine Wasserversorgung herstellen, das heißt wir können aus schmutzigem Wasser trinkbares Wasser machen*" (Interview Austrian RC, 2015). The Austrian Armed Forces provide a similar statement while at the same time referring to the municipality as the responsible stakeholder with uncertainty. "*Also grundsätzlich [ist] immer noch die Behörde, die Behördeneinheit [verantwortlich], also der Wasser … ist eigentlich eine gute Frage muss ich sagen. Ich nehme an die Gemeinde. […] Wir sind eben keine Entsorger. Diese Fähigkeit haben wir einfach nicht. Wir können nur Wasser zur Verfügung stellen*" (Interview NBC Defence School, 2015). Although the Austrian RC states that issues related to toilets are a question of hygiene, which would actually be part of their mandate, their action does not reach beyond the possibility to raise awareness or to take charge for the provision of sanitation facilities (Interview Austrian RC, 2015).

Answers on wastewater disposal were controversial at a few points during the interviews. Most often the interviewees even decided to move to another topic and cut the edge somehow. Although the discharge of wastewater is not in the responsibility of many, it was mentioned as one of the main problems several times. The DWP Vienna, for example, perceives the provision of safe water not as a problem, but the discharge of wastewater from toilets. If the flushing of the toilets does not function, people will be directly affected though it is not often made a topic. "*Wobei […] das größte Problem [ist], so wie ich es sehe, nämlich bei den ganzen normalen Rohrabschaltungen, [wenn] die Leute […] jetzt gar keinen Kaffee mehr kochen [können], ich kann nicht duschen gehen, praktisch nie hör ich ‚wie das Klo funktioniert nicht?'. Wobei, ich glaube, das ist sogar das Hauptproblem. Da ist mir eigentlich die Wasserqualität relativ egal*" (Interview DWP Vienna, 2015).

Crisis communication

A decision-making process without the inclusion of every single business becomes unimaginable due to our interconnected network and expertise (Levy & Bissell, 2013). Those include governments, municipalities, Armed Forces, non-governmental organizations, economic and scientific institutions, private and public providers and consumers to name only a few (Cooper et al., 2004; Hohl et al., 2012). The inclusion of experts of critical infrastructure was mentioned as highly important since they have a central role in the prevention and response mechanisms in case of a disaster (Hohl et al., 2013). At the time of Hurricane Katrina (2005), USA, a lack of coordination and communication between the different stakeholders was easily observable proving that a risk assessment and a response plan are necessary, but also require adaptation to the circumstances (Ruback et al., 2013).

Communicating with a variety of experts on the identification of risks and possible disaster responses is done by a combination of approaches in order to assure a variety of perceptions (WHO et al., 2013). The experts create an extremely complex environment with different opinions and experiences, where it takes a lot of time and patience before one comes to a solution or agreement (Cooper et al., 2004; Hohl et al., 2012). Cooperation between different stakeholders is essential for any analysis and decision. Different groups are needed at different times and for different tasks because of the unique nature of catastrophes (McEntire, 2013). For example, before the Armed Forces approach the disaster scene, it is the first responders who are the first ones to arrive. Therefore and because they often know their habitat better than people coming from the outside, they need to be involved. They can support or reject decisions and help in the solution finding process. They can look beyond the guidelines, define structures and bring creativity into the process (McEntire, 2013).

The Austrian Civil Protection Association (ACPA) (Österreichischer Zivilschutzverband) is an organization that actively includes the population and tries to improve their resilience, which will have a positive feedback on the rescue teams and allows more time for coordination. Therefore, it is even more surprising that the ACPA has only been mentioned by the interviewee of the Austrian RC, but not by the others. Their task is to inform the population about the correct behavior in emergency situations and about civil defence; to promote self-protection behavior through events, presentations and speeches; to coordinate different associations; to seek collaboration with the ministries and emergency organizations; and so on (BMI, nn; Staudinger, 2015). The ACPA even published a short “blackout” brochure, which was not mentioned by one of the interviewees and found by surprise. This allows room for stronger cooperation as it was mentioned by the Austrian RC themselves, who agreed to promote each other and to work together as much as possible. “*Wobei es eigentlich die Kernaufgabe des Zivilschutzverbandes ist, das zu machen, wir aber natürlich auch das Thema Vorsorge, Resilienzaufbau mitbetreuen und in diesem Bereich auch sehr gut, sehr eng mit dem Zivilschutzverband zusammenarbeiten. Man muss ja das Rad nicht immer neu erfinden, denn wenn es eine Bevorratungsliste des Zivilschutzverbandes gibt, dann können wir die genauso promoten und sagen ‚das bitte vorraten und weitere Informationen gibt es auf der Website des Zivilschutzverbandes‘*“ (Interview Austrian RC, 2015).

Equally important is the international communication and cooperation. The European Union, for example, acts as an umbrella organization for the Member States. It cannot only be addressed for help and guidance, but may also spread an emergency request to the Member States decreasing the work load of the single state. “*[…] Wenn wir so eine Situation hätten, würden wir nicht nur bilateral tätig sein, sondern wir würden uns einfach an die europäische Union wenden. Und halt fragen, und auch um Hilfe in dem Sinne suchen*“ (Interview MOTI, 2015). “*Der Sinn der Sache ist, dass einerseits Ankara nicht zig Staaten ansprechen muss, sondern die gesamte Europäische Union anspricht. Und innerhalb Europas und auch innerhalb Österreichs vernetzten wir uns*“ (Interview MOTI, 2015). Depending on the severity of the disaster or as soon as the region or country cannot control the disaster response by itself, which they find out usually the latest within a week, outside help is requested (Levy & Bissell, 2013).

Even for industrialized countries a catastrophe such as water outages cannot often be regulated without outside assistance. In that case plans and protocols for integrating assistance are of high importance to assure quick and coordinated response (Ruback et al., 2013). Since 1992, Austria has concluded around thirteen bilateral treaties with countries from within and outside of the EU such as Germany, the Principality of Liechtenstein, Hungary, Slovenia, Slovakia, Czech Republic, Switzerland, Jordan, Croatia, Morocco, Albania, Moldavia and the Russian Federation. The agreements shall act as disaster support agreements and shall assure collaboration in case of preventive actions and combat of disasters such as guidelines on the provision of contact points; the ease of border movements for disaster support teams, aid resources and machinery; disaster relief; cost division; and common training requirements (BMI, nn). Cross-border support, however, strongly depends on the extent of the blackout. If it affects whole areas of Europe, cross-border support may be limited. If only Austria or wider areas in Austria are affected, help could come from Prague or Budapest to the Austrian cities (Interview MOTI, 2015).

To sum up, the power grids are nowadays more specialized and advanced than ever before, which likewise increased the vulnerability of people to electricity failures (Levy & Bissell, 2013). Though the perception and likelihood for a risk differs between stakeholders, natural, societal and technological causes are not as unlikely as often assumed. The division of tasks, responsibilities and capabilities can be especially helpful if disasters are too complex to assure response by one group or if resources are limited (Nakashima et al., 2014). A “bottom-up” approach” is recommendable, even though it is more time consuming and can be more expensive. It allows better understanding and fosters collaboration, development and coordination within and between all levels (Levy & Bissell, 2013). An integrated risk communication plan can increase awareness and empathy towards application of precautionary measures and help to maintain a certain living standard (Government of Canada, 2003).

The difficulty of all causes for water and power outages provided is that the named hazards are naturally occurring and are often out of reach of human control. Municipalities have the responsibility to prevent disaster, but also to coordinate the local response. They rely on the support of first responders, who though may in the worst case even hinder an effective response if tasks are not assigned appropriately. On the other side, the Armed Forces follow primarily a military responsibility and are not a disaster response team. Hence, in order to complement the existing disaster response structure, the implementation of a THW, that similar to the RC works voluntarily, could be negotiated. The main difference is that the experts of the THW are trained in different critical infrastructures and are in detail selected depending on their knowledge and experience. However, with one more additional group, it also has to be assured that more stakeholders do not lead to more confusion and uncertainty.

5. Assessing the effects of power and water outages

Power outages happen on a regular basis, blackouts definitely do not. Yet, they are not as uncommon as it may seem. In 2003, a blackout stroke from Ohio across the northeast of the USA and as far as Canada affecting more than fifty million people and disturbing the critical infrastructure including the water supply (Chang, 2009; Shinozuka & Chang, 2004). The power was cut for eight to nine days in the region due to a software bug and cost one to two billion Canadian dollars solely for Ontario in Canada. The main problems were the refilling of backup systems with fuel; the congestion of the telephone lines, while the phone system was quickly available again due to the use of batteries; and the connection wholes of the internet; while printing machines continued working because backup systems were used. Also television stations continued broadcasting, though many recipients in the critical area were not able to receive the information. This is compared to radio stations, which continued airing and were received by many recipients who equally used battery equipment (Petermann et al., 2011). Also Europe has already been affected by blackouts. In 2005 a snow storm in central Germany caused a blackout for around a week. A combination of snow, ice and increased wind force caused the electrical grid to loose hold underneath the weight (Bundesheer, 2012).

The effects of a water and power outage range from contaminated water and water-borne diseases, disrupted communication, unpredictable social behavior and halt in information exchange. In an impact assessment a distinction is made between tangible and intangible impacts, and direct and indirect impacts. The primer will not be further discussed here since they require an economic approach categorizing the impacts according to the costs produced. The second categorization differentiates between direct and indirect impacts on the water system depending on time and area that is hit by the disaster.

Table 3 gives a short overview and idea on the effects of a blackout, while additionally expressing severity, controls in place and actions planned. Indirect impacts such as (1) the halt of pressurized water due to a loss of pumping stations; (2) the loss of access to safe drinking-water; (3) a lack of water for sanitation and hygiene such as through contamination; (4) the halt of wastewater treatment; and (5) a lack of preparatory measures in order to react to a water outage are more difficult to define and harder to estimate (Chang et al., 2008).

Table 3: Impact assessment on the effects of a blackout

Effects	Inherent assessment		Controls in place	Action planned
	Impact	Likelihood		
Halt of water pumps	Medium	Medium	Backup systems; gravitational flow	High-storage water tanks; self-efficient energy
Loss of access to drinking-water	High	Medium	Open-source water; bottled water	Water storage; Distribution of filters; public/ private partnerships
Lack of water for sanitation and hygiene	High	Low	Open source water	Water storage
Halt of wastewater treatment	Medium	High	Backup systems	Self-sufficient energy
Lack of preparatory measures	High	Medium	Brochures	Workshops, conferences, etc.
Halt of telecommunication	High	High	Backup generators; direct comm.	Distribution of leaflets; advanced planning
Distorted daily life	High	Medium	Communities; information	Strengthening resilience

Source: Own description according to Keegan (2004) and Van Leuven (2011)

The water sector is often indirectly affected either through a cascade of events leading up to the contamination of water or the leakage of a water pipe, or by threatening adequate healthcare in hospitals and hygiene at home (WHO et al., 2013). These are often unpredictable and complex consequences of direct hazards (Laugé et al., 2013). Effects are also influenced by the hour of the day, the day of the week, the season of the year and the current weather. While in summer a higher amount of electricity is needed for cooling, the same is the case for heating in winter. A blackout occurring over a small area receives quickly help from within the country as well as from neighboring countries. The wider the area is the more difficult will it be to build up the electrical flow again or to provide support (Hohl et al., 2013).

Direct impacts of a blackout include (6) the halt of telecommunication and (7) the distortion of daily life. It may harm the water availability, quality and treatment, but also the communication between stakeholders to organize water provision and with the population to provide assurance and confidence in a quick repair of the problem. If this is not assured social upheaval and aggression are not unlikely. The mentioned aspects are discussed below considering their intrinsic connection to water provision and a power outage.

5.1. Effects of a blackout on water availability, quality and treatment

"*Wobei ich glaube, dass gerade in Österreich bei einer Blackout-Katastrophe das Trinkwasser nicht das Problem ist, weil das Trinkwasser ist ja vorhanden. Also Wienerhochquellwasserleitungen, zum Beispiel. Also Wien wird relativ gut mit Trinkwasser versorgt sein. Aber wenn der Strom ausfällt, dann wird's halt andere Gegenden geben, wo das nicht so ist. Dort kann man sich aber behelfen, dass man Wasser dorthin transportiert. Oder auch Flaschenwasser verwendet. Aber natürlich das Abwasser ist ein Problem*" (Interview Austrian RC, 2015).

The most direct effect a blackout can have on drinking-water provision is a halt of mechanical work. Water is in general pumped from raw water sources to consumers and to especially those consumers living in multi-story buildings or up on hills (Levy & Bissell, 2013). Even if water flows by gravitational force coming from the mountain springs disruptions may take place on its way or within the city (City of Kobe, 2010). The first impression when talking to different stakeholders is that there is no risk for the Austrian water sector. Even if there is no gravitational water flow other means will be found to assure a constant and safe supply such as by high-level water tanks or bottled water (Interview Austrian RC, 2015).

Figure 8: First and second Mountain Spring Pipeline for Vienna's water supply

Source: Wien.at (nn a)

Vienna is lucky to have a profitable geographic location for an independent and a constant water supply. It is considered a rather hilly city for a water system with height differences of around 150 meters from Transdanubien and almost 500 meters to Kahlenberg causing a slight from the east to the west and so to Vienna. It is furthermore blessed by two water systems that retrieve their water from springs from the mountains that are not only naturally safe and of high mineral content, but can be retrieved without any electricity (OVGW, 2015a). The First Main (1. Wiener Hochquellwasserleitung) reaches from lower Austrian Kalk Alps (Rax, Schneeberg, Schneealpe) to Vienna and the second one is fed from the Hochschwabgebiet (Figure 8). In between are several reservoirs that store water and pass it on with a different pressure downwards through the pipes (Interview DWP Vienna, 2015). Anyhow, not all areas of Vienna, approximately five percent, as well as other regions in Austria are that blessed with gravitational flow and rely on pumps. "*[…] Das Wasser rinnt von den Quellen* *selbsttätig nach Wien und die Behälter stehen so hoch, dass das nahezu das ganze Stadtgebiet auch wieder gravitativ versorgt werden kann. Ja, es gibt einige wenige Gebiete, die wir nicht schaffen. Das ist der Wienerwald, das was oben ist. Wenn man es aber dann wieder von der Bevölkerung her sieht, […] das sind maximal fünf Prozent, die wir nicht gravitativ versorgen können*“ (Interview DWP Vienna, 2015).

High-level water storage tanks can substitute a water provision in case of a blackout. However, the water storage tanks have a limited capacity and can only supply the population at locations below the tank, but not at the higher areas. And even once the tanks are empty, which usually takes around two days, immediate reaction is needed to find alternative solutions (Interview NBC Defence School, 2015; Interview DWP Vienna, 2015). Bad Fischau receives its water from water reservoirs that are filled with water from deep wells, which always rely on electricity to pump up water from the underground and to the population. “*[…] Das Wasser kommt ja fertig ins Netz und kommt von dort mal runter vom Hochbehälter und muss aber in das Viertel, sag ich, aufgepumpt werden*“ and “*Das ist ein Tiefbrunnen. In Föhrenwald ist ein Tiefbrunnen, der ist […] sechzig Meter tief, aber die Pumpen hängen bei 37 Meter. Und die fördern das Wasser jetzt über die AOP-Anlage. Da steht das. Und dann kommt’s vom vorderen Behälter wird’s dann von draußen bis zur Kontaineranlage [gepumpt], [da] sind auch Pumpen drinnen und die Pumpen es dann in den Hochbehälter. Und vom Hochbehälter in eine eigene Leitung, in eine Förderungsleitung für‘s Netz kommt das Wasser dann wieder retour, fertig aufbereitet*“ (Interview DWP Bad Fischau, 2015). The pumping of water requires the most electricity in the whole water system, which makes it even more dependent to electricity (Figure 9) (Petermann et al., 2011).

The loss of drinking-water or a water outage is defined as the number of days an individual lives without water though a water supply system is or had been in place (Chang et al., 2008). This can be a loss characterized in the physical availability of water or as a loss of potable drinking-water. Loss of drinking-water quality is especially of importance since it affects the health of the whole population and not just a few. Preventive and control measures are of high importance to contain epidemics and from an organizational point of a few to assure a low amount of people requesting medical aid during a blackout (Bissell & Kirsch, 2013).

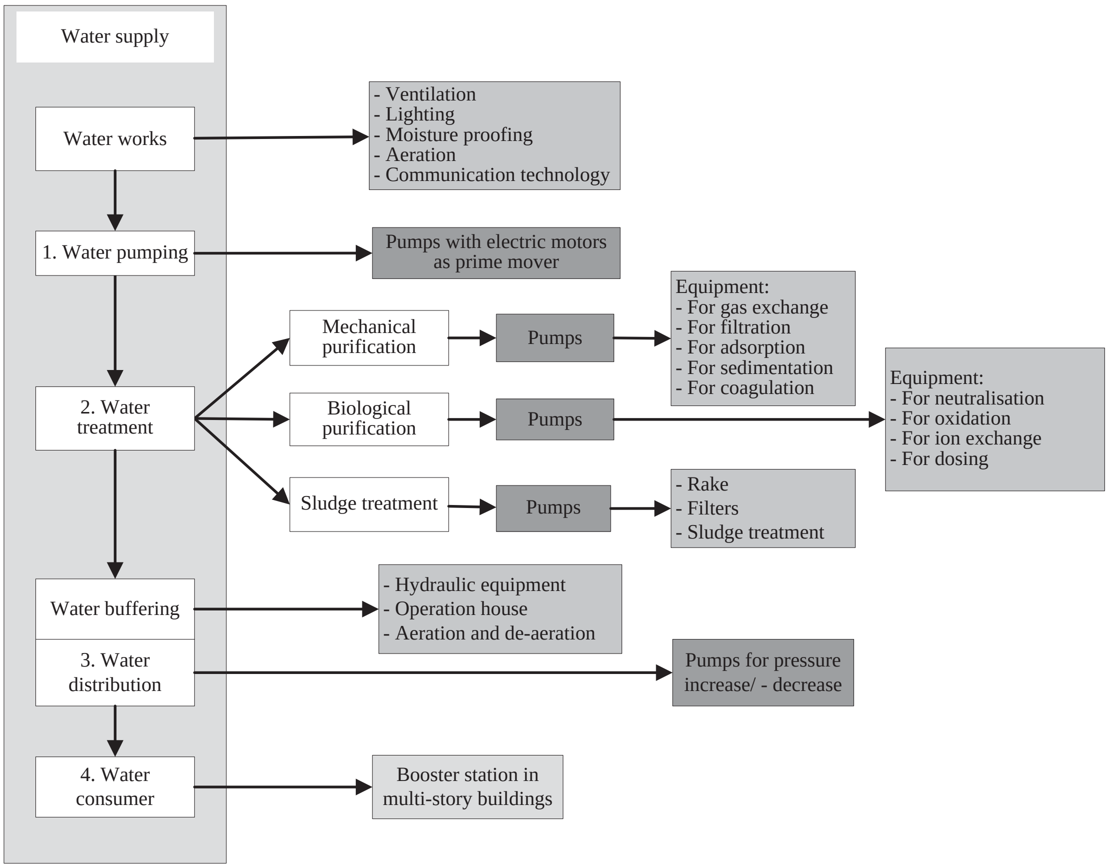

Figure 9: Technical elements in the water supply and the electricity dependency (electricity dependency: white: none; light grey: low; medium grey: medium; dark grey: high)
Source: Adapted according to Petermann et al. (2011)

An interruption of the water flow can cause dehydration if not enough water is consumed or infectious diseases if hygienic behavior cannot be followed. At the same time, the consumption of water from open-sources or otherwise water that is contaminated may cause diseases such as diarrhea, infectious diseases and water borne and water-washed diseases, including gastroenteritis and respiratory tract and skin infections due to a lack of hygiene (Huang et al., 2011). Waterborne droplets transmitted through the air can equally cause influenza (Bissell & Kirsch, 2013). Additionally, the author Mark Elsberg mentions in his novel the subordinate clause that "the problem of hygiene is going to escalate within the next hours" if the population cannot run their toilets (Elsberg, 2012). Subsequently, a water outage may threat the fulfillment of the Millennium Development Goals (MDGs), namely target 7.C "halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation" (WHO et al., 2013).

During the Northeast blackout in the USA in 2003, increased incident of gastrointestinal diseases have been observed in New York City (Beatty et al., 2006). Additionally, Huang et al. (2011) found out that the amount of Taiwanese patients with gastroenteritis, skin diseases and eye diseases increased over the period of a local water outage compared to the time before. The number is even assumed to be low because the population in Taiwan is used to boil water before they drink it. Hence, other sources for infections are assumed to be microorganisms on food, eyes and cuts on the skin as they were practicing less often personal hygiene due to water scarcity (Huang et al., 2011).

If water is taken from open sources and is not cooked in advance, problems with digestions are likely to go as far as epidemics since toilets and so hygiene are not possible as people are used to (Bundesheer, 2012). In case of a water outage, the water quality needs to have high priority. Emergency drinking-water providers such as the Armed Forces refer to national and international drinking-water guidelines such as the one of the WHO, which is a widely used reference report setting requirements for safe water by assuring public health. The most recent WHO publication on drinking-water quality is the third edition of the "Guidelines for drinking-water quality" from 2004, published and updated on a rolling basis since 1958 by the WHO. This edition develops concepts, approaches and information, including the comprehensive preventive risk management approach for ensuring drinking-water quality, and intends to support the development and implementation of risk management strategies that will ensure the safety of drinking-water supplies (WHO, 2011). A special trained expert on water analysis and quality of the Armed Forces has to observe the different guidelines when investigations take place in the laboratory or in the field, of which the latter may have a slightly lower quality. "*Und da spielt auch ein großer Teil die Wasseranalyse, also das*

Qualitätsmanagement eine Rolle. Beim Bundesheer gibt's da eine eigene Ausbildung zum Wasserhygienefachorgan, damit eben in Notfällen, Katastrophenfällen das Wasser recht hohe Qualitätsansprüche hat. […] Das Wasser wird bei uns wirklich analysiert, auch feldmäßig, natürlich nicht in derselben Qualität wie ein stationäres Labor, das da nichts anderes macht, aber in ausreichender Qualität um grundsätzlich den gesetzlichen Bestimmungen Genüge zu tun" (Interview NBC Defence School, 2015).

The treatment of water from open sources in case of a water outage is essential for several reasons, but not always without difficulties. Harmful bacteria that contaminate water as a result of natural disasters or terrorism attacks do not need to be visible, yet causing severe harm sooner or later in time if consumption continues for a longer period of time. "*Nicht jede Verschmutzung ist sichtbar, was für die Bevölkerung gefährlich werden kann […]. Wenn das Wasser dann getrunken wird, muss es nicht sofort zu Krankheiten kommen, sondern die verzögern sich dann über mehrere Jahre. Wenn dann jemand 50 Jahre später stirbt, stellt man nicht unbedingt eine Verbindung zu verschmutztem Wasser her. Die Keime und Bakterien hatte man schließlich nicht sehen können*" (Interview NBC Defence School, 2015). The amount of contaminated water consumed is quantified and follows the base line according to livelong water consumption. This means that a low water quality may be consumed as long as it is for a short period of time of maximum thirty days; required for body functioning and so to do tasks; causing no side effects such as hallucination due to turbid water; and causing no long-term toxic effects. In that case the quality of water is of secondary concern and has no priority. Nevertheless, a water test always needs to be conducted within those thirty days in order to prevent harm thereafter. In order to prevent early on contamination a field analysis is done, which takes up to two hours, while the rest of the sample is send to the laboratory for detailed investigation. "*Und weil man einfach feldmäßig nicht die Möglichkeiten hat eine große Pestizidenanalytik durchzuführen. Das dauert einfach, das braucht Zeit. […] Und die kann ich im Feld untersuchen, mehr oder weniger in Echtzeit, plus minus zwei Stunden, geh ich hin, nehm die Probe […]. Und dann werden die Proben eingeschickt. […] Wenn dann nachher rauskommt „nein", dann muss ich mich wieder versetzen, aber ich habe, 30 Tage […]*" (Interview NBC Defence School, 2015).

An example for when the drinking-water standards could not be followed was applied by the Armed Forces in 2000. The population in Mozambique did not accept the chlorination of water due to its specific smell and taste, wherefore the chlorine added had to be reduced below the already enforced low amounts. This response was only temporary and so over a short period of time, wherefore the population was exposed to no harm (Interview NBC Defence School, 2015). A similar case occurred in Austria, when the chlorinated water provided by the RC was not accepted by the population due to its smell and taste. As a result, the Armed Forces had to step in and treat the water differently. "*In dem Fall hat das Österreichische Rote Kreuz wie üblich das Wasser ebenfalls mit Chlor desinfiziert, was den Bewohnern geruchlich und geschmacklich nicht gepasst hat. Somit mussten wir einschreiten und haben die Trinkwasseraufbereitung übernommen*" (Interview NBC Defence School, 2015).

While preferences in taste can easily be straightened, differences in perception on effects of a water outage such as on the wastewater disposal are not that easy to overcome and differ between population groups and the stakeholders interviewed. Awareness on the connection of the plant to the electricity grid exists, but has not yet been considered as threatening. It was stated that (1) so far only short-term power outages occurred; (2) the overall electricity demand is low; and (3) the plant is connected to several power grids, which allows switching if needed and increases the threat of a power cut (Interview WTP Vienna, 2015). The latter was actually described as one of the threats to the electrical systems in Chapter 4.3: the high-connectivity and the fall out of an energy grid causing all providers to switch to another one that may not be able to respond to the suddenly high demand. Furthermore, the bigger the wastewater treatment plant the higher is the demand for electricity. And the closer to the morning or evening hours the higher the inflow into the wastewater treatment plant and so the higher the electrical demand. During these peak hours the system is used to up to ninety percent for three to four hours, while during the day or in the case of specific seasons and holidays only around thirty percent of the population produce wastewater. "*Sie müssen sich vorstellen, wenn das untertags passiert, sind vielleicht auch nur, nicht* *einmal die halbe,… vielleicht ein Drittel von der ganzen Bevölkerung benutzt dann ein Klo. [..] Da gibt es schon diese gewissen Stoßzeiten, wo eben wirklich dann vermehrt alles genützt wird, sowohl Wasser als auch Abfluss. […] Mittags vielleicht nicht, vielleicht mittags eher 70 Prozent, aber in der Früh und Abends kann man sagen ist [das komplette System zu] 90 Prozent drei bis vier Stunden, genützt […]*“ (Interview WTP Laxenburg, 2015).

Subsequently, not only drinking-water, but also wastewater transmission and treatment need electricity (Figure 10). The wastewater treatment plant in Vienna consumes around one percent of the total energy use in Vienna, which is low for developed countries, but in general a big amount (Gude, 2015; Interview WTP Vienna, 2016).

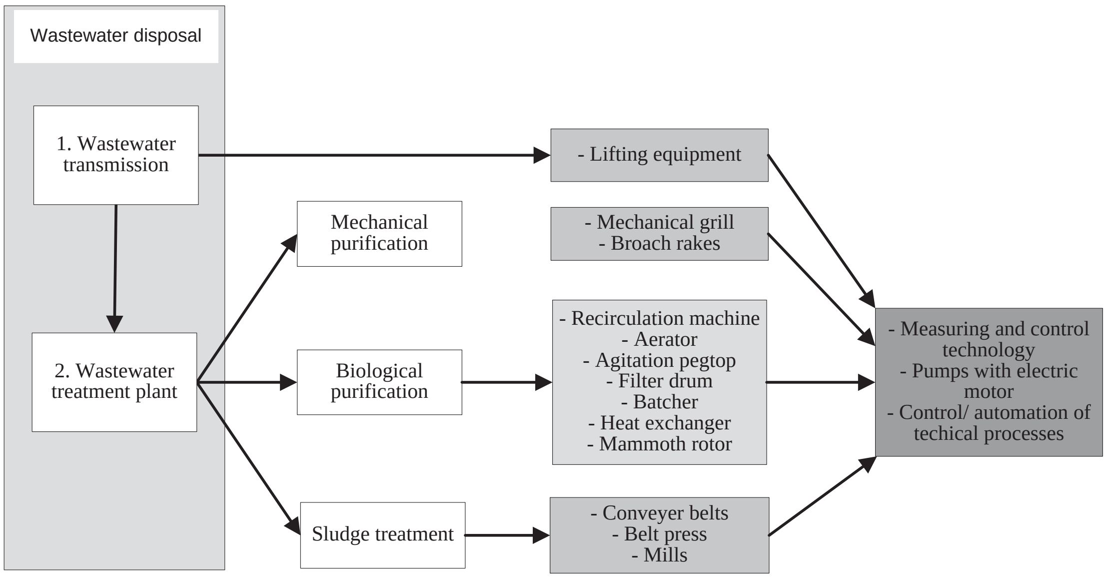

Figure 10: Wastewater disposal and its electrical dependency (electricity dependency: white: none; light grey: low; medium grey: medium; dark grey: high)
Source: Adapted according to Petermann et al. (2011)

Most of the energy is used to pump the wastewater between different heights, which is especially the case for long distance pipelines that rely on several leveling throughout the way. The motors of the pumps require most of the energy with eighty percent of the total energy consumption by the wastewater treatment plant. Gravitation decreases the demand immensely and allows the wastewater to flow independent of energy availability, if the city is constructed on a certain height with the wastewater treatment plant at the lowest point (Gude, 2015). "*Als normal Sterblicher stellt man sich immer vor, man drückt auf's Klo und das Abwasser rinnt in den Kanal und das rinnt dann von selbst weg. Aber so ist es nicht, weil über… große Distanzen kann man zwar ein Gefälle einbauen, aber nicht über hunderte oder etliche Kilometer. Daher muss man einen Niveauausgleich machen. Und den Niveauausgleich macht man so, dass man eine Pumpenstation einbaut. Also das heißt, das Wasser fällt noch tiefer runter, wird dort gesammelt. Und bis zu einer gewissen Hohe, wo der Schacht dann voll ist, fängt die Pumpe wieder an und pumpt diesen Schacht wieder leer und die pumpt das wieder auf ein neues Niveau*" (Interview WTP Laxenburg, 2015).

Secondly, electricity is necessary for the treatment of the wastewater. During the time of the Romans, water was treated via the movement of water over stones, which enhances the amount of oxygen available for biological degradation. Nowadays this movement is conducted electrically, wherefore once the power is out the hydraulic and so the water treatment process would also come to a halt (Interview WTP Laxenburg, 2015). During the northeast blackout in the US, the backup generators of the wastewater treatment plant failed to work, wherefore over 1.9 billion liter untreated sewage floated into the recreational waterways surrounding the affected city. This posed danger to the health of the population and their environment, wherefore the area had to be closed to prevent infections (Beatty et al., 2006). The Danube would be threatened by a similar case. The wastewater treatment plant in Vienna does not currently own a backup generator or any other energy source to assure the mechanical and biological treatment of the wastewater before it is released into an open water source.

Given the unpredictability of the disaster causing the blackout and water outage, chemicals, toxins, oils and solid wastes could be included in the wastewater making any kind of treatment even more difficult. The effect would be a high amount of toxins such as ammonium and phosphate flowing into the open water source killing fish and increasing the amount of algae, which take up a lot of oxygen. "*Ammonium ist ein*

Fischgift, ein totales. Alle Lebewesen in den Bächen würden sofort absterben. Die schlechten Bakterien vermehren sich im Grunde. Vermehrt Phosphate werden herausgeschwemmt. […] Phosphat ist ein Düngemittel, überdüngt das Gewässer, das heißt die Algen würden wachsen […]. Man würde sich aber gegenseitig umbringen, weil es den Sauerstoff wegnimmt“ (Interview WTP Laxenburg, 2015).

Fortunately in case of an immediate blackout when the plant would come to a complete halt the good bacteria would at least continue treating the water until the point when all good bacteria die due to the lack of oxygen. They can usually survive for a minimum of two to three days without an addition of oxygen, but everything beyond this time would be deadly. “*Weil die Belüftung ist das einzige, was funktionieren muss und diese mechanische Vorreinigung, wo eben die groben Stoffe herausgefiltert werden. Aber es muss gegeben sein, dass eine Belüfterwalze […] Sauerstoff einbringt. […] Man braucht Sauerstoff. […] Also ich glaube das braucht schon, für diese Bakterienmasse, die sich hier in der Kläranlage befindet, zwei, drei Tage, mindestens. […] Bis das alles dann tot ist. Und bis da wirklich kein Sauerstoff mehr drinnen ist und alles stirbt*“ (Interview WTP Laxenburg, 2015).

5.2. Disrupted communication

Communication plays an essential part in risk management and should be considered in all stages of a risk assessment as displayed in Figure 2 (Chapter 2.3) (Keegan, 2004). It contributes to an exchange between stakeholders and the population and helps to understand risks and trade-offs leading to a wide-range of acceptance on both sides. Routine reporting and communication within organizations and among stakeholders facilitates the identification of changes that will affect the risk profile (Cooper et al., 2004). Communication has to take place in three levels, which will be looked at in more detail in this chapter: (1) within an organization; (2) with national and international organizations including public and private organizations; and (3) with the general public.

A variety of communication means such as television, the phone, the internet and radio broadcasting connect the different levels with each other. It is one of the few sectors that are almost 100 percent reliant on electricity, which makes it the most vulnerable critical infrastructure in case of a blackout. Moreover it is also the most important one when it comes to exchange and consultation before and during a disaster. Alternative options are direct communication or written posts, which are yet slow and do hardly reach the masses (Petermann et al., 2011). In order to communicate properly and effectively, exchange should have taken place before the power and water outages.

The RC is a positive example with regard to preparatory and preventive internal as well as cross-border organization and communication. The Austrian RC is the umbrella organization of the regional RC organizations that are spread all over Austria. The regional organizations are the first responders in case of a disaster and act regionally as far as possible before contacting other national RC organizations within or outside of Austria. The regional organizations have additionally to the daily first aid teams, their own disaster support and disaster protection units, which have the same structure and knowledge throughout the country. Provinces and borders do not exist in the classical sense, but the institution acts as one, prioritizing help and support. In case a disaster crosses borders, the European Union Protection mechanisms can be contacted by the Austrian RC and all other EU members (Interview Austrian RC, 2015).

The Austrian RC is also part of the so called "Stabsführungsverfahren" within the governmental crisis and disaster protection management (SKKM), which has been created in 2007 for Austria. It constitutes of three levels that consists of a variety of stakeholders including the fire brigade, the Ministry of the Interior, the Armed Forces and other disaster rescue organizations, who come together in case of a disaster. They are all specifically trained in the "Stabsführungsverfahren" in order to assure that "everyone speaks the same language". "*Und auch andere Organisationen wie Feuerwehr, wie das Innenministerium, das Bundesheer, andere Rettungsorganisationen arbeiten in diesem Stabsführungsverfahren auf das man sich geeinigt hat und so hat man eben ein gutes Maß an Interpolarität geschaffen, dass sich die Organisationen dann untereinander im Führungsverfahren verstehen. Also man spricht dieselbe Sprache*" (Interview Austrian RC, 2015).

Nevertheless, not all actors are part of the "Staabsführungsverfahren", which makes communication not less difficult when the energy is out and volunteers and the public need to be reached. For example in Germany, the water sector by itself already counts around 6200 suppliers. These are very heterogenic in customers and location and have different perceptions on risks and effective crisis management (Petermann et al., 2011). An exchange enhances the effectiveness of risk management knowing functions and responsibilities and the priorities set by the individual partner as well as assuring an all-round knowledge within an organization and among different levels on approaches and actions. For example, if one stakeholder identifies a new effective controlling mechanism all others may equally profit from it and should be informed (Keegan, 2004). In the words of the Austrian RC: "There is no need to reinvent the wheel" ("*Man muss ja das Rad nicht immer neu erfinden*") (Interview Austrian RC 2015).

The international Sendai Framework for Disaster Risk Reduction promotes this exchange between all levels including the public and private sector, civil society organizations as well as academia, scientific and research institutions and businesses. All stakeholders should create opportunities for collaboration and for the integration of risk management into their practices (UN/ISDR, 2015). Organizations should encourage exchange with partners that interlink with their own. This can prevent misunderstandings of risk priorities and increase trust knowing if and how the partner has set up its risk management. This is important nowadays when there is a high interdependency on the support and knowledge of one or the other (Keegan, 2004). Furthermore, a priori exchange can improve collaboration in case of a blackout, when direct communication is not or only limited possible. The communication network might not work due to the lack of a backup system, but also due to an overload, when everybody tries to get in touch with each other (Levy & Bissell, 2013). Cell phones are used by almost everybody in industrialized countries, wherefore a blackout would hit the softest spot.

"*[…] Von den […] Telekommunikationsunternehmen, liest man immer wieder Zahlen, dass das Handynetz bis zu 72 Stunden aufrechterhalten werden kann. Ich bin nicht so optimistisch, dass es noch eine halbe Stunde funktioniert. Ich bin überzeugt,* *dass es schneller geht, dass das Handynetz zusammenbricht, nicht weil die Handymasten keinen Strom mehr haben, sondern weil so viele Leute ins Netzt gehen, dass das Netz von sich aus auf Grund der Überlast zusammenbricht*" (Interview WTP Vienna, 2015). The interviewees from the wastewater treatment plant in Vienna and DWP Vienna agree that communication will be one of the main problems in case of a blackout. Telecommunication providers believe that the mobile net will last for up to three days, while the WTP Vienna is convinced that after thirty minutes the lines will be dead due to overload. Nevertheless, everybody relies on mobile phones though they will be one of the first ones to loose connection during a power outage. "*Wo wir sicher Schwierigkeiten haben werden, das liegt auf der Hand, ist dann die Kommunikation. Wir sind momentan relativ Handy-fixiert, obwohl wir auch Funkkommunikation haben, aber das verwendet keiner, weil das Handy einfach so praktisch ist. Also wie wir so aus unseren Beratungen heraus wissen, das Handy ist dann eines der ersten, das wahrscheinlich dann nicht mehr funktioniert*" (Interview DWP Vienna, 2015). In the end nothing will help, but radio communication or walking, driving or cycling to people depending on what is available and possible (Interview DWP Vienna, 2015).

Smaller cities definitely have an advantage when communication is disrupted. They seem to have fewer problems with internal communication, inter-communication and are also less dependent on electrical communication. In the case of the villages Laxenburg and Bad Fischau, for example, communication between people and volunteers was not mentioned as a problem. Everybody knows each other and most often many people are in the same working group or somehow involved in the same response team, which simplifies communication a lot. "*Und da gibt es eben drei Leute, die sind genau für das zuständig und die, die organisieren das alles. Also wir wissen ganz genau, was wir machen müssen und wo es draufankommt und…*" (Interview WTP Laxenburg, 2015). "*Wir haben keine Berufsfeuerwehr, wir haben lauter Freiwillige. Und das sind alle von da. […] Der Großteil von der Gemeinde ist sowieso verpflichtet. […] Und die Berufstätigen, wenn sie nicht so viel haben, rennen die auch mit. Und so glaub ich, wird's kein Problem geben*" (Interview Bad Fischau, 2015).

The Austrian RC confirms this faith in the population by saying that the readiness to help others even increases in disasters. "*In der Katastrophe steigt die Hilfsbereitschaft der Menschen enorm an*" (Interview Austrian RC, 2015). Such a conclusion can be drawn from the flooding in Austria in 2002 and 2013, when the population was described as excited being able to help. Communication and especially mass media communication contributed immensely to this success. Radio stations, television programs, the internet and social media were strongly used to share pictures and information on the developments in the crisis regions overwhelming the population with news, donation notifications and emotions. Social media such as facebook especially improved public communication due to the personal contributions and often even the quicker distribution of news than the classical news media stations. "*[…] Ab dem Zeitpunkt, wo diese Katastrophe medialisiert wird […] und sie emotionalisieren natürlich auch die Bevölkerung. Und da ist man mittlerweile durch die heutige Technik viel, viel schneller also noch vor 20 oder 25 Jahren, also die Bilder aus dem Katastrophengebiet kommen viel schneller flächendeckend an die Leute, also das heißt über Radio, Fernsehen, Internet, wobei ich glaube mittlerweile gerade auch die sozialen Medien spielen eine wesentliche Rolle. Sie sind noch wesentlich schneller teilweise als die klassischen Medien, weil dort nicht nur unbedingt Nachrichten sind oder Journalisten über das Berichten, sondern die Bevölkerung selbst. Also in dem Katastrophengebiet, macht Fotos von Dingen und schreibt einen Text dazu und stellt das auf facebook und das ist dann sofort in ganz Österreich sichtbar*" (Interview Austrian RC, 2015).

The use of media seems in general a promising communication source for any crisis and is regularly used by rescue teams. On the one hand the population can be reached quickly in case volunteers or donations are needed. On the other hand, it is needed to inform the public about how to respond to the disaster, equally to reduce or prevent rumors and misinformation and to demonstrate good leadership causing calmness that things are being talked about. Any kind of exchange is essential to calm down people and to assure that no wrong information is shared causing panic. Facebook, Twitter and other forms of social media quickly and easily spread information and even pictures of people and disaster responders affected by the event without the consideration of any standard ethical code. Private information and wrong news can quickly spread and strongly influence the population negatively (Schwab & Beatley, 2013).

In the worst case such as in the case of a blackout, telephone and other electronic means may not function for long into the power outage. During the Kobe earthquake telephones and radio communication was interrupted because the lines were overloaded and broke down within the first hour of the disaster (Menoni, 2001). As a result the government tried to share information with the citizens by distributing newsletters and using the city's information service, facsimile and the media. Nevertheless, a quick response as it was requested by the public was not possible given the constraints and the constant change in needs and demands directed to officials (City of Kobe, 2010). Luckily though, public telephones continued working in the city, which were then occupied by rescue workers and coordinators to stay informed and exchange guidance (Menoni, 2011).

Public telephone boots and emergency telephones close to streets, in tunnels and in train stations are landlines that continue working since they are fed with solar energy or have an external energy supply receiving electric impulses. Phones that are charged with batteries, energy cache or backup systems can only keep up for another few minutes to eight hours. A better solution would be self-sufficient units such as rechargeable batteries, digital ISDN-connections, end-user equipment, DSL-router or analog telephones (Petermann et al., 2011). Satellite communication would be an alternative option for communication as it is used by the Austrian RC and DWP Vienna. It works for several days in stand-by and can even get in contact with telephones and mobile telephones as long as rechargeable batteries are available. "*Wir können als […] noch relativ lange über Kurzwellenfunk kommunizieren, mit unseren Landesverbänden. Wir haben unsere Funkgeräte, aber wenn ich die Akkus natürlich nicht mehr laden kann und irgendwann werden auch die Batteriekapazitäten der Kurzwellenstationen erschöpft sein, dann ist es vorbei*" (Interview Austrian RC, 2015). The transmission is assured via a station relying on electricity. Once this station is out of electricity, a foreign station could be contacted, but would be an expensive alternative option (Petermann et al., 2011).

Instead of electrical communication devices, other creative options need to be found on how to reach other rescue teams and the general public. This can be the distribution of leaflets via the bike, putting up signs in municipalities or making announcements via loudspeakers given that a few stakeholders still have fuel in cars. “*Jetzt etwas überspitzt, aber, wenn kein Strom mehr da ist […] dann muss ich vielleicht wirklich noch handgeschriebene Meldungen […] mit dem Fahrrad überbringen. […] Je länger er [der Stromausfall] dauert desto kreativer werden auch die alternativen Kommunikationsmittel sein müssen, damit man noch mit der Bevölkerung kommunizieren kann. […] So, zum Beispiel, gibt es das schwarze Brett in der Gemeinde, dort kann ich im Notfall an die Flipchart noch was mit dem Stift drauf malen. Solange ich noch Treibstoff habe, können Feuerwehr, Polizei, unsere Fahrzeuge, wenn’s einen Lautsprecher am Dach gibt zumindest noch Lautsprecherdurchsagen machen*“ (Interview Austrian RC, 2015).

Another point is that certain communication means are not accessible by all people during a blackout due to a few electricity islands and the misconduct to reach out to vulnerable groups such as migrants or homeless people before the disaster. They might not have access to electronic devices, wherefore other means need to be found to inform them and to make them more resilient. “*Resilienz heißt natürlich auch vulnerable Gruppen zu identifizieren und zu inkludieren und nicht auszuschließen. Zum Beispiel, Obdachlose. Wenn ich mich jetzt zu stark auf soziale Medien stürze, hilft das den Obdachlosen oft wenig, weil die keinen Zugang zu diesen sozialen Medien haben, das heißt ich muss auch irgendwie identifizieren, wie komme ich an diese Gruppen heran*“ (Interview Austrian RC, 2015). This matter is also recognized within the Austrian “National Progress Report on the Implementation of the Hyogo Framework for Action (2013-2015)” according to which the social media outreach in the country still needs to be improved to reach all people (Staudinger, 2015). This includes all groups within a nation, wherefore different approaches need to be applied, but also further research is needed. For example, immigrants need to be informed differently than national citizens.

They might use different information channels and require brochures in their mother tongue in order to overcome language barriers and cultural differences. “*Wie transportiere ich die Nachrichten richtig, so dass sie auch ankommen in dieser Community. Dann ist es natürlich ein Integrationsthema. Also bei den Integrationsgruppen gibt‘s meistens so eigene Communities, da reinkommen, Sprachenbarrieren, was auch immer. Also das ist ein sehr, sehr breites Thema, wo man, glaube ich, auch noch viel Forschungs- und Entwicklungsarbeit vor sich hat*“ (Interview Austrian RC, 2015).

Culturally sensitive projects need to be conducted regionally or sometimes even locally. The information shared with the population should be specifically assigned for the regional situation in order to be meaning- and helpful (Nakashima et al., 2014). This can contribute to a feeling of credibility to be concerned with the specific problems and create trust among the population, stakeholders and the ministries (Petermann et al., 2011). In this regard, a community-based approach should be prioritized to an organizational approach (WHO et al., 2013). When it comes to prevention, resilience and similar topics, the importance of communication and cooperation is undeniable.

5.3. Social upheaval and unrest

Water and power outages by themselves will not yet create a disaster, but the social perception, resilience and response contributes immensely to the effects. Our daily life is influenced by machines, equipment, computers, heating and cooling, communication and entertainment and so on, which a blackout would bring to an immediate halt. How such a halt would affect the behavior of people is marginally empirically analyzed. It is known that the feeling of not receiving any information and not knowing how long the water outage will last are especially of concern for people. A power outage causes stress and highlights the feeling of dependency, which may cause aggression and depression. On the contrary such a disaster can also lead to fascination and closer ties between neighbors and families (Petermann et al., 2011).

Once a water outage occurs, it can be equalized with a “cultural blackout”. Common behavior structures are questioned, order diminishes, preferences cannot be followed, expertise is unnecessary and inhibitions are lowered. This also includes sexual-aggressive behavior and crime when the known cultural structures fall apart and wide spread uncertainty takes over. According to Petermann et al., abnormal or deviant behavior is the least like behavior to be found among the population, while normal behavior including Ego strength and Ego weakness are most likely observable. This includes sticking to culture; active response and preservation of order; and rustic survival; but also excessive demand; and apathy and depression (Figure 11) (Petermann et al., 2011).

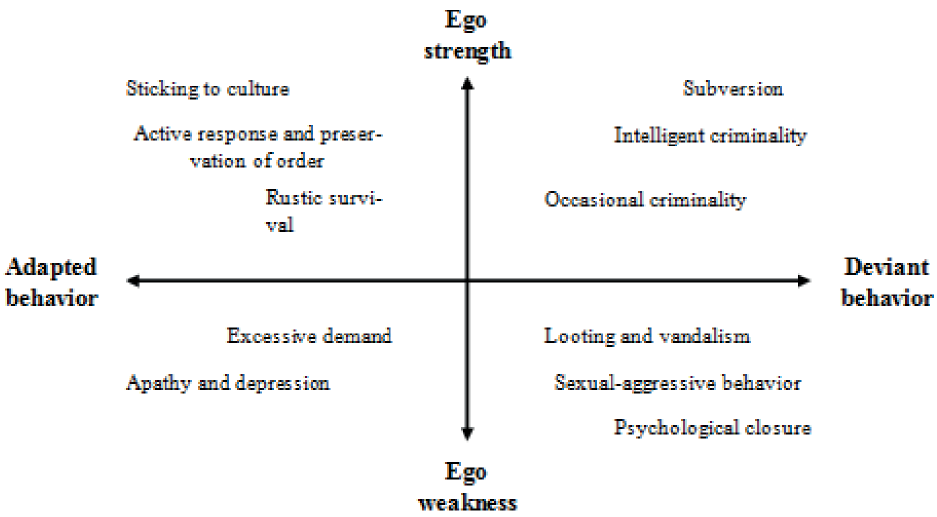

Figure 11: Four typical behavior types

Source: Adapted according to Vierboom & Härlen (2009) in Petermann et al. (2011)

Although a resilient characteristic (ego strength-adapted behavior) can have a positive influence on the situation, a blackout may contribute to social, human and financial loss and loss of income over the period of the disaster leading to depression. In case of a halt or delay in drinking-water supply and wastewater disposal of sanitary devices, people may be forced to leave their houses and apartments behind and seek shelter somewhere else, which may not be easy to cope with (Chang et al., 2009). “*Und* *die hygienische Situation wird dramatischer, so […] dass man einfach Wohnbereiche, Wohnhäuser evakuieren muss. Um eben Krankheitsausbrüche und Erkrankungen aufgrund der hygienischen Zustände zu vermeiden. Das ist natürlich schwierig, weil […] wenn der Wasserzulauf steht, steht auch der Wasserablauf*“ (Interview Austrian RC, 2015). In case of such stress, the few volunteers of the Austrian RC are trained to provide social and mental support during the disaster (Interview Austrian RC, 2015).

The security and safety of the population need to be assured all the time and their aggression and eventual criminality (deviant behavior) understood. The affected population may develop asocial, illegal and aggressive behavior (Petermann et al., 2011). The experience during the Kobe earthquake confirms this behavior, but only to a certain extent where time is a strong factor. The Kobe City Waterworks Bureau’s Head Office analyzed around 2500 customer’s complaints received by telephone according to the voices. They found out that within the first week complaints mainly included questions on recovery options and the supply of water tanks. In the second week similar questions were raised, while in the third and fourth week anxiety and impatience arose. The population was wondering why no detailed information was shared and complained that the water supply was insufficient. From the fifth week onwards increased anger and bitterness was expressed on the phone. People lost patience and complained about their exhaustion and pain (City of Kobe, 2010). Subsequently, deviant behavior does only develop over time and with uncertainty and a lack of information and resilience.

Independently, security forces need to be in place to regulate the general safety such as prevention of crime when the alarm systems and metal detectors stop working and they need to assure fair and safe distribution of resources. Those resources include water and food as well as medication (Interview MOTI, 2015; Levy & Bissell, 2013). According to the NBC Defence School (2015), control of people and a fair distribution of water should not be a problem, because the population is forced to carry the heavy water and food and cannot drive it as they are used to. “*Das ist ja nicht das große Problem. […] Die Leute müssen es ja eh selber holen und dementsprechend reguliert sich das ganz von alleine, weil Wasser ist schwer. Ich hole mir nicht 100 Kilo oder 100 Liter Wasser, weil das muss ich dann tragen*“ (Interview NBC Defence School, 2015).

Police protection need to be assured for transportation, distribution and general observation during the day and night, which requires a big amount of human resources (Levy & Bissell, 2013). The experience in Kobe showed that illegal business was flourishing during the time of the disaster. People were selling items such as beds as well as water filters often of questionable quality and at extremely high prices. Others pretended to be volunteers entering houses and taking out money and valuables (City of Kobe, 2010).

Not only transportation and buildings would need protection, but also the companies that have backup generators and water storages. Aggression and upheaval might occur once they know who has heating and food. "*Du musst dir vorstellen, es ist dann rundherum alles finster und du hast ein Notstromaggregat und du hast Licht. Das kann […] nachteilige Folgen […] haben, dass du jetzt plötzlich von einer Masse an Bevölkerung gestürmt wirst. Also auch das sind Überlegungen, die man sich in so einem Prozess im Zuge dieser Arbeit machen muss*" (Interview WTP Vienna, 2015). For the company itself, such an upheaval and anger cannot only result in adverse economic impacts, but also damage the reputation of the service provider (DHS/OCIA, 2014). Firstly, they may have lacked preparation and will need to take responsibility for their unawareness. Secondly, if an organization acts too late, too slow or uncoordinated they will be held reliable at some point in time. Hence, a lack of communication between the stakeholders can equally cause a loss in reputation. Furthermore, stress and frustration of rescue teams can cause a slowdown of aid. Communication and collaboration is therefore essential to prevent criticism and to assure loyalty and calmness within the population and the teams (Petermann et al., 2011).

The population needs to be sensitized for a delay in support, the possibility of water and power outage and the affects they may have on their living such as a lower hygiene and sleep deprivations due to a lack of heating or cooling (Bissell, 2013). Such knowledge would encourage people to take their own responsibility and become more resilient in case such an event happens. For example, crisis scenarios can be played through in workshops and personal emergency plans can be created to improve resilience (Bundesheer, 2012). Some people may have experience from camping, survival training or the like, while others create strength and control on the spot and can take up the role of leaders in case of a disaster. Such leaders again can help others cope with the situation and stress having a positive effect on their surrounding (Petermann et al., 2011).

The knowledge of resilience can act like a vaccine. One resilient person can encourage and motivate many others enhancing them to equally express humanity, altruism, resilience and carrying following and during the disaster (Prisching, 2008). Panic and asocial action are not considered the regular behavior in a disaster, but the population seemed rather controlled, made rational decisions and showed altruism and active behavior. The Austrian RC had the experience that they often find spontaneous volunteers from within the population at the point of the disaster. "*[…] Trotzdem hat sich in den Katastrophen bewiesen, [dass] die Hilfsbereitschaft der Bevölkerung steigt in dem Moment, wo die Katastrophe passiert und medial transportiert wird […]. Also, genauso wie wir spontane Freiwillige bekommen, die gerne bei Katastrophen mithelfen wollen*" (Interview Austrian RC, 2015).

Following the Kobe earthquake eighty percent of the people trapped underneath buildings were actually rescued by neighbors and friends and not the fire fighters or rescue organizations, which shows the significance of mutual help. Such help deriving from within the community is termed as "social capital". It refers to the "social relations that are necessary to enhance social efficiency and to function effectively in growth, development, and sustainability even among people who don't know each other by encouraging them to take collaborative actions towards common objectives" (City of Kobe, 2010)

The described behaviors are based on assumptions and one-time examples and definitely need more research. This could include qualitative research talking to a population group who has experienced a blackout such as in the Netherlands, comparing them to a group who has not yet experienced a power cut and personnel working in crisis and disaster management who have and do not have experience with power outages (Petermann et al., 2011). This said, the reaction and action of the population cannot be predicted and so it is difficult to make recommendations on how the population will act or should not act (Interview MOTI, 2015).

Experience shows though that people tend to support others in times of a disaster. Physically strong and positive-thinking people are especially important since they can act like a vaccine providing comfort to others and giving them strength and resilience to do the same and to cope with the disaster. The effects of power and water outages severely disrupt the known daily life. Water has to be fetched and treated appropriately before it is safe to drink, water needs to be transported, information has to be retrieved through direct contact and resources can only be obtained via bike or by foot.

Organizations and rescue teams can lower the negative effects as long as preventive communication and planning has taken place before the occurrence of the blackout. Public telephone boots or landlines and satellite communication units are promising options to communicate long-distance, but only as long as the transmission station is supplied by a backup generator. Alternatively, flyers and leaflets should be distributed as often as possible, to as many people as possible and in a variety of languages in order to prevent wrong information and ensure trust in the response measures of the stakeholders.

6. Management mechanisms for safe drinking-water and hygiene

"*Wenn ich will kann ich in einer Katastrophe trotzdem noch meine Leistungen durchführen. Und das ist natürlich schwierig, weil wir sprechen von einem Szenario, wo wir zwar Thesen aufstellen können und Szenarien abbilden und auch theoretisch durchspielen, aber in der Praxis ist das nicht gegeben. […] Man kann sich nur so gut wie möglich darauf vorbereiten, mal was zu tun, Material vorzuhalten, vor allem dann auch noch seine Mitarbeiterinnen und Mitarbeiter erreichen zu können. Wie auch immer. Unsere Dienststellen einigermaßen Einsatzbereit halten, zu schauen, dass es an Versorgung und Treibstoff als an Fahrzeugen, etc. eine ganze Kette an Maßnahmen, die man da durchsetzen muss, um leistungsfähig zu bleiben. Aber gut, daran arbeiten wir.*

[…] Ich bin nicht wirklich heiß drauf dieses Konzept irgendwann einmal durchführen zu müssen. Also, wenn das kommt“ (Interview Austrian RC, 2015).

No risks and emergencies are equal to one another. Not a single emergency plan can be applied in a static way. Each emergency is a complex construction with different needs and outcomes (Levy & Bissell, 2013). In order to provide well-defined and specific responses, experience, judgment, skills and training are needed by teams with members of different expertise on the specific critical infrastructure and, hence, on the crisis management in the water sector (WHO, 2011). The aim is to provide insights into what has already been done with regard to risk preparation and management mechanisms on what could be done, while the focus is not on the elimination or decrease of the likelihood of a water outage, but on being prepared and responding properly in case a disaster happens which would bring the water supply to a halt. Addressing risks is helpful to turn decrease threats and risks and to make use of opportunities and strengths. Ways to addressing risks are by treating and thus taking control of them (Keegan, 2004).

Crisis management entails preparatory measures and yet, preparation by itself does not solely include planning, but also meetings, discussions, emergency drills and publications. Planning is an essential step towards preparation, but being physically prepared is the step to aim for. It includes internal measures such as decision-making and communication, community education and first responder training (Bissell, 2013). In order to be actively prepared, a plan of action should be set up so that not much time is lost once a disaster occurs (Valcik & Tracy, 2013). This internal plan should address questions such as

- Which resources are available?
- Who needs to be contacted?
- What is the scope of the intervention?
- Which types of threats need to be addressed?
- What are the major organization’s vulnerabilities?

All those questions have been addressed in the previous chapters in relation to the possibility of water and power outages and the overall effects on daily life. As previously stated by the Sendai Framework for Disaster Risk Reduction "*clear vision, plans, competence, guidance and coordination within and across sectors as well as participation of relevant stakeholders are needed*" (UN/ISDR, 2015). Such a plan should never be static, but strengthens risk governance, collaboration and partnerships across institutions (Valcik & Tracy, 2013).

This chapter shares mechanisms on how the water sector can be made safer and can be prepared for a rapid and effective response in case of an outage. It covers crisis management such as renting storage facilities or investing in backup generators, and disaster management, which requires on-the-spot preparations. Overall, not only technical aspects, but also managerial and societal responses measured are shared, which equally contribute to the reduction of the vulnerability of people and organizations, thus immensely increasing the effectiveness of the response (Chang, 2009; Menoni, 2001). The main purpose is to constrain the risk rather than to eliminate it and to raise awareness rather than to deny it.

6.1. Possibilities to raise awareness and attract action within institutions

Exchange of information and communication through different means can substantially contribute to raising awareness, thus leading to action. In order to address the risk of a water outage it must be considered as a priority on the national and local level and on the European and international level. Such a prioritization on the governmental level and/ or between organizations can encourage businesses and municipalities to take action and to provide direction for emergency risk management (WHO et al., 2013). Since a water outage is not of a major concern in Vienna as discussed above, it becomes even more interesting to see which circumstances made a water outage a topic on the local realm.

The first circumstance mentioned by several stakeholders that drew their attention to blackouts was due to the increased information on the weaknesses of the European electricity grid and the resulting regular interventions. "*Jetzt haben wir aber* *gehört, dass das europäische Stromnetz Schwachstellen hat. Und in gewissen Phasen, besonders im Winter, immer wieder regulierend eingegriffen werde muss*“ (Interview WTP Vienna, 2015). As a consequence, the wastewater treatment plant in Vienna decided to form a working group in summer 2014, where they discussed the electricity dependency and the effects a blackout could have on the system. Their conclusion is that a risk analysis for a blackout can only be done for a maximum of a week. Any analysis exceeding this time frame would be unpredictable and beyond imagination. “*Wir haben […] verschiedene Phasen betrachtet. Wie sind wir aus heutiger Sicht aufgestellt, also status-quo? Was können wir präventiv verbessern? Was können wir machen, wenn's eingetreten ist? Kurz vor der Wiederzuschaltung und das Hochfahren. Differenziert nach verschiedenen Zeiträumen – vier Stunden, ein Tag, drei Tage und eine Woche. Aber ich sag mal, alles was Richtung eine Woche geht… vergessen sie's. Dann ist es Kaffeesud, wie wir in Österreich sagen. […] Du kannst es eh nichtmehr sagen, was dann passiert*“ (Interview WTP Vienna, 2015).

The DWP Vienna also created a working group with the turn of the millennium to the year 2000. The worldwide believe was that the computer systems would shut down or cause problems with the change of the digits from 99 to 00. Therefore, the DWP Vienna conducted a risk analysis looking at the effects a shutdown of the computer system would have on the water provision. Unfortunately, this report could not be found publicly and it was later added that the analysis focuses primarily on risks such as terrorist attacks or a satellite drop and does not yet include a water outage caused by a blackout (Interview DWP Vienna, 2015). Similarly, the water provider in Bad Fischau perceived the risks of a blackout as topical only after the trainer during a water technician seminar raised attention to the risk of a power outage. “*Weil das [der Stromausfall] halt jetzt immer auftritt. Ich war jetzt bei der Wassermeisterschulung, da ist das gekommen. Damit wird sich jetzt jeder befassen müssen*“ (Interview DWP Bad Fischau, 2015).

Besides publishing news and giving workshops, a third option of raising awareness is through environmental and political actions. This includes setting up environmental monitoring systems, more stringent land-use or counter terrorism policies, and information-sharing technologies between states, organizations and stakeholders (Bissell, 2013). In this regard, the wastewater treatment plant in Vienna, for example, is certified as environmentally safe. Therefore, the management is obliged to follow a good example and create a risk profile to show that it fulfils the environmental quality standards at all times (Interview WTP Vienna, 2015).

Subsequently, a risk assessment for a blackout may not necessarily be carried out because of a fear of a water outage. Instead it may be politically guided. On a national level, since 1959 Austria has a Water Rights Act, which was lastly adapted in 2011. The Water Rights Act assures that the water sector and industries affecting water sources guarantee safe water quality by following environmental quality standards, restore the water quality after a disaster such as a flood, and mitigate possible risks to the water sources by applying safety measures. If these are not followed a fine has to be paid (Gugerbauer, 2015). In order to assure safe water quality, the wastewater treatment plants had to renovate their old water plants in the 1990s due to the safety guidelines while considering the amount of people relying on the plant and its size. Therefore, the wastewater treatment plant in Laxenburg renewed the whole plant and acquired a backup system. "*Das wurde angeschafft [das Notstromaggregat], ja das musste angeschafft werden. Ja, weil die Gesetzeslage danach verlangt hat. Ab einer gewissen Einwohnerzahl, ab einer gewissen Größe der Kläranlage, ab einer Größe des Kanalnetzes hat man das vorgeschrieben*" (Interview WTP Laxenburg, 2015). In the case of Laxenburg, the population stood up to make sure that the safety and security standards are followed. If they raise their voices and feel the need of change, the provider has to act (Interview WTP Laxenburg, 2015).

On an international and European level, a Global Platform for Disaster Risk Reduction, regional platforms for disaster risk reduction as well as international and regional forums for cooperation have been created in the course of the Hyogo Framework for Action 2005-2015. The framework was successful in raising awareness and in increasing the exchange of strategic advices among the public and institutional stakeholders and within the political arena (UN/ISDR, 2015). The European Union created a European Forum for Disaster Risk Reduction (EFDRR) to encourage exchange, facilitate discussions, advocate effective action to reduce disasters, enhance safety/ resilience and reduce vulnerabilities on a regional level. Among the focus areas of the EFDRR is the protection of the critical infrastructure. Unfortunately though, the website has not been update since 2011 and the most recent workshop report on "Natural-hazards triggering technological accidents" (Natechs) to which Austria contributed with a presentation and where blackouts and life line disruptions were equally mentioned was submitted in 2008 (UNISDR, 2011).

A fourth important point is to raise public awareness, which can contribute to the follow up on frameworks and encourage the implementation of disaster risk response measures. Apart from internal training and education, the RC offers on their website interactive games and brochures on preventive measures such as the storage of water, storage tanks and treatment of water for use by the general public. An additional method of reaching out to and informing the public, which he perceives as his duty, is to arrange an "Open Day" as was done by the water provider in Bad Fischau. "*Du bist ja verpflichtet die Leute zu informieren. Und 2013 war dann die neue Anlage und da haben wir gesagt ‚ja, dann machen wir gleich einen Tag der offenen Tür'. […] Und heuer hab ich gesagt, mach ich das wieder. […] Da mach ich vielleicht so einen Schulwanderwassertag*" (Interview Bad Fischau, 2015). On that day the population can visit the water system, receive information on the processing and the origin of their water and collect material on risks for a water outage and possible response measures. That way awareness and resilience can be raised for a possible blackout and the need for political action facilitated.

The most effective way to raise attention to blackouts in different age groups and across households seems to be through the book "Blackout" published by Mark Elsberg in 2011. All interviewees asked had read the novel and seemed to have derived a lot of their knowledge and assumptions of it. Since the novel covers the topic in an entertaining way attention can be caught easily, especially once public discussions are organized subsequent to the publication.

6.2. Relocation as a response measure for a blackout and water outage?

In case of disasters such as flooding and earthquakes a common first response measure is the evacuation of the affected population, which is often inevitable. In case of water and power outages destruction does not occur, wherefore a clearing of an area may not be immediately necessary or even of harm to the population. Assuming that a far-reaching water outage occurs, there are not just a few people who would have to be taken care of. In the case of Vienna over two million people would be directly affected. The Ministry of the Interior proposes to people, who have no other obligations or reasons to stay in the city, to move to the countryside and to relatives or friends for the time being rather than to stay in the city. There they can be more independent falling back on forest wood for fires and lakes or rivers for water supply "*[...] Wir können eigentlich nicht wirklich realistisch abschätzen wie viele Menschen werden dann in einem großstädtischen Bereich verbleiben, entweder freiwillig verbleiben oder auf Grund von besonderen Aufgabenstellungen verbleiben müssen. Und eigentlich wäre einem jedem, dem nur möglichst anzuraten, wenn er irgendwo am Land wo Leben kann, sei's bei Verwandten, sei's das ich selber irgendwo ein Häuserl hab, dass er dorthin geht, weil dort ist er wesentlich autonomer. Dort hat er Werkzeug, dort hat er eine Grünfläche, dort hat er vielleicht die ein oder andere Möglichkeit zu heizen ohne, dass er auf Strom angewiesen ist. Im städtischen Bereich haben sie halt all diese Möglichkeiten nicht, im Ballungszentrum. Da sind sie einfach ausgeliefert*" (Interview MOTI, 2015). When discussing mitigation mechanisms a distinction needs to be made between people living on the countryside and those living in the city or having a house outside of Vienna, given that they can also reach it during a blackout.

For all others, who cannot leave their home during a water outage, alternative solutions to water retrieval, flushing and wastewater discharge need to be found. One option would be the relocation to evacuation camps, which the Ministry does not recommend as long as destruction will not be observable. In the case of Vienna, none of the assisting organizations would be able to find such a big refuge to set up the camp and to keep it under control, especially when there is not any electricity and when everything would have to be built manually (Interview MOTI, 2015).

An alternative option to an evacuation would be to provide plastic bags or to set up Dixi toilets that allow for safe disposal in designated areas (Interview Austrian RC, 2015). The problem, though, is that waste bags would have to be removed and the Dixi toilets would have to be cleaned on a regular basis requiring once more transportation trucks and water for cleansing. "*Die [Dixi-Klos] sind ja relativ schnell voll. Wo wollen sie damit dann wieder hin. Wenn sie ein Dixi-Klo wohin stellen, brauchen Sie ja Transportkapazität, dass ich das vielleicht jeden Tag entsorge. Das heißt, ich muss also Fahrzeuge haben, die das entsorgen und der bringt das irgendwo hin und dort muss auch wieder maschinell irgendwas funktionieren, damit ich's entleeren kann und dann einigermaßen hygienisch reinigen. […] Und der braucht dafür auch wieder Wasser […]*" (Interview MOTI, 2015). In this regard, the Armed Forces would be willing to provide logistics to clean and transport the mobile toilets and is also interested in discussing a possibility of a public/ private partnership with a mobile toilet supplier since the Armed Forces are not able to provide them. "*[…] Dann gibt's insofern die Möglichkeit als das man so Sanitärcontainer aufstellen kann. Das ist aber dann meistens eine Kooperation. Also das Bundesheer stellt dann nicht diese Sanitärcontainer zur Verfügung, aber das Bundesheer kann mit den Anlagen diese Sanitärcontainer dann betreiben. […] Es ist sicher auch interessante sowas auf der Abwasserseite anzudenken, das man eben mit Mobil-Klo oder auch immer mal Kontakt aufnimmt*" (Interview NBC Defence School, 2015). Apart from that solution rescue workers or people affected could dig a small channel in the ground where the waste could be stored as it was done in former times. This is necessary not only when people stay at home during the water outage, but even when evacuation camps have been set up.

The problem in cities and camps is that the number of people per square kilometer is denser requiring more work and preparation and the likelihood of sanitation problems is higher if immediate solutions to flushing are not provided. The City of Kobe decided to set up temporary toilets at sixty sites in the city and in schools and another 300 temporary toilet units are now stored in warehouses and elsewhere and can be retrieved easily in case of need. This was a response to the Kobe earthquake when many buildings as well as schools used as evacuation units were found flooded with human waste and odor because no other means were shared with people on how and where to defecate when water supply had stopped. The hygienic situation was critical due to a lack of cleaning tools, which could have resulted in an outbreak of diseases. Subsequently, cleaning water for the mobile toilets is needed and could be addressed, for example, by retaining swimming pool water and rainwater. In addition to the temporary toilets, manholes have been installed in parks and other places and are now connected to the city's sewage system (City of Kobe, 2010).

Another point to be raised is the disposal of feces in relation to safe drinking-water sources and general hygiene. Feces from humans and animals can contaminate water and can cause severe health problems if ingested as they are sources of pathogenic bacteria, viruses, protozoa and helminthes, which lead to influenza, intestinal parasites or Malaria (WHO, 2011). The Ministry of the Interior assumes no threat with regard to the disposal of feces or wastewater, while the Austrian RC promotes an evacuation in case disaster strike in summer and the wastewater were not flowing away or pumped out of the system, because it might cause a critical hygienic situation (Interview Austrian RC, 2015). On the contrary, the Ministry assumes that the population will quickly know how to construct pit latrines in the garden and fill them with chalk for disinfection. This might well be feasible for people living on the countryside, but might be more problematic in areas with a high population density. "*Er wird dann eine vernünftige Lösung finden und wird halt nicht mehr aufs Klo gehen, sondern halt in den Garten hinaus und das wird sich von selber lösen. Und das wird überall in diesen Siedlungen, Einfamilienhausbereichen und so weiter, früher oder später eine Lösung sein*" (Interview MOTI, 2015).

The negotiation of a public/ private partnership such as for the provision of mobile toilets seems inevitable considering three main points. First of all, every person has a desire for privacy when using a toilet and thus, may not feel comfortable digging a hole in the garden or a park. Especially women, the elderly, pregnant women and children will worry about unwanted exposure and fear sexual harassment when using open toilets. In Kobe it was observed that several elderly people avoided the consumption of water during the water outage in order to reduce the times they have to go to the toilet or open pit, which caused them to get sick due to dehydration (City of Kobe, 2010). Secondly, tourists that reside in the city during the water outage may assume that it would not last long. Some might leave given their cars have enough fuel or the plains still fly, others might actually stay or need to stay since they would have no other means of leaving the location. They also need to be supported and need water and other resources (Interview MOTI, 2015). Thirdly, given the information from the DWP in Vienna that the capital city would continue receiving water even during a blackout, it can be assumed that people would not leave the city, but that additional, affected people arrive. Hence, the assumption would be the contrary. The population in the city would increase and bring along additional problems that may require a need to provide evacuation units and to give them a place to stay in Vienna for the time being. This demonstrates that even if the supply of water is not a problem, the disposal will be. Therefore, both aspects should not be looked at separately, but equally require preparation and discussion.

6.3. Backup generators and other means of technical preparation

"*Der Stromausfall ist das größte Szenario. Da ist dann mehr oder weniger alles weg. Oder wir überlegen uns dann, wann können wir wirklich Notsysteme aufrechterhalten, durch Notstromversorgungen, über Tage hinweg, ohne dass Strom weiterhin fließt?*" (Interview MOTI, 2015).

Technical preparation in order to prevent a lack of water or a halt of wastewater treatment in case of a blackout is essential, but its ability to assure a continuous energy flow over an undefinable period of time is questionable. Furthermore, most communities in Austria are located in the Alpine region assuring a hilly landscape and a downward water flow. The delivery of water for drinking, hygiene and sanitation can be assured at all times to many locations, even in the event of a blackout (Bundesheer, 2012). As mentioned earlier, risk perception of a blackout and its effects are rather low in Vienna, due to this gravitational water flow, wherefore risk management is less likely to take place. "*Stromausfall ist Gott sei Dank bei uns net ein sehr großes Thema. Jetzt in der Vorausschau. Wenn's wirklich dann mal ist, werden wir wissen, wo wir wirklich hängen* *werden. Aber derzeit sehen wir das eigentlich nicht als sonderlich großes Problem*“ (Interview DWP Vienna, 2015).

Several locations in Austria are not that lucky. They receive their water from deep wells and hence rely on electricity to pump up water into high-level water storage tanks as is the case for Bad Fischau. For them planning, cooperation, communication and awareness-raising are essential. The primary and most obvious mitigation measure to plan for a water outage due to a blackout would be the organization of backup generators that allow the motor of the pumps to continue working. Backup generators usually work without electricity, but through the provision of diesel. “*Und die Pumpen, die wir verwenden um […] das verschmutzte Wasser raus zu pumpen [aus dem offenen Gewässer] beziehungsweise das reine Wasser umzupumpen sind Pumpen, motorbetriebene Pumpen, die meistens mit Diesel angetrieben werden. Das heißt, ich brauche zumindest den Treibstoff, um Wasser produzieren zu können*“ (Interview Austrian RC, 2015). In this regard, the organizations do not only need to own and store backup generators in order to be actively prepared. Moreover, they need to assure a certain supply of fuel in order to keep the backup generators running for a longer period of time (Interview Austrian RC, 2015).

Both the RC as well as the Armed Forces own backup generators and have a gas station on their own premises to store fuel, which can be retrieved via manual pumps. “*Im Stromausfalls ist so, dass alle Tankstellen [die des Bundesheeres] sind mit Handpumpen ausgestattet und so weiter. Also […] die Kaserne hat ein eigenes Notstromaggregat. Das ist in jeder Kaserne so*” (Interview NBC Defence School, 2015). The Austrian RC and some of its national organizations do not have their own storage houses. Instead they distribute their fuel and equipment between two warehouses. The interviewee does not know the exact amount of the stored diesel, but it should cover the consumption of a car for at least 72 hours to a whole week. He considers this duration realistic and feasible, while outages that would last to up to a month sound unrealistic. “*Ich glaub da muss man eher schaun, was, wie man anstreben, oder was ist eine realistische Zeit und ich denke mir zumindest, wir sollten gewährleisten können, dass wir unsere Fahrzeuge so lange wie möglich am Laufen halten können. Aber zumindest*

24, 48 Stunden auf jeden Fall, 72 Stunden, vielleicht bis zu einer Woche. Aber ich glaube von einem Monat zu sprechen ist unrealistisch“ (Interview Austrian RC, 2015). However, in the case that electricity is rationalized or prioritized at an early point into the blackout by turning off lamps and computers, the amount of available fuel could reach up to one month. The duration of supply is yet of secondary concern to the RC because their aim is not to assure an endless support of electricity, but to think pragmatically and to focus on the overall goal, namely sustaining lives (Interview Austrian RC, 2015).

Hence, stakeholders do not need to aim for a continuous supply of water and treatment of the wastewater in case of a blackout, but should consider, for example, a secure shut down of the facility so that no harm is or can be done and assuring the functioning of other vital equipment. This could include safety doors and observation stations at entrances, fire alarm equipment, computers, gas detectors, communication media, charging stations for rechargeable batteries for mobile lamps and so on (Interview WTP Vienna, 2015). In the case of wastewater treatment plants this could mean that the plant runs only a minimal treatment process. Then the water is not treated to the same amount as under routine conditions, but at least as much as possible.

The interviewee of the wastewater treatment plant in Laxenburg decided that the most important task is the removal of solid wastes from the wastewater including toilet paper. Subsequently, Laxenburg owns a backup system that contains at least 200 liter of fuel, which should last for around two days, according to the interviewee. He and two additional stakeholders, one working for the wastewater treatment plant, one for the sewerage and one for the road and park maintenance, share the backup generator and make sure that it is maintained. “*Das ist unseres. Das gehört niemandem anderem. Das ist auch Gemeindeeigentum. Und wir die Zuständigen sind dafür da, dass wir das überwachen, kontrollieren und immer im Stand halten, also in Bewegung halten und funktionieren muss. Wir drei Leute sind dafür zuständig*” (Interview WTP Laxenburg, 2015). It is a mobile backup system that is stored at a local place in the center of the village. It can be used whenever needed to remove the solid wastes and to start the pumps so that they transfer wastewater from one area to the next ending up in the plant.

Afterwards, the backup system is used for the hydraulic moves and integrates air to the process allowing good bacteria to metabolize the organic content in the wastewater. This needs to be done for maximum of a day and then the plant can function again by itself for another day or two, during which time the backup system can be used by the other two stakeholders for their tasks (Interview WTP Laxenburg, 2015).

Such a sharing mechanism seems to be a good solution especially when the probability of harm is considered low and the costs for mitigation measures are high. A shared mobile backup generator has several positive benefits for providers such as a wastewater treatment plant. First of all, they do not rely on a constant and immediate supply of electricity in case of a power outage. "*Wir haben ja Zeit. Ich muss ja nicht abrupt jetzt den Schalter, wenn er ausgeschaltet ist wieder einschalten. Muss ich nicht. Weil das Szenario auf der Kläranlage zieht sich so und dauert und ist keine Gefährdung da, keine direkte, sofortige*" (Interview WTP Laxenburg, 2015). The cited wastewater treatment plant already had the experiences that the power was cut for around eight hours and a second time for around twelve hours. In both cases the plant had no problems with a continuous biological treatment. Subsequently, the plant would be able to continue treating water for another three to four days without electricity depending on the time and season of the year and the treatment efficiency aimed for (Interview WTP Laxenburg, 2015). This is only possible for smaller plants. The wastewater treatment plant in Vienna would not be able to cover its electricity demand with a backup generator given the amount of fuel it would need in order to maintain the operation (Interview WTP Vienna, 2015; Petermann et al., 2011).

Secondly, a shared backup generator requires good communication. According to the interviewee there is no competition between the three stakeholders about who gets it first or for how long in case of an emergency. Since it is a village of roughly 3000 inhabitants, the three of them know each other quite well (Interview WTP Laxenburg, 2015). Nevertheless, as described in Chapter 5.3, behavior is unpredictable in case of a disaster. In order to prevent miscommunication or disaccord, an agreement could be set up defining who gets the backup generator when and for how long in case of a power outage. Alternatively to shared backup generators, Bad Fischau proposed to buy or rent one from EVN Group, an Austrian electricity producer and transporter, in case a power outage occurs. One problem mentioned, though, was that several people may have the same idea and limiting availability (Interview DWP Bad Fischau, 2015).

The Armed Forces have individual backup systems already connected to their own mobile water treatment units and pumps. Without an electrical outlet or a diesel generator water units would not be working. They need to pump up many liters of water in a short period of time in order to reach out to as many people as possible. The preferred water sources are therefore domestic wells, cisterns filled with rain water, artificial static water supply sources or open sources since they provide the necessary refill (Interview NBC Defence School, 2015). Some wells provide as much as twenty cubic meters or more of water per hour. The minimal amount per person needed including hygiene resembles seven to fifteen liters per person per day. Germany set up over 5000 wells for the provision of drinking-water in emergencies in order to have a continuous water provision source (Petermann et al., 2011; Ray & Jain, 2014).

A pump of a wastewater treatment unit can work three to four hours with a full backup generator. Once the Armed Forces are called for support, they can provide supplies for at least a week to up to thirty days (Interview NBC Defence School, 2015). Nevertheless, assuming that not enough fuel is available, gravitational flow or natural pressure do not exist, or the filled high-level storage tanks are empty, alternative solutions need to be found (Petermann et al., 2011). Neither the wastewater treatment plant in Vienna nor the drinking-water provider in Bad Fischau owns backup generators, and thus discussed alternative ideas.

Renewable energy sources

The first alternative solutions to backup generators are renewable energy sources, which are not only a sustainable solution, but also decrease the environmental impact (Gude, 2015). The drinking-water operator in Bad Fischau is currently considering the introduction of a photovoltaic system that could produce the energy needed for water pumps. This project is a cooperation between Bad Fischau and the EVN Group and is intended to not only reduce the dependence on the interlinked energy supply, but also to reduce the overall costs. One of the main questions that need to be answered is where the photovoltaic panels could be placed due to their big dimensions and heavy weight. “*Drum ist ja auch nicht schlecht, wenn man wieder auf das Photovoltaik zurückkommt, weil man da den Strom macht und wandelt das um auf das Aggregat, dann kannst du immer was [Wasser] aufi fördern. […]Das wird schon eine Riesenfläche. […] Drum suchen sie, glaub ich, wirklich noch einen Standort*” (Interview Bad Fischau, 2015). The hours of sunlight should not be a problem, but rather the amount of energy that photovoltaics can produce and the question whether this is enough for water transmission. An example is given comparing the calculated results for the energy production of a solar panel and the energy need of a water pump. Due to the reason that parameters such as depth of the raw water source or the efficiency of the solar panel differ, the results should only be used as approximations.

One solar panel produces around 200 watts per hour, which varies depending on the size of the solar array, for example one solar panel could be around two square meters large; and efficiency of the solar panel, which ranges between five to eighteen percent; the regional sun hours; and the intensity of the sun during the different hours of the day and the seasons (Llorens, 2012). Considering the assumptions stated below, the electrical demand of a water pump per hour can be calculated using the formula of Figure 12.

$$P = [(1m^3) * (1000kg/m^3) * (9.81m/s^2) * 20m)] / [(60s * 0.5)] = 6540\ J/s = 109\ W/h$$

	P	power
$1m^3$ = 1000 liters	q	flow capacity
$1000kg/m^3$	p	density of fluid
$9.81m/s^2$	g	gravity
20m	h	pumping height
60s	t	time
0.5	n	pump efficiency

Figure 12: Energy demand of a water pump

If water has to be pumped up from a depth of twenty meters the pump would require 110 watts energy per hour. In order to meet the demand of two hours pumping with one cubic meter per hour, approximately one solar panel would be needed (200 watts divided by 110 watts). For ten hours daylight this would mean that ten solar panels could pump up twenty cubic meters or 20000 liters of water per day. A person needs a minimum of seven to fifteen liters of water per day for drinking, hygiene and cooking, wherefore between 1300 and 2900 people could be supplied with water per day. If the solar panel is around twenty square meters large, that would make a required area of around 700 square meters. Since water pumps require a lot of electricity and rely on a big amount of solar panels and a large area, the use of renewable energies for water transmission in cities should be questioned, while villages might profit from their integration into the energy system. For example, Kobe installed four photovoltaic systems and one small hydroelectric generator, which were not sufficient to assure enough power for the water pumps, but which are sufficient to assure a constant flow of water or groundwater to the channel that had been constructed following the earthquake to prevent another water outage (City of Kobe, 2010; Interview Kobe City, 2015a).

An alternative solution to energy production during a disaster mentioned was to transport mobile photovoltaic panels to the emergency location. However, this idea was quickly put down again due to the low electricity production compared to a backup generator and the time it would take to transporting the heavy panels. In case of a disaster a lot of electricity is needed as well as a fast supply, which features mobile panels would not (yet) be able to meet the demand. "*Also im Übrigen gibt's ja immer wieder auch Initiativen und Forschungsergebnisse, wo man zum Beispiel versucht Solarpanels also alternative Stromquelle für den Katastropheneinsatz [einzusetzen], also das Problem ist nur, die bringen momentan einfach die Leistung nicht. Der Aufwand, also diese Solarpanels auf Anhängern hat einfach eine Größe von dem Raum, bringt aber weniger Leistung als wie ein Notstromgenerator, der auf Diesel betrieben ist […]. Das Problem ist, ich brauche im Katastrophenfall schnell und meistens viel Strom und das schaffen eben momentan die Solarpanel noch nicht wirklich. Der Transportaufwand wäre ein Wahnsinn*" (Interview Austrian RC, 2015).

The alternative to solar would be wind energy. Its limitations are similar to those experienced with photovoltaic systems since the use of wind energy strongly depends on the place where electricity is needed. Such a solution was provided for supermarkets which are likely to be located in empty spaces outside of villages and cities and which could integrate wind or solar energy in order to assure cooling of warehouses as energy islands (Petermann et al., 2011). Unfortunately, wind parks do not produce enough power to meet the demand of water pumps and the operation of a wastewater treatment plant by itself, while at the same time peak hours may produce too much electricity. Therefore, a flexible energy system is needed.

Energy self-sufficiency of wastewater treatment plants

An option would be to combine renewable energy sources with an energy self-sufficient system that produces its own energy, creates an independent source of energy and acts in case of a power outage (Petermann et al., 2011). Self-sufficient energy systems seem to be a good alternative option for wastewater treatment plants as was done in Kobe City (Interview Kobe City, 2015b). The advantages are manifold including the reduction of air pollution and greenhouse gas emissions and enhanced energy independency (Gude, 2015). The wastewater treatment plant in Vienna is currently discussing the introduction of a self-sufficient energy system that would start producing the needed electricity by 2020. As described by the interviewee at the wastewater treatment plant in Laxenburg, a specific scraper collects the sludge on the ground of the treatment plant and puts it in a separate tank. In this tank the sludge rests for fermentation. After a while the fermentation produces the gas methane, which is highly flammable and can be used for electricity production (Interview WTP Laxenburg, 2015). In the end, biogas is produced and can be used for heating and electricity production (Interview WTP Vienna, 2015).

This concept is mainly profitable for big wastewater treatment plants, since the collection and burning process take time and a lot of sludge and energy of their own, diminishing the possible profit made by producing their own electricity. "*Es ist leider Gottes so, dass wir so von der Energie und vom Aufwand her, leider so viel Energie und* *so viel Aufwand brauchen, dass du mit diesem, das du dann erzeugst, das nicht decken kannst. Ich kann keine Kläranlage mit dem Gas, das ich mir erzeuge oder erzeugen kann, die komplette Anlage betreiben. […] Es ist einfach zu wenig. […] Im Schnitt ein Drittel kann ich mir ersparen. Nicht viel*" (Interview WTP Laxenburg, 2015). Independent of the size of the plant, together with the implementation of a self-sufficient energy system, the treatment process has to be changed towards an enhanced water, energy and nutrient recovery process. This means that fewer nutrients should be kept for the biological process in order to increase the quantity and quality of the wastewater, which are essential for an autarky system (Gude, 2015). In the end, the plant should be able to work more or less independently from outside electricity influx, while at the same time feeding the public grid with electricity in times of overproduction.

High-level water storage tanks

The third and most obvious solution is the storage of water in high-level water storage tanks. Vienna has around 29 water tanks with a total volume of 800 million cubic meters (around 30000 cubic meters per tank) and two water tanks just outside of the city with another 800 million cubic meters. In case of a water outage, the Viennese population would receive water out of these tanks for another four days and if the water is prioritized and the use restricted to the basic needs, the water would even last for a longer period of time (Wien.at, nn b). In constant exchange water comes down from the Mountain Spring Pipeline, is "stored" in these high-level water storage tanks before it is taken out again and transported to the population allowing a constant in and out flow without electricity (Interview MOTI, 2015). Nevertheless, the transportation to and from the high-level water storage tanks may also rely on pumps depending on location and water source. "*Bei den Vorsorgemechanismen der Wasserversorgung ist es nämlich auch so, dass sie angehalten werden zumindest eine gewisse Minimalversorgung über Hochbehälter sicherzustellen, das heißt, dass quasi die Schwerkraft die Arbeit erledigt und zumindest, für gewisse Wassermengen, dass die Leitungen unter Druck bleiben und so weiter. Aber zumindest für ein bis zwei Tage das sichergestellt ist […]. Das ist natürlich nicht überall möglich, aber im Großen und Ganzen versucht man schon dort* *eine Redundanz zu schaffen, weil die Hochbehälter brauchen eben keinen Strom, weil […] ich hab's natürlich rauf gepumpt und jetzt ist der Stromausfall und es braucht sowieso eine Zeit bis der oben leer ist. Das wäre eine Variante wie ich wirklich gar keinen Strom brauche, um trotzdem weiter zu versorgen*" (Interview NBC Defence School, 2015).

Water channels and mechanical water pumps in cities

A fourth alternative to backup generators would be mechanical energy, which is already of major importance in disasters. The Armed Forces, for example, use human strength to pump up the fuel from their gas stations (Interview NBC Defence School, 2015). With regard to water, the government in Kobe implemented wells with hand-turned pumps around the city that allow the retrieval of water in case water flow continues, whilst the power is out (Figure 13) (City of Kobe, 2010).

Figure 13: Hand-turned pump to retrieve water in Kobe, Japan
Source: City of Kobe (2010)

In case there is no gravitational flow of water or the water supply is interrupted or not available for other reasons, a fifth alternative solution would be to make sure that water channels or open water distribution channels have been created in advance. Kobe implemented several water channels or streams along the roads in the city that can be used by the fire brigade, but also the general public. These channels are now located in three areas of the city and are regularly filled with treated wastewater, spring water or well water (Figure 14). Since algae grow in the open channels if exposed to sunlight, an additional agreement on the management and cleaning of the channels had been concluded. The residents agreed to clean them at regular intervals. Additionally, agreements had been closed with landowners since streets, roads and parks were narrowed to make space. Furthermore, in depth information sessions, workshops and inclusion of the wide public in the planning and construction of the channel sites had been undertaken (City of Kobe, 2010).

Figure 14: Water channels in Kobe, Japan

Source: City of Kobe (2010)

Domestic water wells

A sixth solution depends on the area that is affected. If, for example, only a specific area or village is not able to pump up water, there is the option of using water from household water wells. In that case a test on water quality, e.g. nitrate and bacterial counts, would be necessary, because if consumed in high amounts they may affect the health of the population. Then the water would need to be further diluted or disinfected accordingly (e.g. chlorine addition) in order to meet safe drinking-water requirements. "*Sagen wir die Anlage fällt jetzt drei Wochen aus, da hab ich eben einen Brunnen. Da muss man nur aufpassen, der hat viele Nitratsachen drin, dass man nicht über den Grenzwert kommt. Den kann man immer nehmen wenn man mischt, aber im Notfall speist man ein nur eine bestimmte Zeit, dass man unter dem Grenzwert ist*" (Interview Bad Fischau, 2015).

Cooperation with neighboring cities

A further option to backup generators would be to conclude contracts with the neighboring cities in order to support each other in case one or the other faces water shortages, a broken pipeline or a water outage. Bad Fischau, for example, has already been in contact with neighboring cities as all three of them could easily connect their pipelines, insert a meter that counts the amount of water pumped from one city to another and calculate the amount that needs to be paid for. Such an agreement requires a lot of preparation, consultation and political discussions before it can be concluded (Interview DWP Bad Fischau, 2015). Overall, such cooperation could be of great value for neighboring cities of Vienna, since the capital city is provided with gravitational water flow even during a blackout and could prevent a struggle to find safe drinking-water.

6.4. Supplying, treating and storing water for direct consumption at home

With the onset of a water and power outage, many problems will become visible at the same time. Not only will the communication be interrupted, but also priorities will be set differently. Following the 2010 Haiti earthquake the provision of potable water was one of the priorities of the international communities' response. WASH organized bottled water and water trucks and worked on the reconstruction of the water system. Without immediate reaction, the population would have had to drink out of contaminated springs, rivers and open water sources causing diarrhea, dysentery and hepatitis. Until a response unit arrived water-borne diseases had already become one of the leading causes of death in Haiti following the earthquake, according to the Pan American Health Organization (PAHO) (Kirsch et al., 2013). The provision of water and disposal of wastewater must not necessarily be targeted first since within the first two days of the outage other drinking sources are usually still available. "*Wobei man auch sagen muss, im Falle eines Stromausfalls ist kein akuter Bedarf. Gerade beim Trinkwasser. Es heißt ja nicht von einer Minute auf die nächste „jetzt brauche ich das Wasser", sondern es wird nach zwei Tagen wird's happig*" (Interview NBC Defence School, 2015).

In some areas first responders, rescue teams or other stakeholders may not be immediately available to treat water from open sources given that they are even directly accessible. For example, untreated water or flood water should never be consumed in case of an emergency due to increased health risks as the water may contain heavy metals, toxic chemicals and germs that cause diseases (CDC, 2014). Or the water outage takes a long time using huge amounts of personnel and materials, wherefore alternative options need to be made available (Petermann et al., 2011).

While Vienna in specific and Austria in general have water tanks that can store water up to at least a few days, their amount is limited depending on the size of the tanks, the season of the year and the duration of the water outage. The high-level water storage tank is usually only filled with more or less sixty percent of the possible capacity, which would last for around two days. In winter the tank is filled with slightly more water than in summer since not that much water is used. In the summer, however, water use is much higher due to increased watering of the garden and hence almost no water is stored in the tank, but just runs through (Interview DWP Bad Fischau, 2015). Subsequently, water tanks are a short-term solution only.

Apart from water tanks, the Austrian RC and the Armed Forces own mobile water tanks (Interview Austrian RC, 2015; Interview NBC Defence School, 2015). Trucks loaded with water tanks can drive from one village to the next and either wait at central places until people pick up water before they continue to the next village or they refill so called intermediate parking containers, which stay and can be used to fill water bottles. During the Bosnian mission of the Armed Forces in 2014, a central water provision place had been set up and temporarily 35 additional distribution spots, which were filled daily by two teams (Interview NBC Defence School, 2015). Over time Japan actually moved from a water tank supply to a pipe supply. The difference is that in case of tank supply, the population has to stand in line and wait for their turn, which can take several hours. In case of the pipe supply, a certain amount of temporary faucets are installed at the pipes from which water can be retrieved (Figure 15). That way, more people can get water independently, quicker and at the same time (City of Kobe, 2010).

Though this is a creative solution, the limitations in supply and transportation of water on trucks need to be considered as regular gas stations cannot pump fuel anymore and mechanical failures cannot be repaired easily (Levy & Bissell, 2013). Additionally, transportation on the streets becomes more dangerous due to failing traffic lights, street lights and tunnel lights. Unfortunately, the train system is not an alternative solution since it also receives its electricity from public power plants (Petermann et al., 2011).

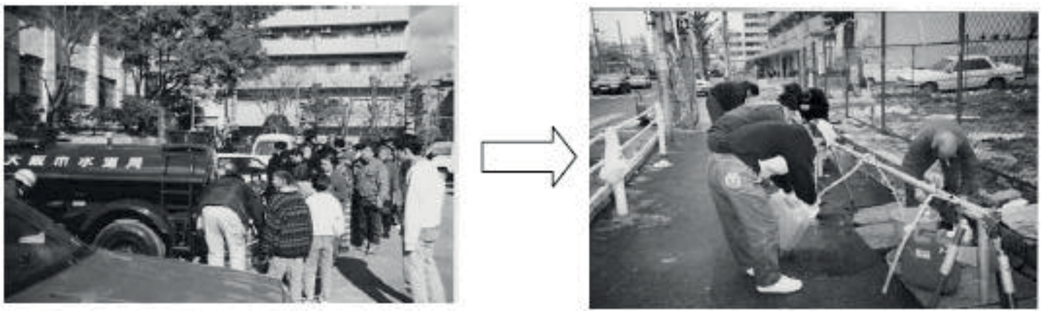

Figure 15: Shift from Tank Supply to Pipe (road faucet) Supply in Kobe, 1995

Source: City of Kobe (2010)

Another threat to the population would not be a halt of the water supply, but its limitation. Water coming from the Mountains Springs to Vienna is regulated by pressure zones depending on the height of the areas it has to cross. These pressure zones can be regulated in the water tanks spread along the pipelines or with pressure reduction valves which the house owner can regulate (Interview DWP Vienna, 2015). These pressure zones can be restricted in order to assure that water is available for longer, yet at a limited amount. Then people living in multistoried houses would not receive water anymore, except for those living on lower levels. This solution is especially promising as the supply of water for toilets would be limited but still continue flowing (Petermann et al., 2011). Such limitations may not be unusual in such cases where water is essential for survival, for instance at hospitals. Additionally, Vienna has priority in contrast to cities located at the Mountain Spring Pipeline due to political regulations. "*Das ist an für sich in all diesen Verträgen, die es in der Verbundwirtschaft gibt, sicher gestellt. Also, wenn Wien Wasser braucht, Wien zuerst. […] Also die Geschäftseinteilung in Wien wird von der Politik abgesegnet. Also das ist natürlich auch der Wunsch der Politik […] und ja, in dem Fall ist immer Wien zuerst*" (Interview DWP Vienna, 2015). Subsequently, other cities need to be aware that their water provision may be interrupted or limited in order to save water and to prioritize specific areas and institutions.

In the case of a water outage either the responders or the population are required to reach back to water sources and simple drinking-water treatment mitigation measures. Depending on the season and the weather, water could be collected from rain water or from domestic wells, for example, if no other sources are available. A couple of households in Austria still use domestic wells for their water provision. During the flood in 2013, the RC found several of those to be flooded and covered by sewage and garbage, wherefore the water provision was cut for many living in the region. However, it was not an issue of the water supply being interrupted as such, but the drinking-water quality was dangerously inadequate (Interview Austrian RC, 2015; Interview NBC Defence School, 2015). The advantage of rain water compared to domestic wells or open water sources is that it has no threat to be contaminated with or by sewage or wastewater. The sewage could be simply diverted by gravity-based systems as well as pumping facilities (Levy & Bissell, 2013).

Drinking-water treatment becomes important not only when water has been retrieved from open sources, but also if the handling of water was unhygienic during transportation or if safe storage of water at home cannot be assured. Several purification technologies exist, which vary depending on several criteria: rapid response in the case of a disaster; sustainable and long-term response; electricity availability; required amount of safe water; and knowledge of water purification of the rescue team. Though most purification options allow a complete reduction of pathogens, the effectiveness might be reduced if inappropriate technology is used for the specific amount of water needed (Table 4) (Ray & Jain, 2014; WHO, 2011).

Table 4: Water treatment technologies according to amount needed and duration of application

Long-term (communities)	Point-of-use (households)
Chemical disinfection (chlorination)	Thermal technologies (pasteurization or boiling)
Plain filtration (sand)	Silver chloride pills
Granular activated carbon filter unit (GAC)	UV light irradiation (solar)
Coagulation, precipitation and/ or sedimentation	Plain filtration (towel)
A combination of several treatment technologies	

Source: Ray & Jain (2014)

The Austrian RC has the possibility to treat big amounts of water by using two different types of filtration units, which are considered as low-energy applications units since they are low in energy use (Ray & Jain, 2014). One of them is the pool filtration unit, which is a sand filter unit. In this case water is treated with coagulants and pressed into a container where the particles can settle down and clot. Then the water is pressed through different sizes of gravel and sand or even a towel can be used, to which the particles stick while the safe water ends up in a tank. The towels are usually distributed to the population by the international community, the EU crisis management, UNDP or similar organizations for point-of-use treatment at home in case of emergencies. Lastly, the water is treated with chlorine preserving it and making it safe to drink (Interview Austrian RC, 2015; Interview NBC Defence School, 2015).

The second unit is a granular activated carbon (GAC) filter unit. It is similar to the previous one, but here a ceramic candle filter is used. The water is pressed together with powdered activated carbon through the filter, clotting the particles, while the safe water is pressed out and treated with chlorine for storage. The water received is not only safe to drink, but can also be used for medical appliances. The pool filtration unit and the GAC filter unit are the two units used in Austria, while the RC and other organizations in other countries use a different variety of units such as UV filtration units or Oxfam Tanks (Interview Austrian RC, 2015).

Figure 16: Water treatment training by the RC

The Armed Forces use reverse osmosis units or a chemical-physical process for water treatment followed by a filtration unit, separating water into drinkable and concentrated water. In this case, only fifty percent of the filtered water is used as drinkable-water in order to ensure a quick dilution of the concentrated water within the open source. Additionally, active carbon is added similar to the case of the carbon filter unit of the RC, which assumes the odors and tastes. In the end this water is once more filtrated and another disinfection chemical is added to make it storable for longer periods of time (Figure 16) (Interview NBC Defence School, 2015).

Despite these preparations and transportation of water, even in an emergency situation the drinking-water needs to be tested in order to assure that the treatment is sufficient. This is not always possible because of limited resources, time constraints and constantly changing water quality. Therefore, the population should be able to meet their own needs by using bottled water, packaged beverages or know-how to treat and filter their own water from open sources. "*Wien wird relativ gut mit Trinkwasser versorgt sein. Aber wenn der Strom ausfällt, dann wird's halt andere Gegenden geben, wo das nicht so ist. Dort kann man sich aber behelfen, dass man Wasser dorthin transportiert. Oder auch Flaschenwasser verwendet*" (Interview Austrian RC, 2015).

Independent of the treatment technology applied, chlorination of water is an unquestionable and even statutory application. "*Wir haben als einzige Aufbereitungsstufe eine Desinfektionsstufe. Das ist von der Hygiene her vorgeschrieben. Das ist eine Chlorierung*" (Interview DWP Vienna, 2015). Chlorination is a disinfection process that kills pathogenic microorganisms and assures safe drinking-water. Its effectiveness can only be guaranteed in low-level contaminated water, but not in water contaminated by protozoan pathogens and several viruses. Furthermore, chlorination has no or only a limited effect in turbid water, in which chlorine can even enhance the growth of microorganisms (WHO, 2011). It is most likely used for water disinfection in communities rather than single households though either option would be possible (Ray & Jain, 2014). According to the drinking-water provider in Bad Fischau, chlorine is added and dosed automatically within the water transmission system. If the amount of water fed into the high-level tanks increases, the amount of chlorine added increases automatically as well. In this regard, the water that is already in the tank is also already treated, so that a halt of chlorination would not pose a risk to the stored water (Interview DWP Bad Fischau, 2015).

In cases for short-term application or when immediate support by first responders cannot be assured, the population should be able to take care of themselves by having safe water stored or by being aware of at least a few water treatment options that can be applied at home and without the need of electricity. The treatment of contaminated water in the individual household is referred to as point-of-use or point-of-entry water treatment as it is consumed immediately, and the quantities are small and limited to a few people (WHO, 2011). Treatment options include water filtrations and silver chloride pills (Table 4). Silver has been a common chemical for water purification for several decades and is also often used as an impregnation for carbon filters. Alternatively, the individual household could rely on solar light to purify water. In this case, certain wavelengths of the sun, usually in the UV spectrum of 200 – 400 nm, are strong enough to destroy certain microbes independent of the temperature. This requires that UV-transparent containers are used that allow solar radiation to pass (Ray & Jain, 2014).

Other options to assure safe drinking-water are pasteurization or boiling of water. Both kill microbes effectively, but heavy metals, salts and other chemicals remain in the water (Bissell & Kirsch, 2013). Pasteurization is the heating of water for a short period of time to around 65 degrees Celsius, which is already enough to kill dangerous microbes such as salmonella and enteric viruses. Since the temperature is low, it requires less fuel and energy and thus is a more feasible alternative to boiling the water at 100 degrees Celsius, especially when burning material is limited (Ray & Jain, 2014).

The mentioned mechanisms to safe water are mainly temporary approaches and not necessarily a solution for long-term. Depending on the duration of the blackout, some of the proposed solutions are difficult to continue increasing the risks for unhygienic behavior and so the outbreak of diseases such as cholera. Before the population has to fall back on open water sources, it is recommended to meet water needs first with bottled water. The Center for Disease Control (CDC) (2014) provides a general guideline for the population in case of an emergency in order to reduce the impacts of possibly contaminated water. They recommend never risking dehydration. Even though the present amount is limited it is important to drink the amount needed and to worry about the rest on the next day. Subsequently, a person should drink at least two liters of water per day, while three to four liters should be the intake during hot days or for pregnant women, sick people and children (CDC, 2014).

Furthermore, the CDC also provides recommendations on storing water in order to be prepared for possible short-term water outages such as due to broken pipes, but also for long-term events. In order to bridge the time until the Armed Forces step in to help out, the population should store water for at least three days. It is the task of the water providers to educate people about this necessity and to assure self-sufficiency amongst them (Van Leuven, 2011). The CDC provides comprehensive information on water storage and on water that is safe for drinking as listed in Figure 17 (CDC, 2014). If these guidelines are followed up on the population should become more resilient to water outages caused by blackouts and hence, should be less likely to panic (Van Leuven, 2011). And in case water is not treated or safe to drink, it may still be used to flush the toilet or for similar means. Similar to the CDC, the ACPA in Austria also shares a short brochure on blackouts where the provision of water and the disposal of wastewater are included. Surprisingly, the ACPA has not been mentioned as an information source by six of the seven interview partners. Since the brochure does not provide the date on which it was published, it could have been a few weeks or a few years ago and thus be unknown at the time of the interviews.

- The amount stored should be at least three liters of water per person per day for a minimum of three days.
- Water should also be put aside for animals (also three liter per day).
- Store water in a cool, dark place in the house, office or car.
- Replace water every six months and check expiration dates on store-bought water.
- When using your own storing containers, make sure to sanitize them first by washing them with soap, adding a chlorine solution and rinse thoroughly again afterwards.
- Assure that the container can be thoroughly closed.

Figure 17: Information on safe water storage

Source: CDC (2014)

6.5. Refining cooperation and public involvement

"*Also wichtig ist, Vorbereitung auf beiden Seiten. Natürlich darf man die Infrastruktur, die kritische Infrastruktur, Infrastrukturbetreiber auch nicht außen vorlassen. Die müssen natürlich auch ausreichend vorbereiten, aber so kann jeder seine Schaufel dazu beitragen, um einfach gegen die Folgen oder die Auswirkungen von Katastrophen besser gegenwirken zu können oder besser damit umgehen zu können*" (Interview Austrian RC, 2015). Preparation is important on all sides, not just one stakeholder or one organization, but everybody, in order to prevent or lessen the effects and consequences of a disaster.

Some critical infrastructure facilities such as governments, hospitals, first responder facilities, water and sewage systems and banks have backup power generators in place, which is an inevitable prevention mechanism since stakeholders need to take a leading position in coordination and control of the situation and assure law and order for which electrical devices, drinking-water, computers and telephones are indispensable (Levy & Bissell, 2013). Since the supply of backup generators is often limited to a few hours up to a maximum of a few days, the risk of a water outage should not only be addressed by the means of technical devices, but also by cooperation and collaboration between different stakeholders and the public (Bruch et al., 2011). Unfortunately, soft approaches tend to be neglected since they are hardly visible compared to new technological gadgets and cannot be measured on the basis of money spent regardless of the actual efficiency (Menoni, 2001). Preventive measures are most likely applied if an observable financial profit can be witnessed by applying measures (Levi & Bissell, 2013). Managerial and societal approaches such as strengthening resilience among employees and the population thus receive only little credit, though they often represent prevention measures close to "zero" costs (Menoni, 2001).

Training of personnel

Response takes time, preparation and most often infrastructure itself in order to replace and repair destroyed infrastructure. Therefore, the availability of personnel preparation and first responders is essential (Levy & Bissell, 2013). A well-grounded exchange and training within the organizations can highly improve the effectiveness of the disaster response. The RC, for example, is well prepared with regard to internal coordination and drinking-water treatment. Several national organizations are specialized in training and provide courses for RC volunteers and individuals within the WASH (water, sanitation and hygiene promotion) department, which follows up on research and development in the water sector and provides guidance and consultancy on water issues. The training includes the use of technical equipment and drinking-water guidelines. The volunteers often already have a background in biology, hydrology, microbiology or similar and bring a specific qualification with them. The first step is the national course with a focus on the national water guidelines. If desired an international course offered by the International Federation of the Red Cross and Red Crescent (IFRC) can be visited in a second step include advanced drinking-water treatment courses as well as courses on hygiene promotion and international drinking-water guidelines. The knowledge is regularly updated in refresher workshops or additional trainings (Interview Austrian RC, 2015).

Not all preparation work out that well in praxis though. The national and international relief teams active after the Kobe earthquake complained about disorganization and a lack of guidance that could have been provided in advance (City of Kobe, 2010). An option to overcome a lack of coordination, training courses with simulations could be undertaken. This said the technical preparation can only be as good as the human preparation is and is otherwise likely to fail (Menoni, 2001).

The Armed Forces, for example, make sure that each shift that takes care of the drinking-water treatment has at least one expert who has been trained at the NBC Defence School and so is familiar with the drinking-water treatment utilities, but also with the general understanding. The operation itself can be done by the professional soldiers, who have not a background in water treatment. "*Also in der Wasseraufbereitung ist das Bedienen der Anlagen ist jetzt nicht das große Problem, das ist an den, an den Berufssoldaten bleibt das hauptsächlich hängen. Aber das hygienische Verständnis, das Aufbauen, das Legen von den Schläuchen, das gesamte System, das ist* *sozusagen dort wo man die Manpower braucht. Wenn man das nicht versteht tut sich nicht mehr viel*“ (Interview NBC Defence School, 2015).

Public/ private partnerships

Additional human resources for water treatment and time can be saved through public/ private partnerships. A large percentage of critical infrastructure is owned by private companies, wherefore emergency stakeholders should start involving them in planning processes, drills and evaluations. A brewery, for example, could modify its system and distribute safe, potable water to those needed, given, of course, that a backup system exists or water has already been stored (Levy & Bissell, 2013). The NBC Defence School (2015) refers during the interview to the water association “Nördliches Burgenland”, which has such a cooperation agreement with the Coca-Cola company (TCCC). In case of need, TCCC would store bottled water and keep it ready for the rescue teams to pick it up. “*Also es gibt verschiedene Kooperationsverträge. […] Der Wasserverband „Nördliches Burgenland“ hat sich insofern damit beschäftigt, dass er mit Coca-Cola einen Abrufvertrag hat, dass wenn es wirklich eng wird, dass die Mineralwasser im großen Stil vorhalten und lagern. Also das ist natürlich wieder die Trinkwasserseite, aber es ist sicher auch interessante sowas auf der Abwasserseite auch anzudenken, das man eben mit Mobil-Klo oder auch immer mal Kontakt aufnimmt*“ (Interview NBC Defence School, 2015). This is an example of an effort that is not solely on paper or halted until the final disaster occurs, but is part of an active response plan.

On the contrary, the ministry does not see the necessity to take a preliminary approach or to create a contract since the assumption is that producers have a lot of resources stored already. “*Wir haben ja Gott sei Dank relativ viele Mineralwasserabfüller in Österreich. […] Die werden vielleicht das ein bisschen geregelt mit dem Notstrom herunterfahren können, aber die haben ja an sich keinen Bedarf ständig Wasser zu fördern. Die haben aber sicher einiges auf Lager liegen, das heißt da kann man wahrscheinlich schon einiges [vorfinden]*“ (Interview MOTI, 2015). Even if this is the case, in advance communication, exchange and the setup of legislation is strongly recommended not only for the public sector, but most likely insisted on by the private sector, because they need to be assured control and liability of their products (Levy & Bissell, 2013). In the case of Hurricane Katharina in the USA, WalMart and other commercial powerhouses showed great commitment and support efforts when offering supplies from their big logistic capabilities. Unfortunately, they were not allowed to deliver any to the affected population, because they did not own the required permits or governmental recognition which is necessary during a disaster (Levy & Bissell, 2013). The question is how the case is in Austria. Are supermarkets allowed to distribute the stored water to the population without an official permission?

The Armed Forces have a private warehouse in which they store heavy equipment such as water treatment units and backup systems (Interview NBC Defence School), but also the Austrian RC workers together with two outside partners the so called Einkaufen-Service Gmbh and a warehouse at the outskirts of Vienna. Both provide equipment, medical appliances, emergency tents, heating devices, backup generators, water treatment utilities and other resources needed for daily tasks and the disaster response, which can also be send abroad if needed. Additionally, each national association has a small storage facility in order to be prepared all-round (Interview Austrian RC, 2015). The ministry is not in favor of warehouses due to the perceived low likelihood of power and water outages and the amount of food stored, but never used. The only contract they have is with the pharma industry in order to make sure that a certain amount of medication is available when needed. "*Nein, nein. Wofür sollten wir diese riesen Lager vorrätig halten? […] Es gibt Bevorratungen im Medikamentenbereich, aber auch nur für ganz was bestimmtes und nicht generell. Und dann Verträge mit Pharmafirmen, dass man sozusagen Prioritär bedient wird, wenn man bestimmte Dinge abrufen würde. [Und warum haben sie kein Lager?] Weil es einfach von der Wahrscheinlichkeit des Eintretens, das man es nutzt, mit dem Aufwand und dann noch in welchen Bereichen. Also, ich hab so viele Lebensmittelproduzenten in Österreich, die haben selbst genug auf Lager. Die kann ich ja jederzeit nutzen. Also dass nicht wir selbst ein Lager aufbauen, wo wir alles was da drinnen ist, entweder rechtzeitig wieder weitergeben müssen oder wegschmeißen, weil's abgelaufen ist*" (Interview MOTI, 2015).

An alternative option to storing food, water and equipment in warehouses would be to choose local schools or other public areas such as a stadium. This depends on the storage capacity of the place, but since schools also act as evacuation centers the problem of transportation would also be solved. Nevertheless, supermarkets usually have a lot of drinks and food stored that would last for up to four days, wherefore cooperation should in either way be considered. “*Und wenn man mal so durchrechnet so ein Großlager mit den wichtigsten Lebensmittelvorräten und das, was wir so in den Supermärkten haben, naja so zwei, drei, vier Tage kann Österreich schon noch davon leben*“ (Interview MOTI, 2015).

In order to be on the safe side, Petermann et al. (2011) highlight to conclude a safety partnership (“Sicherheitspartnerschaft”) between the public organizations or the ministry and private providers in which a disaster-proven supermarket and a warehouse offer storage space, communication means and backup generators. The warehouses and supermarkets would be noted down in an online platform and on a paper file that help to coordinate distribution even during a power cut (Petermann et al., 2011). According to the “National Progress Report on the Implementation of the Hyogo Framework for Action (2013-2015)”, Austria is planning to construct such a platform for disaster risk reduction. This platform shall include the common stakeholders such as all federal ministries, the Red Cross and other response organizations, but also the private sector and academia in order to improve collaboration (Staudinger, 2015).

A national platform can help define the task of who is responsible for what within the cooperation, whether it is the government, the responder organization, the water provider or the public. Regular meetings can assure an indirect control if the responsibilities are met, provide input due to differences in expertise and assure exchange since many tasks are covered by a variety of individuals. At the same time, though, unexpected situations may occur that require quick, flexible and on the spot decisions and actions (Menoni, 2001).

Public involvement

The possible creation of the platform emphasizes that communication with employees, the public sector and the population should have taken place already in advance in order to assure a consistent water provision and wastewater disposal. Before a disaster may have the chance to occur, it is essential to raise awareness among the population of industrialized nations since they usually have the financial and storage-related means to sore resources and in order to assure that they also take responsibility for their life in case of an emergency and do not only rely on outside support. The WHO emphasizes a bottom-up and community-based approach, which includes not only passive participation in decision-making processes, but also active involvement in training and education to enhance a change of attitude and awareness of the population and to create an environment of health, safety and resilience (WHO et al., 2013). Awareness-raising plays an essential role not only to increase the resilience, but also to decrease the likelihood of being affected. Given, that water or power outages are abstract in developed countries and often associated with severe weather events or terrorism attacks that take place in other countries than the own, the perceived likelihood is in general low.

People need to be informed about threats and risks, be motivated to store resources and increase the ability to help themselves by knowing water purification technologies (Petermann et al., 2011). The population will most likely not know how to use water treatment units, which can be especially dangerous when this lack of knowledge becomes obvious during the disaster (Ray & Jain, 2014). Therefore, the share of information on preventive measures and their application before and during a disaster plays an essential role and can be done via media channels, trainings and workshops or online via brochures (WHO et al., 2013). Important information that should and can easily be exchanged in advance is where the residence can procure safe water for drinking, cooking and personal hygiene either from bottled water, treatment tanks or open sources (Huang et al., 2011). By providing workshops and courses, the population can be guided on how to become more resilient to a possible blackout and water outage and how to pass this on to others (Bundesheer, 2012). Public support, for example, was essential after the Kobe earthquake and became increasingly visible via “self-governance” and “solidarity”. In the end 1.3 million volunteers worked in the disaster area. They were engaged in sorting, transportation and distribution of relief good, cleaning shelters and playing with children. Many of them were actually students operating the evacuation shelters accounting for half of the total amount of volunteers. In any case, many of the volunteers were disorganized and also did not receive any guidance from the government though they officially accepted them to help. Only by their own initiative, volunteers assigned leaders, individual duties and shifts (City of Kobe, 2010).

Hence, one of the main target groups should be young adults and students at universities. They should be prepared for disasters and learn how to act, to conduct first response and to treat, for example, water apart from similar first response mitigation measures. Such information is especially important since volunteers can also hinder the work of rescue teams. A second target group should be children. They need to be educated about altruism and helpfulness to neighbors, vulnerable population groups and friends (Interview Austrian RC, 2015). Sharing such values can improve the response and support within the population immensely allowing the organizations to focus on the most in need. Poor people and those with disabilities are usually more affected and vulnerable to emergencies than their healthy and educated counterparts (WHO et al., 2013). The population can help in such cases for which they need to be made aware. Hence, the Austrian RC currently tries to answer question on how to make the population more resilient. They have met up with other European RC national organizations, organized workshops and developed trainings. Such courses are not generalized, but adapted according to the region and the threats the population in this specific area may face. An area, for example, prone to flooding would focus on flood prevention. Within the workshops, the teams talk to the population about risk perception and awareness and threats while jointly developing solutions and response mechanisms at the end of the day (Interview Austrian RC, 2015).

Means to communicate with stakeholders and the public

Within those workshops, communication possibilities during a blackout also need to be covered. It can take place via alarm systems, radio broadcasting, flyers, personal communication and loudspeaker announcements. Furthermore, city halls, fire brigade houses and municipality houses can be used to distribute information, to put up notes, to share a radio and to provide personnel for private questions (Petermann et al., 2011). Additionally, schools and stadiums, which tend to be used as evacuation houses, could be used as distribution and coordination units. Once the population knows where they will receive information and support, a constant communication exchange and trust towards the stakeholders can be assured.

The Armed Forces use radio-relay systems, which can eventually also receive internet and ISDN, in order to communicate with different stakeholders and to pass on essential information. Alternatively, field wire and satellite communication can be used. However, field wires require mobile electricity providers, which need to be refueled regularly, and satellite telephones need to be connected to a base station, which also needs electricity. Radio communication systems work with batteries, rechargeable batteries and solar panels. A disadvantage here is that these need to be replaced regularly, so the question remains for how long these solutions are actually practicable (Petermann et al., 2011). According to the Austrian RC, short wave radio gadgets should function relatively long with car batteries. They are prepared to communicate with the national organizations via short wave radio gadgets at least as long as the batteries work. "*Wir können als […] noch relativ lange über Kurzwellenfunk kommunizieren, mit unseren Landesverbänden. Wir haben unsere Funkgeräte, aber wenn ich die Akkus natürlich nicht mehr laden kann und irgendwann werden auch die Batteriekapazitäten der Kurzwellenstationen erschöpft sein, dann ist es vorbei. […] Wenn ich kein Treibstoff mehr hab, kann ich zumindest die Autobatterien noch rausnehmen und an die Kurzweilstationen hängen […] und kann halt dann meine Kurzwellenkommunikation relativ lang noch mit Autobatterien aufrechterhalten. Aber irgendwann ist auch da Schluss*" (Interview Austrian RC, 2015). Hence, a continuous technical communication will not be possible to be maintained, wherefore active and direct communication will be indispensable the longer the blackout takes (Petermann et al., 2011).

Once also satellites and backup systems are dead, communication with employees, volunteers and the public can only continue via flyers or loudspeaker announcements. The downsides are that either requires printing machines to print the flyers, cars with enough fuel or other transportation means to pass on the information and a big amount of human resources to move from house to house. In case cars or fuel are not available anymore or are needed for other tasks, bicycles need to be available and thus should be stored by organizations so that they can be used as alternative transportation means. That way, hand-written leaflets could be distributed from house to house or be put up in the town hall or at community places (Interview Austrian RC, 2015). And in case languages differ, the Armed Forces can refer to a multilingual team or may request interpreter and translator from the embassies on site, who help communicating with the population in international missions, but also within Austria when immigrants need to be addressed (Interview NBC Defence School, 2015).

Throughout this chapter several management mechanisms for safe-drinking water and hygiene have been collected. A simply mechanism cannot be created given all the uncertainties that come along a risk as mentioned before. There are multiple authorities, legal guidelines and foreign players, a variety of disasters and unpredictability in duration, wherefore a wide overview and a lot of flexibility in preparation and response are necessary (Bissell, 2013). The overall goal to aim for is to minimize human suffering and upheaval, to keep economic losses as low as possible and to assure the continuity of the daily life as much as possible. In this regard, organizations and institutions do not need to aim for a continuing electricity supply, but to support and guide the population as good as possible in taking active preparatory steps.

This means that in advance communication and cooperation is inevitable. The population needs to be informed about water storage and treatment possibilities by having a stock of bottled water or keeping water taps and filters at home, and available communication means in times of a power outage. Furthermore, the water supply may be prioritized for certain institutions and areas limiting the available quantities. Active preparation is essential in order to assure resilience and be less dependent on outside help. This is also the case for the stakeholders, who should either rely on backup generators, renewable energy sources or self-sufficient energy systems. Solar panels, biogas and hand-turned pumps seem to be promising alternatives and are already worldwide used. Additionally, public/ private partnerships can help to provide storage places and bridge shortages in water supply and other resources. Some mitigation measures may not seem cost-effective for industries or businesses, while experience though shows that a lack of mitigation measures can have severe consequences for the public.

7. Implementing risk mitigation mechanisms

"Und man in gewisser Weise vorbereitet ist oder sich vorstellen kann wie es sein könnte…? Das ist nicht wie der Hase vor der Schlange steht, sondern ‚ok, das haben wir in der Tasche, da wissen wir wie das funktioniert"‘ (Interview DWP Vienna, 2015).

The last part of the risk management approach (Figure 2) summarizes possible implementation mechanisms for industrialized countries as exemplified for Austria and based on the literature and interviews mentioned in Chapter 6. The three main groups identified are water, electricity and fuel, and communication, which are essential for our daily life. Accordingly, these will be further investigated for possible implementation options by stakeholders.

First of all, implementation is not possible without risk awareness. Awareness of a direct correlation between an energy blackout and a water outage seems to exist in theory, but is missing in practice. This means that all of the interviewed stakeholders are familiar with the topic, one or the other even has already conducted a risk analysis for the water system, but a defined structure in thoughts and response mechanisms has not been identified yet. While Vienna receives water by gravitational flow, other households in Austria rely on groundwater wells or are located at hillsides for which electrical pumps are needed. Furthermore, Austria is prone to heat waves, flooding, snow storms and avalanches, which may all directly affect the electricity sector and indirectly the water sector. Power and water outages are usually the result of a cascade of events as the example in the introduction shall illustrate. Even if such an event seems surreal, a zero-risk never exists. Industrialized countries are equally prone to natural, societal and technical disasters as every other country. All of them cause harm to water availability in quantity and quality and subsequently, are threatening the health of people and the environment.

Table 5 provides an overview on the effects a blackout can have on water, electricity and fuel, and communication considering duration. The aim is to provide an idea on how much time stakeholders have until one or the other sector falls out, which should be prevented as much as possible. With every hour, day, week and month different sectors are affected, which makes mitigation and response more complicated. A lack of appropriate preparation measures would lead to economic costs for Austria of up to EUR 990 million within the first day and of up to EUR 1700 million on the second day. Duration and effects are based on experiences and observations shared by the interviewees and in the literature and should not be taken for granted, but assist as a guideline.

The water sector is the first one to come to a halt. With hour zero the population relies on own stored water sources and the help of first responders. At the same time or at least within the first day, the water stored in the toilet will come to an end depending on how often the toilet is flushed. If the population has stored bottled beverages or own filters to treat water from open sources, they should be able to cover the drinking-water demand for at least three days. Afterwards, the Armed Forces can help out for up to one month. The second sector to be limited is communication. Without backup generators or batteries telephone devices will not continue working. Satellite communication works for the longest time with up to three weeks. Yet, the longer the power outage takes the more necessary it is to communicate with the population. From week three onwards, people express anxiety, impatience, anger and even bitterness. This may cause upheavals and threatens their safety worsening the overall situation.

Table 5: Timeline of effects on water risk management caused by a blackout

	water	electricity and fuel	communication	side notes
blackout	water pumps stop working			
1 hour			telephones stop working	
12 hours	water storage in toilet is (close to) empty		telephones and electrical units with batteries stop working	
1 day	2-3 liter of water are needed/ person/ day			damage costs Austria: EUR 990 million
2 days		backup generators stop working		damage costs Austria: EUR 1700 million
		empty high evel water storage tanks		start of supply provision by the Armed Forces
3 days	Home storage of water and beverages comes to an end			
4 days	halt of wastewater treatment		minimum time satellite communication continues	
5 days				
6 days		latest day when tank in cars is empty		
1 week	restart of water in Los Angeles	restart of electricity in Kobe, Canada and Germany		Call out for international support
2 weeks			anxiety and impatience among the people no telephones in Kobe	
3 weeks			anxiety and impatience among the people	
			maximum time satellite communication continues	end of supply of the Armed Forces
1 month	maximum time water with low quality may be consumed	time until fuel is available if rationalized	anger and bitterness among the people	
2 months	restart of water in Kobe		anger and bitterness among the people	

Source: Own description

Emergency power is the most important aspect in case of a blackout. It can last the longest as backup generators work up to two days and fuel in cars is available for three to six days. If the fuel is rationalized it may even last for up to one month. These are all only approximate values dependent on the location, preparation means in place and season, but can help as a guideline to define priorities. In the end mitigation mechanisms should exist for at least a week. This is the time it took in Kobe, Germany, Canada and Los Angeles until the electricity and/ or water supply was back again. Some areas in Kobe were even without water for up to three months. It is difficult to make predictions on public behavior when the power and water have been out for over a week. Therefore, following week one, a call would be made for international help to support internal responders and to assure safety. This means, active preparations should not just be limited to one week, but should go beyond one week.

Independent of the duration of the power and water outage, several mitigation options have been identified for the three sectors, water, electricity and fuel, and communication, and are combined in Table 6. When discussing risk mitigation options, the most important point is that communication and the exchange of information should always take place in advance. As shown in Table 5, within the first hour to maximum twelve hours there will be no possibility to reach out to the public through the usual channels such as mobile phones. External communication is limited to landlines, which work through electric pulses assuring communication even when the power is out; loudspeaker announcements; radio broadcasting; and brochures and flyers at the time of the blackout, but also in advance. The latter could be, for example, the blackout brochure published by ACPA and should be made easily and quickly available. The other organizations do not need to create new information, but share the one that already exists. This could be online or when no internet exists in city halls, fire brigade houses and municipality houses, where also hand-written notes can be put up in case no printing machines function any more.

Internal communication within emergency response units is more complicated since direct and quick communication is necessary at the point of the blackout. Some organizations can rely on radio relay systems or satellite communication units, but they are not to all accessible. Therefore in advance, training, workshops and meetings are indispensable. Risk communication channels to raise risk awareness vary from news publications to international and national platforms where all stakeholders are identified as well as their specific responsibility. The last option seems especially promising.

Table 6: Implementation options to mitigate the effects of a water and power outage

Water	Electricity	Communication
Water sources: • pool water • rainwater • domestic water wells • artificial static water supply sources • open sources • hand-turned pumps • high-level water storage tanks • mobile water tanks • water from neighboring cities • small water channels • bottled water **Water treatment:** • water filtration • silver chloride pills • UV light irradiation • boiling • distillation • chlorination **Hygiene:** • mobile toilets • plastic bags • manholes in public places connected to the sewage system	**Emergency electricity provision:** • backup generators plus fuel • shared backup generators • rent backup generators • energy self-sufficient systems: photovoltaic panels, wind parks, sludge fermentation	**Internal communication:** • radio-relay systems • field wire • satellite communication systems with batteries, rechargeable batteries or solar panels • short wave radio gadgets with car batteries **External communication:** • alarm systems • radio broadcasting • flyers and brochures • personal communication • loudspeaker announcements **External communication places:** • city halls • fire brigade houses • municipality houses **Risk communication channels:** • news • specific events: change of the millennium • seminars, workshops • environmental and political actions • public incentives • platforms • books

Source: Own description

Without electricity, emergency communication or online documents are though not available. Therefore, backup generators should be stored, shared or rented in order to continue management procedures and to keep an overview about happenings. Self-sufficient energy systems such as photovoltaic, wind and biogas systems are currently only considered as an option to minimize the effects of a blackout and not yet reality. Their advantage is that one or the other is implementable for either small or big industries and thus can keep at least a minimal operation possible. For example, a 100 percent water supply or a complete wastewater treatment should not be taken as a goal, but priorities should be set to cover the areas that are most essential to not harm the health of the population and to not threaten the environment.

In addition to energy self-sufficient systems the following preparatory “water sources” could be considered: high-level water storage tanks and reservoirs, domestic water wells, hand-turned pumps, water from neighboring cities and bottled water. Water fountains that are supplied with piped water through gravitation, for example, could be put up at central points in cities and villages, which allow retrieving water with a hand-turned pump. This is especially promising in cities such as Vienna, where the water flow would not be disrupted due to the Mountain Spring Pipeline. Cities and villages surrounding Vienna could equally make use of this favorable construction and retrieve the water needed. Furthermore, given that the power and water outages are locally- or regionally-limited, neighboring cities could install a connection between their water pipelines in order to help each other out. The transmission could be controlled through a contract person. An agreement would also be recommendable for providers of bottled water and drinks. Supermarkets and beverage providers could distribute stored bottled water to those who do not have their own water stored or who already ran out.

Alternatively, the population needs to be made aware on how to treat water. Some might need to refer to open water sources, rainwater or pool water to meet their demand. Several treatment options exist such as chlorination, filtration and silver chloride pills. All of them do only work to a limited degree of contamination, wherefore pretreatment, e.g. filtration, is required and further pollution of the water should be prevented. This also implements for the wastewater treatment plant, which might have to dispose untreated wastewater directly into open water sources. Plastic bags or mobile toilets need to be distributed, picked up and cleaned in case the flushing of the toilet is not possible. Alternatively, manholes could be dug at public places, connected to the sewage systems and surrounded by walls in order to prevent open defecation and to protect privacy.

Although, water pumps will stop working immediately following a power outage, the water provision and wastewater disposal may not be the first problem, a lack of planning certainly is. "*Und in ein paar Stunden habe ich kein Problem mit der Wasserversorgung und –entsorgung. Ich meine, ja klar, es wird irgendwann mal eine Verstopfung geben, aber da haben wir nicht wirklich eine bedrohliche Situation. Spannend wird's erst, wenn wir wirklich sagen, jetzt geht mal zwei, drei Tage nichts. Und dann müssten wir uns überlegen, was für ein Szenario wäre denn das*" (Interview MOTI, 2015). So far there is a lot of trust between different stakeholders without knowing what the other one is doing or not doing. For example, neither of the interviewees felt responsible for the wastewater disposal and the assurance of water for hygienic matters though this is an essential part of the daily life.

A couple of management mechanisms have been provided, but now it is up to the stakeholders to consider one or the other option depending on their needs. A SWOT analysis (strengths, weaknesses, opportunities and threats) may help to investigate the current state-of-the-art. It helps to identify potential strengths, weaknesses, opportunities and threats of an organization or strategy and unsheathes possible improvements, gaps and obstacles (UK Cabinet Office, 2004). Such obstacles could include the lack of a backup system, a lack of awareness and prioritization, but also the implementation of a self-sufficient energy system or good solidarity between stakeholders. A general weakness may be the lack of a public/ private partnership. This seems to be an easy and quick way to assure supply and support by warehouses, supermarkets, mobile toilet suppliers and drinking-water providers while assuring control and liability for their products.

Overall, several ways have been found to increase awareness and attract attention to power and water outages in industrialized countries. In the end, it does not only depend on the stakeholders to take action and to apply plans, but also on the population to make compromises, to prepare and to share ideas.

8. Conclusion

"*[…] Wir sprechen von einem Szenario, wo wir zwar Thesen aufstellen können und Szenarien abbilden und auch theoretisch durchspielen, aber in der Praxis ist das nicht gegeben. Und jetzt muss man natürlich sagen, das heißt der Amokhirsch Blackout, was jetzt so auch ein Amokschwert ist, nämlich insofern, dass wahrscheinlich keiner wirklich genau sagen kann, wie eskaliert's und wie schnell eskaliert's*" (Interview Austrian RC, 2015).

The causes for a blackout and a water outage are as diverse as the effects a blackout can have on the daily life including water supply, water quality and wastewater disposal. With the help of a risk management approach a reference to the objectives mentioned in Chapter 2.1. and a variety of additional insights have been given. The objectives are to (1) define and analyze the threat a blackout can have on the water system; (2) express the necessity of planning with and integrating of different stakeholders in the decision-making process, trainings and workshops; and (3) show the necessity to communicate with different groups before a disaster may occur. The overall aim is to raise awareness, attract attention and assume responsibility for risks associated with a water outage caused by a blackout that cause severe disruption of daily life.

The most important conclusion is those risks always exist. There can never be a "zero-risk", because either the severity of harm or the probability of occurrence of a hazard exists, causing the risk to be greater than zero. Due to the increased interconnectedness of today's energy grid, the critical infrastructure and life in general, there are not only positive conclusions to be drawn, but also the amount of possible threats have exponentially increased. This work shall help closing the lack of publications defining the connection between blackouts and water outages and the need for mitigation measures. Risk assessments and implementation of prevention measures are cost- and time-intensive, but economic damages are equally high and indirect costs such as human suffering cannot be quantified. Even if the probability of a disaster may be very low, the gain from prevention from a human perspective is priceless.

Early planning and preparation including all possible stakeholders are necessary due to the variety of causes for a blackout and water outage and the diversity of sectors within the critical infrastructure that are hit. A blackout must not be the disaster itself, but can be caused by natural, societal or technical events. Positive developments, for instance increased interconnectedness between technological systems or mobile phones, bring new problems with them. For example, changes in the energy sector towards increased implementation of renewable energy sources may lead to an overload of the energy grid due to peak loads; improved technology make the system more complex and defective providing reference points for cyber-attacks; or more extreme climate events such as winds and flooding may break electricity transmission lines and contaminate open water sources. In all cases the energy and water sector would directly or indirectly be affected and come to a complete halt.

Domino effects are the most threatening for today's society and yet create a vulnerability paradox contradicting the perception of risk and reality. An assumption of a low likelihood or a denial of a possible blackout due to a lack of local experiences or the perception that no preparations can be taken either way lead to low or no preparation measures at all increasing the severity of the consequences. For example, if no organization feels responsible for the wastewater disposal, the outcome might be a lack of hygienic behavior and waterborne diseases due to the contamination of open water sources. An approached discussed was to conduct public/ private partnerships with beverage suppliers or mobile toilet providers. A contract would speed up and simplify the response rather than waiting until the disaster occurs. This said, in case of a blackout the means to communicate to stakeholders are limited to nonexistent.

Traditional telecommunication via mobile phones is ceased and only satellite communication and radios work for a few more days as long as backup generators or car batteries are available. Mobility is limited to bikes and by foot, emphasizing the need to communicate early on. First responders and on the spot volunteers are essential in case of disasters due to their local knowledge and early on availability. They need to be trained in first response mechanisms and simple water treatment technologies. If this is not the case, response might be delayed or even miscommunicated causing distrust and anger with proceeding time. Independent of how and when communication takes place, the goal of respective stakeholders should be to minimize human suffering, to keep economic losses low and to assure the continuity of daily life as much as possible.

Several management mechanisms exist of which the essential ones are awareness-raising and the attraction of attention. Risk perceptions and tolerability depend on mental constructions, resilience and vulnerabilities. Subsequently, mitigation measures need to be adapted according to the region, the population density, the existence of vulnerable groups such as migrants or the elderly, and the environmental threats and potentials. There is not a sole risk management guideline that can be created or applied, but flexibility and a situational analysis are required to increase effectiveness. Independently, certain mechanisms can be implemented that can constrain the risks and effects. One point that applies to all disasters is the importance of being aware and communicating before a disaster occurs, and to prepare actively applying technological, societal and managerial approaches. Awareness is the first step, but it is not enough since blackouts and water outages pose nowadays major risks to industrialized countries.

References

Austrian Association for Gas and Water (OVGW) (2015a): Ein Blackout und die Wasserversorgung. In: Wirtschaftskammer Oesterreich (ed.), Tagungsband. Symposium Wasserversorgung: 152-159.

Austrian Association for Gas and Water (OVGW) (2015b): Blackoutprävention. Netzsicherheit. In: Wirtschaftskammer Oesterreich (ed.), Tagungsband. Symposium Wasserversorgung: 160-168.

American Society of Civil Engineers (ASCE) (2009): Guiding Principles for the Nation’s Critical Infrastructure. http://content.asce.org/files/pdf/GuidingPrinciplesFinalReport.pdf - accessed: February 1, 2015.

Austrian Power Grid AG (APG) (2011): APG-Masterplan 2020. 4 edition. http://www.apg.at/de/netz/netzausbau/masterplan (accessed: 2 April 2015).

Beatty, M.E.; Phelps, S.; Rohner, Ch. & Weisfuse, I. (2006): Blackout of 2003: Public Health Effects and Emergency Response. Public Health Reports. Centers for Disease Control and Prevention: 121, 36-44.

Bissell, R. (2013): What is a Catastrophe, and Why is This Important? (Ch1). In: Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Bissell, R. & Kirsch, Th. (2013): Public Health Role in Catastrophes (Ch8). In: Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Bruch, M.; Kuhn, M. and Schmid, G. (2011): Power Blackout Risks: Risk Management Options. Emerging Risk Initiative – Position Paper. https://www.allianz.com/v_1339677769000/media/responsibility/documents/position_paper_power_blackout_risks.pdf - accessed: October 3, 2014.

Bundesheer (2012): Blackout. Truppendienst 325: 1. http://www.bundesheer.at/truppendienst/pdf/blackout1.pdf - accessed: October 22, 2015.

Bundesministerium für Inneres (BMI) (nn): Zivilschutz in Österreich. http://www.bmi.gv.at/cms/bmi_zivilschutz/ - accessed: January 21, 2015.

Bundesministerium für Wissenschaft, Forschung und Wirtschaft (BMWFW) (2014): Energiestatus Österreich 2014. Entwicklung bis 2012. http://www.bmwfw.gv.at/EnergieUndBergbau/Energieeffizienz/PublishingImages/Energiestatus%20%C3%96sterreich%202014_HP-Version.pdf - accessed: March 14, 2015.

Castillo, A. (2014): Risk Analysis and Management in Power Outage and Restoration: A Literature Survey. *Electric Power Systems Research 107*: 9-15.

Center for Disease Control (CDC) (2014): Emergency Water Supplies. http://emergency.cdc.gov/preparedness/kit/water/ - accessed: October 5, 2014.

Chang, St. E. (2009): Infrastructure Resilience to Disasters. Frontiers of Engineering Symposium. Session on “Resilient and Sustainable Infrastructures”: 1-4.

Chang, St.; Pasion, C.; Tatebe, K. & Ahmad, R. (2008): Linking Lifeline Infrastructure Performance and Community Disaster Resilience: Models and Multi-Stakeholder Processes. Technical Report MCEER-08-0004: USA.

City of Kobe (2010): Comprehensive Strategy for Recovery from the Great Hanshin-Awaji Earthquake. http://www.city.kobe.lg.jp/safety/hanshinawaji/revival/promote/img/English.pdf - accessed: March 15, 2015.

Cooper, D.F.; Grey, St.; Walker, P. & Raymond, G. (2004): Chapter 1: The Project Risk Management Approach. http://media.wiley.com/product_data/excerpt/17/04700228/0470022817.pdf - accessed: March 25, 2015.

Department of Homeland Security Office of Cyber and Infrastructure Analysis (DHS/OCIA) (2014): Sector Resilience Report: Water and Wastewater Systems. 29.12.2014.

Elsberg, M. (2012): Blackout. Morgen ist es zu spät. Novel: 15th edition. Blanvalet Verlag: Germany.

Gude, V.G. (2015): Energy and water autarky of wastewater treatment and power generation systems. Renewable and Sustainable Energy Reviews 45: 52-68.

Gugerbauer, N. (2015): Wasserrechtsgesetz (WRG). https://www.jusline.at/Wasserrechtsgesetz_%28WRG%29_Langversion.html – accessed: June 6, 2015.

Government of Canada (2003): A Framework for the Application of Precaution in Science-based Decision-making About Risk. http://www.pco-bcp.gc.ca/docs/information/publications/precaution/Precaution-eng.pdf - accessed: March 25, 2015.

Hillson, D. (2004): When is a Risk not a Risk?. http://www.who.int/management/general/risk/WhenRiskNotRisk.pdf - accessed: March 24, 2015.

Hohl, M.; Brem, St.; Balmer, J.; Schulze, T.; Holthausen, N.; Vermeulen, E.; Bohnenblust, H. & Zulauf, Ch. (2013): Katastrophen und Notlagen Schweiz. Risikobericht 2012. Bundesamt für Bevölkerungsschutz. http://www.alexandria.admin.ch/bv001490434.pdf - accessed: March 29, 2015.

Huang, L.-Y.; Wang, Y.-Ch.; Liu, Ch.-M.; Wu, T.-N.; Chou, Ch.-H.; Sung, F.-Ch. & Wu, Ch.-Ch. (2011): Water Outage Increases the Risk of Gastroenteritis and Eyes and Skin Diseases. BMC Public Health 11: 726-733.

Hunter, P.R.; Payment, P; Ashbolt, N. & Bartram, J. (2002): Chapter 3. Assessment of Risk. http://www.who.int/water_sanitation_health/dwq/9241546301_chap3.pdf - accessed: March 24, 2015.

Interview Austrian Red Cross (Austrian RC) (2015): Division Operations, Innovation and Subsidiaries, January 20, 2015, 09:00 – 11:30.

Interview Drinking-water Provider (DWP) Bad Fischau (2015): February 26, 10:00 – 11:00.

Interview Kobe City (2015a): Kobe City Waterworks Bureau, March 13, 2015.

Interview Kobe City (2015b): Planning Division Sewage Works and River Management Department, Kobe City Public Construction Projects Bureau, March 19, 2015.

Interview Ministry of the Interior (MOTI) (2015): Division Operation, Crisis and Disaster Coordination, Directorate-General “Public Protection”, January 26, 2015, 09:00 – 10:30.

Interview NBC Defence School (2015): Chemistry, Water Analysis and Water Hygiene Specialist, January 23, 2015, 09:15 – 10:30.

Interview Wastewater Treatment Plant (WTP) Laxenburg (2015): January 24, 2015, 09:00 – 11:30.

Interview Wastewater Treatment Plant (WTP) Vienna (2015): January 22, 2015, 09:15 – 10:00.

Interview Wiener Wasser (MA31) (2015): Outer Pipe System and Crisis Management, March 19, 2015, 09:00 – 09:45.

Keegan, M. (2004): The Orange Book. Management of Risk – Principles and Concepts. HM Treasury. http://www.who.int/management/general/risk/managementofrisk.pdf - accessed: March 25, 2015.

Kirsch, Th.; Kiriu, N. & Bissell, R. (2013): Catastrophes in Haiti and Japan (Ch15). In: Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Laugé, A.; Hernantes, J. & Sarriegi, J.M. (2013): Disaster Impact Assessment: A Holistic Framework. In: Proceedings of the 10th International ISCRAM Conference. Comes, T.; Friedrich, F.; Fortier, S.; Geldermann, J. & Müller, T. (eds.), DE: 730-734.

Levy, M.J. & Bissell, R. (2013): Overview of Critical Infrastructure in Catastrophes (Ch7). In: Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Llorens, D. (2012): How much electricity does a solar panel produce? http://www.solarpowerrocks.com/solar-basics/how-much-electricity-does-a-solar-panel-produce/ - accessed: June 6, 2015.

McEntire, D.A. (2013): Understanding Catastrophes. A Discussion of Causation, Impacts, Policy Approaches, and Organizational Structures (Ch2). In:

Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Menoni, S. (2001): Chains of Damages and Failures in a Metropolitan Environment: Some Observations on the Kobe Earthquake in 1995. *Journal of Hazardous Materials 86*: 101-119.

Ministry of Life (2014): Kommunales Abwasser. Österreichischer Bericht 2014. The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW). http://www.bmlfuw.gv.at/publikationen/wasser/abwasser/EU-Richtlinie-91-271-EWG--ueber-die-Behandlung-von-kommunalem-Abwasser-Oesterr---Bericht-2014.html - accessed: June 8, 2015.

Nakashima, M.; Lavan, O.; Kurata, M. & Luo, Y. (2014): Earthquake Engineering Research Needs in Light of Lessons Learned from the 2011 Tohoku Earthquake. Earthquake Engineering & Engineering Vibration 13(1): 141-149.

Petermann, Th; Bradke, H.; Lüllmann, A.; Paetzch, M. & Riehm, U. (2011): Was bei einem Blackout geschieht. Folgen eines langandauernden und großflächigen Stromausfalls. 33 Studien des Büros für Technikfolgen-Abschätzung beim Deutschen Bundestag. Edition Sigma, Berlin.

Prisching, M. (2008): Vorbemerkung: Katastrophen, ihre Deutung und ihre Bewältigung. In: Allgemeine Perspektiven der Krisen- und Katastrophenforschung. Grossmann, G. (ed.). LIT Verlag GmbH & Co. KG: Austria. i-viii.

Ray, Ch. & Jain, R. (2014): Low cost emergency water purification technologies. Integrated water security series. Butterwoth-Heinemann (BH), USA.

Reichl, J. & Schmidthaler, M. (2011): Blackouts in Österreich (BlackÖ. 1). Teil 1. Endbericht. http://www.energyefficiency.at/dokumente/upload/Endbereicht-Blackoe_e544f.pdf - accessed: March 29, 2015.

Renn, O. & Klinke, A. (2015): Risk Governance and Resilience: New Approaches to Cope with Uncertainty and Ambiguity (Ch. 2). In: Risk Governance. The Articulation of Hazard, Politics and Ecology. Paleo, U.F. (ed.). Springer.

Ruback, J.R.; Wells, A.S. & Maguire, B.J. (2013): Methods of Planning and Response Coordination (Ch11). In: Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Schwab, A.K. & Beatley, T. (2013): Ethics in Catastrophe Readiness and Response (Ch3). In: Preparedness and Response for Catastrophic Disasters. Bissell, R. (ed.). CRC Press. Taylor & Francis Group: USA.

Shi, P. & O'Rourke, Th.D. (2008): Seismic Response Modeling of Water Supply Systems. Technical Report MCEER-08-0016. Cornell University.

Shinozuka, M. & Chang, St. E. (2004): Evaluating the Disaster Resilience of Power Networks and Grids. In: Modeling Spatial and Economic Impacts of Disasters. Okuyama, Y. & Chang, St. E. (editors). Springer-Verlag: Germany: 289-310.

Staudinger, M. (2015): National Progress Report on the Implementation of the Hyogo Framework for Action (2013-2015). http://www.preventionweb.net/files/43252_AUT_NationalHFAprogress_2013-15.pdf - accessed: April 30, 2015.

United Kingdom (UK) Cabinet Office (2004): Strategy Survival Guide. www.wlga.gov.uk/download.php?id=225&l=1 - accessed: March 25, 2015.

United Nations/International Strategy for Disaster Reduction (UN/ISDR) (2007): Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf - accessed: March 30, 2015.

United Nations/International Strategy for Disaster Risk Reduction (UN/ISDR) (2015): Sendai Framework for Disaster Risk Reduction 2015-2030. http://www.wcdrr.org/uploads/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf - accessed: May 4, 2015.

United Nations Office for Disaster Risk Reduction (UNISDR) (2011): European Forum for Disaster Risk Reduction (EFDRR). Organization Profile. http://www.preventionweb.net/english/professional/contacts/profile.php?id=8679 – accessed: May 4, 2015.

Valcik, N.A. & Tracy, P.E. (2013): Case Studies in Disaster Response and Emergency Management. CRC Press, Taylor & Francis Group: USA.

Van Leuven, L.J. (2011): Water/Wastewater Infrastructure Security: Threats and Vulnerabilities (Ch. 2). In: Handbook of Water and Wastewater Systems Protection. Clark, R.M.; Hakim, S. & Ostfeld, A. (eds.). Springer: 27-46.

Wien.at (nn a): The First Vienna Spring Water Main – A history of Vienna's water supply. http://www.wien.gv.at/english/environment/watersupply/supply/history/first-pipeline.html - accessed: May 29, 2015.

Wien.at (nn b): Wasserbehälter der WienerWasser. http://www.wien.gv.at/wienwasser/versorgung/wasserbehaelter/ – accessed: June 6, 2015.

World Bank (2014): Infographic: Thirst Energy – Energy and Water's Interdependence. http://www.worldbank.org/content/dam/Worldbank/Feature%20Story/SDN/Water/Water-Thirsty-Energy-Infographic-FULL-Vertical-900.jpg - accessed: March 25, 2015.

World Health Organization (WHO) (2011): Guidelines for Drinking-water Quality. Fourth Edition. Switzerland.

World Health Organization (WHO); Public Health England & United Nations Office for Disaster Risk Reduction (UNISDR) (2013): Emergency Risk Management for Health. Overview. Emergency Risk Management for Health Fact Sheet. http://www.who.int/hac/techguidance/preparedness/risk_management_overview_17may2013.pdf?ua=1 - accessed: March 25, 2015.

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