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Virtual Energy Hero: Virtual Reality Gamification of Smart Energy - Smart City Technologies

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Virtual Reality Gamification of Smart Energy – Smart City Technologies

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Bachelor of Science degree

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Abstract

Virtual reality has been labelled as the gaming technology of the future for its ability to place the player in an immersive game experience. Its expansion has pushed into several subjects, including education. This project recommends ways of improving a virtual reality demonstration game, called Virtual Energy Hero (VEH). VEH’s aim is to increase public awareness on smart energy, smart city, and renewable topics in the city of Winterthur, Switzerland. We conducted expert interviews, workshops, and surveys, with the purpose of gathering information on VEH. By analyzing the available data and responses, our IQP team provided recommendations for the continued improvement and success of the game, such as improved interactivity, optimized knowledge transfer, and extended accessibility of VEH.
Acknowledgements

This project would not have been possible without these individuals and organizations, to whom we extend our sincerest thanks:

- The Zurich University of Applied Sciences (ZHAW), for hosting us and allowing us to contribute to the development of a pioneering project in the field of virtual reality.

- Worcester Polytechnic Institute (WPI), for granting us the opportunity to work with ZHAW and securing the necessary accommodations for our stay.

- Our project advisors, Professors Dirk Albrecht and John Orr, for their continued support and highly valuable feedback that helped steer the development of our project to its fullest potential. Their rapid responses to our paper submissions helped us fine-tune and concisely communicate our ideas. Of course, the occasional free food is also not to be forgotten.

- Our project leads, Mirjam West, Onur Yildirim, and Juliana Zapata, for their guidance and input during the development of our recommendations. Without their hard work and key insights, we would not have been able to develop the game recommendations to the extent that we did.

- Our interviewees, Dr. Silvia Ulli-Beer, Vicente Carabias-Hütter, Pascal Kienast, Monica Castillo, and Professors Lee Sheldon and Jeffrey Kesselman, for sharing their expertise with us, allowing us to produce well-informed recommendations for the further development and extension of Virtual Energy Hero.
Executive Summary

In the past several decades, energy demand in developed nations has drastically increased while quality of life (determined using the change in average life expectancy as well as per capita gross domestic product (GDP) for median-income households) has remained largely stagnant. High-consuming countries such as the U.S. and much of Europe have continued to devote significant resources towards expanding and maintaining current levels of energy generation and delivery with disproportionately small reward to quality of life. The global energy future is an issue of critical importance, which can be addressed in part through raising public awareness and positive motivations towards smart energy and smart city initiatives. To do so, a proper educational platform is required. Labelled as the gaming technology of the future for its ability to fully immerse the player in a comprehensive game experience, virtual reality’s expansion has pushed into several fields, including education.

This project, sponsored by the Zurich University of Applied Sciences (ZHAW), uses virtual reality as a platform to gamify smart energy and city topics. With the help of an avatar, Oscar the Owl, the game takes the player through the city of Winterthur, where our project is located (see Figure A). The game, titled Virtual Energy Hero (VEH), quizzes participants on various aspects of smart energy, with the intent of raising their awareness and motivations towards an energy transition in Switzerland. The final goal of this project is the further development of the VEH game concept in accordance with ZHAW initiatives and those of its partner organizations in order to expand its applications as a tool for education, research, and enjoyment. To accomplish this, we provide three specific sub-goals to help VEH achieve its intentions:

1. Implement a method to draw relevant statistical value from participant data in VEH, including alteration of the question script and story line.
2. Through VEH, raise participant awareness and motivations towards the implementation of smart energy, smart city, and renewable initiatives in Winterthur.
3. Demonstrate the use and versatility of virtual reality gamification for research, education, and entertainment through the applications and possibilities of VEH.
Methodology and Results:

For the completion of the project goals, our IQP team conducted a literature review and interviewed experts to gain a solid foundation, held meetings with industry partners and sponsors to understand their goals, ran surveys on the existing game, and applied the information that was gathered in a variety of recommendations: applying VR gamification in energy and marketing research, improving player immersion and interaction, and optimizing knowledge transfer of smart city and smart energy topics.

The literature review covered smart energy and smart city technologies with an enhanced focus on the energy infrastructure in Switzerland; a broad overview of gamification and discussion of what constitutes success within gamification; virtual reality systems and problems; and the transfer of knowledge from experts to laymen. The information was supplemented by several expert interviews both in the United States and Switzerland.

Initial tests of ZHAW’s VEH were conducted through personal playthroughs of the current game, with later tests conducted by demonstrating VEH at public events and surveying participants, which allowed us to understand prominent areas for improvement. First, the storyline featured a weak narrative which gave players little reason or motivation for their actions. Next, the gameplay mechanics were similar to a 2D quiz, which did little to deliver an engaging and immersive experience to the player. Finally, the transfer of knowledge had much room for optimization, with the point system and many of the current questions lacking meaning or relevance to smart city initiatives and consumer awareness. From our tests and surveys, we gained valuable knowledge on VEH from a user experience standpoint. Focusing on player
immersion, educational value, and the implementation of smart technologies to serve the interests of stakeholders, this collection of responses helped steer our development of the game concept into an immersive, comprehensive educational tool.

Throughout the implementation of our methods, project goals often changed direction due to rapidly growing interests in gamification and VR from new parties. This resulted in many separate ideas, such as a storyline for a specific utility company that shifted the game to be a marketing tool. In various workshops conducted with our stakeholders, our team presented concept drafts aimed at improving VEH according to stakeholder needs. Using the feedback from these workshops and the various project changes, our concepts, priorities, and therefore recommendations were further refined. To this end, we provide a multitude of recommendations for the continued improvement and extended applications of ZHAW’s VEH such as changing the storyline to improve interactivity and optimize knowledge transfer within the game, and adding a website to expand the accessibility.

**Recommendations:**

A compelling story is paramount to any game, in order to induce a lasting impact on the player. Through interviews with a serious games expert and the literature review, the storyline was quickly identified as a much-needed area for improvement in VEH. Our final storyline recommendations split into two avenues. One longer storyline focused on interactivity in addition to maximizing player engagement with a more compelling narrative: saving the future of Winterthur through making concrete energy changes. The other storyline was identified by holding meetings with industry partners and sponsors; it focused on marketing real life energy services and products in a concise game where the player becomes an intern for a utility company and learns about their available products. These storylines can have a larger knowledge transfer impact with the implementation of three brand new scenes: The Balloon Over Winterthur, Smart Living and Smart Home scenes. These scenes would fully encompass smart city and smart energy topics and allow for increased interactivity via a greater influence over the game environment, enhanced utilization of VR’s capabilities, more variety in the game’s challenges and the introduction of specific products and services into the game.

An overarching theme to the game concepts is optimizing knowledge transfer in the game. It is important to have a profound effect on players during the short time they are playing
the game. This can be accomplished through the reworking of the question and quiz system in the game. There exist trivia questions in the game that can be seamlessly replaced with important flexibility, consumer mindset, and other specific energy topic questions. The inclusion of these new topics in combination with a more engaging game environment work to further improve upon knowledge transfer.

Introducing proper game mechanics helps to streamline the knowledge transfer, interactivity, and general aesthetics of VEH. The quiz in the game is a two-dimensional wall of text that is near impossible for the player to miss (see Figure B). The format for the initial game was appropriate, but as it develops the format has to improve concurrently to become more interactive to make use of virtual reality as a platform, such as replacing the quiz formats with highlighted areas for the player to interact with. This can be seen in the new Smart Home scene, where the player would be surrounded on all sides by objects and can select five from a possible 15 changes inside the house that they believe carry the largest impact.

![Figure B: VEH Current Question Display](image)

Finally, drawing relevant statistical data from the game yields many avenues to explore in the future. With the inclusion of an extractable data system, this can be accomplished. This feedback system would allow for player responses, answers to survey questions, and general data from the game to be taken and utilized in several facets, including product design. This can help extend the game to become a research tool as well as a marketing tool.

The recommendations embedded in this report fully address the goals of the project. With their implementation, VEH can grab the attention of players and encourage them to pursue and
apply energy efficiency in their own lives. Additionally, the concepts aid in the expansion of the

game as an educational, entertainment, and research platform.
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Authorship

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Chapter 1: Introduction

In the past several decades, energy demand in developed nations has drastically increased while quality of life (determined using the change in average life expectancy as well as per capita gross domestic product (GDP) for median-income households) has remained largely stagnant (Mazur, 2011). The objective of this project is to raise public awareness of the dangers of overconsumption of nonrenewable energy sources, as well as the transition towards the implementation of more renewable energy systems through the utilization of a virtual reality (VR) game. Our project was completed alongside the Institute of Sustainable Development at the Zurich University of Applied Sciences (ZHAW). To reach the public on these energy issues, they are beginning to explore the use of VR in a short, 10 minute demonstration tool on the HTC Vive: Virtual Energy Hero (VEH). VEH is to be used at various events to increase users’ understanding of the ongoing energy transition in Switzerland and its impact on their everyday lives. Further development of VEH yields opportunities to contribute to ZHAW’s research and aid their industry partner, Stadtwerk Winterthur, a utilities company in Winterthur.

Citizens of high-consuming countries such as the U.S. and much of Europe continue to devote significant resources towards expanding and maintaining current levels of energy generation and delivery with disproportionately small reward to quality of life. Since 1985, primary energy consumption in the U.S. has risen by over 25%, whereas median-income GDP has risen by only 4% since 1986 (FRED, 2014), and life expectancy by only 3.7% since 1986 (World Bank, 2017). The US alone spends hundreds of millions of dollars per year maintaining outdated energy infrastructure (DOE, 2017). Here, it is apparent that overconsumption of energy is an issue of critical importance which demands to be addressed. Determining the point at which quality of life plateaus with regard to energy usage will alleviate economic and environmental pressures, allowing nations to seek other avenues to improve quality of life for their citizens. The most important step toward reducing energy consumption is raising public awareness of how we may save energy at a marginal cost to the quality of everyday life (Mazur, 2011). The Swiss Federal Institute of Technology in Zurich based their proposed 2000-Watt Society vision, a policy model that aims to reduce per capita energy consumption, on the idea that quality of life plateaus at around 2000 watts of energy usage per person at any given moment, or 17.5 MWh per capita annual consumption. A study conducted by Allan Mazur in 2011 goes further to argue...
that life expectancy plateaus at only 5 MWh per capita annual consumption. Additionally, the increase in energy usage between 1980 and 2006 came with almost no increase to indicators of quality of life (Mazur, 2011).

Raising public awareness of the relationship between energy consumption and quality of life as well as the benefits of energy awareness and conservation is of critical importance in today’s world. A 2013 study conducted by the University of Cambridge found that public disapproval of smart metering technology that would track usage data has gone down from 30% in 2010 to 22% (Oseni et al., 2013). Keeping this trend of increasing public approval on a global scale, in addition to bolstering public support for the implementation of renewables, will facilitate the transition of the most over-consuming countries towards becoming more energy efficient. The Swiss Smart Energy Strategy 2050 tackles challenges such as those mentioned above; their plan hinges on increasing energy efficiency, upgrading energy infrastructure to be more heavily dependent on renewables (solar, wind, hydro, biomass, etc.), and phasing out nuclear energy (DETEC, n.d.). This relates directly to demand-side flexibility, which presents even greater opportunity to optimize the cost efficiency of energy infrastructure. For example, easing grid load during peak hours reduces consumption and infrastructure needs, but requires consumers to be more cooperative with the timing of their energy use. This can be achieved in part by raising public awareness and positive motivations towards smart energy and smart city initiatives, and therein lies the objective of this project.

VEH combines learning and entertainment to raise awareness of energy topics. This kind of game is known as a serious game, and the coupling of learning and fun has been found to positively influence the public in regards to energy conservation and energy awareness (Johnson, 2017). Additionally, VR has recently improved in both quality and availability, providing a new medium for serious game creation (Lamkin, 2018). This relatively new technology comes with some concerns, including the possibility of dizziness or nausea. This becomes less of a problem as the hardware improves, but is also dependent on the game’s programming (Hettinger & Riccio, 1992). Some broader concerns, not specific to VR, include whether the educational aspect of the game is overshadowed by the entertainment, whether users learn from the game, and whether the knowledge they gain will be retained and applied in the future.

The vision of our project is to continue the development of ZHAW’s VEH in cooperation with the game’s developers, Cymmersion, both evaluating the current tool and areas it can be
improved as well as proposing future additions or changes to VEH so it can help ZHAW and Stadtwerk Winterthur in their work. Based on a review of literature, supplemented by discussions and interviews with local experts, our team developed a plan of action for our time in Switzerland: conduct expert interviews, present at workshops with industry partners, display the game at various events, and survey the players of the game. By analyzing the data we collected through our interviews and surveys, we evaluated the existing game and provided recommendations for improving and expanding the tool for further applications that benefit ZHAW, Cymmersion, and Stadtwerk Winterthur.
Chapter 2: Goals and Deliverables

The final goal of this project is the further development of the VEH game concept in accordance with Stadtwerk Winterthur, Cymersion, and ZHAW initiatives in order to expand its applications as a tool for education, research, and enjoyment. The purpose of VEH is to increase people’s awareness of energy consumption and the implementation of smart technologies. We extend its purpose to advance VR applications for beneficial research in smart energy and smart city technology as well as for our industry partners. In order to achieve our final goal, we divided it into three specific sub-goals:

1. Implement a method to draw relevant statistical value from participant data in VEH, including alteration of the question script and story line.
2. Through VEH, raise participant awareness and motivations towards the implementation of smart energy, smart city, and renewable initiatives in Winterthur.
3. Demonstrate the use and versatility of virtual reality gamification for research, education, and entertainment through the applications and possibilities of VEH.

This encompasses the scope of the project work. The goals were achieved through the execution of the following deliverables for our project:

1. Compiled stakeholder initiatives into concepts for VEH, ensuring that most needs and desires of industry partners and sponsors are met.
2. Provided a set of recommendations on how to apply VR gamification in energy and marketing research.
3. Provided a set of recommendations on how to improve immersion and interactivity within VEH.
4. Provided a set of recommendations on how to optimize knowledge transfer of smart energy/city topics in VEH.
Chapter 3: Background

In this chapter, we describe key concepts needed in order to fully understand ZHAW’s project and our perspective on it. A description of the game will be given in section 3.1 to provide context for the project. The research begins with section 3.2 on smart energy and smart city technologies, with an enhanced focus on the energy infrastructure in Switzerland. Section 3.2 promotes gamification, providing a broad overview, discussing what constitutes success within gamification, and tying it into the context of section 3.3 on virtual reality. We then transition into section 3.4 about knowledge transfer and its interplay with gamification. These concepts provide the background needed to develop a work plan to accomplish the project goals.

3.1 First Version of the Game

Before arriving in Switzerland and after background research was conducted, the complete game storyline was developed by ZHAW and Cymmersion (See Appendix K for the translated script). In this current version of the game, called Virtual Energy Hero (VEH), users begin in the attic of the ZHAW Technikum, where they are introduced to the talking companion for their journey, Oscar the owl (seen in Figure 1).

![VEH Avatar, Oscar the Owl](image)

Oscar explains the importance of the Energy Strategy 2050 and Winterthur’s progression towards becoming a 2000-Watt Society. Afterwards, Oscar and the player set out on an
expedition in a hot air balloon. Next, the player sees a view of the city of Winterthur from the hot air balloon, where they see four “hotspots”, as seen in Figure 2. These hotspots represent unique parts of the city, including the train station (Bahnhof), one of the only waste incineration plants in Switzerland (KVA), the offices of ZHAW (Technopark), and the main university building (Technikum).

![Figure 2: VEH View of Technikum and Bahnhof Hotspots](image)

The player then chooses a hotspot and is transitioned to their selected spot. The transition is made through the clouds, with the purpose of reducing vertigo and other negative feelings. Each hotspot will have a 360-degree view of the area for the player to experience. The player will then be presented with questions based on smart energy and smart city topics, with correct answers rewarding two “energy points”. After this scene, the player is taken to a home owned by Oscar’s friend Bettina. In order to help Bettina and her family become more energy-friendly, the player is faced with more questions. For each, they must choose between three possible measures of improvement with energy points ranging 1 to 3 rewarded based on the relative merit of the measures. Changes made will be shown visually in the player’s environment, e.g. replacing a diesel car with an electric version. For the end scene, the player will be returned to the balloon over Winterthur, where Oscar presents them with a certificate displaying their final score, indicating they have done a great job yet encouraging them to continue learning (seen in Figure 3). Finally, the balloon ascends to space for the credits scene.
The physical setup for VEH, as seen in Figure 4, includes a wooden representation of a hot air balloon basket, protecting the player and providing a connection to the real world. It also acts as an eye catcher to draw in players, alongside a screen that displays the player’s field of view to people in line and passers-by.
3.2 Smart Energy and Smart City Technology

As technology evolves and the world modernizes, the current energy infrastructure seems to lag further and further behind. Traditional energy delivery systems are simply not able to keep up with the demand of such a rapidly changing world in an economically efficient way. Electricity transmission and distribution alone comprise 41% of US electricity costs (EIA, 2017). Today’s power grids are not well-equipped to optimize energy storage and delivery, and efficiency will only continue to suffer as demand increases. To address this issue, it quickly becomes apparent that a modernized approach to energy delivery is necessary. This involves a shift towards a more decentralized energy infrastructure. A decentralized power grid is characterized by “a large number of small energy prosumers (i.e. both producers and consumers) [who] generate energy and may participate in the energy market… energy is usually traded at a time prior to the time of delivery in an exchange, based on forecasts of the production and the consumption” (Vergados, 2016). Critical to the accuracy of these forecasts is real-time data on energy consumption. Smart grid technology, discussed in this chapter, offers the potential to track and communicate energy usage data so that the grid is able to instantly react to changes in energy demand. However, despite increasing efficiency and offering consumers in-depth analyses of their energy usage, smart grid technology can only go so far in increasing end users’ active participation in their energy use.

In developing our research, we examined the current state of smart grid and smart city models worldwide in order to better our understanding of the future of infrastructure. From there, our team is able to more effectively educate and motivate consumers in the evolving field of smart energy. We had a particular focus on the state of smart energy in Switzerland, our project site. Additionally, we will delve into the current state of smart city technology including its potential.

3.2.1 What is Smart Energy?

Smart energy is characterized by a system of sustainable, renewable energy generation and delivery that is facilitated through a more connected infrastructure and consumer base such
that the system is able to more quickly respond to the rapidly changing demand for energy in the modern world (U.S. Department of Energy, 2018). In order for a smart energy system to be effective on a large scale, however, the decentralization of energy generation becomes necessary as infrastructure becomes more dependent on renewable energy sources.

A key component of the Swiss transition towards smart energy is the modernization of their energy infrastructure. The growing popularity of decentralized power in Switzerland, coupled with its increasing energy efficiency, has made possible the future implementation of a smart energy system in the form of smart grids. A smart grid is defined as “a fully automated electric power system controlling and optimizing the operation of all its interconnected elements, in order to guarantee safe and efficient operations of energy generation, transmission, and distribution” (Cecati, 2011). These smart grids will be able to more effectively exchange information to “create integrated data and electricity networks with pioneering functionalities” (Swiss Federal Office of Energy, 2016). The explosive popularity of smartphones and massive internet culture are reshaping the way utility companies are able to communicate with customers. The capabilities of these new smart grids include the safe and efficient operation of the power grid while significantly reducing the need to expand the power grid (see Appendix I).

A smart grid has been implemented in Worcester, Massachusetts as of summer 2014. Being the largest smart grid deployment in Massachusetts, the National Grid’s Smart Energy Solutions Program serves approximately 15,000 customers in the city of Worcester (National Grid, 2018). An interview with Monica Castillo, a representative from the National Grid Sustainability Hub in Worcester, Massachusetts provided some insight into the implementation process of the new smart grid, as well as customer feedback. Starting in 2013, National Grid installed new advanced metering infrastructure (AMI) throughout the city of Worcester. The AMI is a network of smart meters that utilize advanced data management and storage systems in tandem with communications systems to facilitate a constant stream of information sharing between customers and utilities. In 2015, National Grid sent out a notice to inform its customers of the switch over to smart grid technology, and allowed customers to opt out if so desired. The program had only a 5% opt out rate (See Appendix B). The new AMI meters allow energy usage to be tracked in 15 minute intervals, which enables the consumer to be much more aware and proactive in their energy consumption. Castillo further offered that smart grid participants are much more likely to save on their electric bill, citing one customer that saved $100.00 in her first
six months in the program (See Appendix B). The potential for energy savings that the smart grid offers is made evident by the relatively small scale grid implemented in Worcester, Massachusetts, which our group hopes to communicate to the citizens of Winterthur, Switzerland.

3.2.2 What is a Smart City?

While it is difficult to give a concrete definition for “Smart City,” the Legislative Council of Hong Kong has compiled research from numerous smart city projects around the world, and offers that the two defining traits of a smart city include: “(a) being a city that leverages on the information and communication technology infrastructure and uses innovative solutions to address issues in one or more aspects of the city including governance, economy, mobility, environment, living and people; and (b) aiming at improving the quality of life of the citizens and enhancing the sustainable growth and competitiveness of the city through the ‘smart’ initiatives” (Cheng, 2015). Internet of Things (IoT) technology is a critical and highly versatile component of smart city infrastructure. The IoT is yet another ambiguous topic with broad technological and societal implications (Lee, 2013). It is most broadly characterized by an “internet-connected web of citizens and electronic sensors/devices” which work to exchange information in real-time (Boulos, 2014). With uses spanning the fields of home and industrial automation, mobile healthcare, security, intelligent energy management, and beyond, the IoT offers significant potential for efficient resource management and increased productivity within a smart city (Zanella 2014).

Smart City Winterthur is a collaborative project founded in 2013 by Stadt Winterthur (city of Winterthur), ZHAW, and energie bewegt winterthur (energy moves winterthur). It further contextualizes the characterization of a smart city: a city that maximizes the quality of life of its residents while minimizing resource consumption via a holistic approach to the modernization of energy, transportation, and communications technology (Smart City Winterthur, n.d-c). Strategies along these lines are being adapted and implemented all over the world, in cities such as London, New York City, Barcelona, and Swiss cities Zurich and Winterthur.
3.2.3 Energy Flexibility

With the rising number of consumer-owned renewable energy systems, the prospect of demand-side flexibility creates the potential for a more stabilized energy infrastructure. Flexibility is defined as “the ability to quickly and inexpensively adapt his [the customer’s] own power generation and demand in response to varying electricity prices, electricity market conditions, transmission and distribution system conditions, and of regulation” (IEA DSM Programme, 2012, p.11). Most energy infrastructure today is built around maintaining supply-side flexibility by means of peak power plants and centralized energy storage and delivery. However, the increasing number of prosumers (consumers who also produce energy) and associated fluctuations in the power grid have created the potential for significantly greater demand-side flexibility; a much more efficient means of regulating energy supply and demand (Kubli 2018).

A ZHAW study published in 2018 examined the willingness of prosumers to contribute to creating flexibility by selecting participants with renewable energy systems to take part in a choice experiment. The participants were given different energy usage options corresponding to different levels of flexibility ranging from “super flex” to “no flex” (it should be noted that because flexibility depends on changing one’s usage patterns to even out power grid load, greater flexibility compromises one’s freedom of energy use or “comfort”; it was the purpose of this study to determine the extent to which prosumers are willing to contribute to flexibility with marginal impact on their comfort). For example, participants could choose different overnight charging cycles for their EV car ranging from a guaranteed 40% overnight charge dispersed at different times of the night (super flex) to a guaranteed 100% charge as soon as possible (no flex). In this case, participants were found to only be marginally uncomfortable with just a 60% overnight charge. Participants only showed a preference toward the least flexible option in the case of their heating and showering (Kubli, 2018). This study thus shows an enormous untapped potential in demand-side flexibility, which will help even out the grid load and reduce energy costs as the number of prosumers increases. An important step in increasing public support of a more decentralized, consumer-flexible Switzerland is to educate and inspire the public towards the future of a sustainable Switzerland.
3.2.4 Smart City Technology in Today’s Switzerland

The Swiss Federal Office of Energy (SFOE), through projects such as Smart City Switzerland (see section 3.2.5), is working toward broadening the implementation of a more intelligent infrastructure. Buildings that produce energy to give back to the community, investment in the electric car industry, and the promotion of renewable energy are only a few of the steps being taken towards achieving Switzerland’s 2000-Watt Society goal (SFOE, 2018). The 2000-Watt Society is a research-backed vision for better energy legislation enacted in 1998 by the Federal Institute of Technology in Zurich (ETH Zurich). By 2050, the initiative aims to reduce overall power consumption to 2000 watts per person without compromising quality of life in Switzerland (Huebner, 2009). At the present moment, Switzerland uses approximately 6000 watts per person. To achieve the goal of the 2000-Watt Society, Stadt Zurich has committed to pursuing smart city development goals such as raising building standards to be more sustainable, increasing efficient mobility by expanding public transit, and raising public awareness by funding events at the municipal level (City of Zurich, 2011).

The Swiss Competence Center for Energy Research (SCCER), another joint project of the Committee of Technology and Innovation (CTI) and the Swiss National Science Foundation (SNSF), has laid out a multi-phase “innovation roadmap” to implement smart infrastructure and further the Swiss Energy Strategy 2050 (SCCER, 2018). Phase I, running from 2014-2017, involved generating solutions to known issues in the current Swiss energy infrastructure. Today, in phase II, the best of those solutions are continuing to be further analyzed and tested on the real grid for compatibility with current infrastructure. Additionally, “knowledge and technology transfer and training activities are implemented in parallel in order to ensure that the acquired knowledge is properly and adequately transferred to both industry and young scientists” (SCCER, 2018). Next, we will delve into the projects and initiatives in the city of Winterthur, where our project is located, starting with the utility company Stadtwerk Winterthur.

3.2.5 Smart Technology in Winterthur

As part of our project, we met with Stadtwerk Winterthur to explore how VEH can be developed to fit their interests. Stadtwerk Winterthur is a city-owned utility company in the city of Winterthur. It falls under the control of the Department Technische Betriebe, or Department of...
Technical Operations (Stadtwerk Winterthur, n.d.). Stadtwerk Winterthur supplies customers with electricity, gas and water. It also cleans wastewater, incinerates and recycles waste, and builds Winterthur’s fiber optic network. As it is controlled by the city of Winterthur, Stadtwerk Winterthur works to support the goal of the 2000-Watt Society, participating in initiatives aimed at reducing energy consumption and supporting smart technologies (Stadtwerk Winterthur, n.d.).

Similarly, the Smart City Winterthur project is currently working on numerous initiatives that will increase its overall energy efficiency and connectivity in Winterthur, and potentially all of Switzerland. Each of these initiatives work to advance Winterthur as a smart city according to the concepts emphasized by Smart City Switzerland as the most important aspects in the development of a smart city (see Figure 5).

Examples of the Smart City Winterthur initiatives include:

1. **Intelligent public lighting systems**: As Winterthur’s public lighting systems become aged and in need of replacement, smart technology systems are being utilized to reduce energy consumption in such a way that “safety, ecology, economy, and design are meaningfully combined” (Smart City Winterthur, n.d.-a). Key to urban energy planning (see Figure 5), the use of radio controlled intelligent LED luminaires, as well as solar lights are just a couple technologies leading the way toward a smart Winterthur.
2. **Gamification of reduced energy consumption:** A new game app is being developed by ZHAW in tandem with the University of Applied Sciences and Arts of Southern Switzerland, Stadtwerk Winterthur, and Azienda Elettrica Massagno SA to increase public awareness of household energy consumption. The project stresses the importance of communication with stakeholders as a critical step in becoming a smart city. The game includes social interactions, cooperative and competitive power saving strategies, and several other playful elements to promote awareness. A three-month trial with 120 households concluded that the game helped reduce energy consumption by as much as 7%. While there was not much difference between the cooperative and competitive power saving groups, both outperformed the control group which did not use the app (ZHAW, 2016).

3. **Energy database:** A comprehensive energy database that is building-specific is being used to substantially lower energy consumption on the way to the 2000-Watt Society. This project demonstrates good governance (see Figure 5) by the city of Winterthur. By analyzing precise heating needs and enacting stronger thermal insulation legislation, this project promises to significantly reduce CO₂ emissions based on evaluations of 412 buildings.

4. **Data centers and network hub:** The data centers and network hub currently being operated by the city of Winterthur were due for renewal. Methods for energy optimization included the use of passive cooling doors, and recooling using the concept of free-cooling (the utilization of low external temperature air to assist in cooling water systems for industrial use). These changes resulted in an energy savings of 150,000 kWh and further demonstrate good governance and the implementation of smart building concepts to move Winterthur closer to the 2000-Watt Society goal (Smart City Winterthur, n.d.-a).

These projects offer us a deeper understanding of Stadtwerk Winterthur’s role in the community as both a utilities provider and a proponent towards the modernization of Winterthur’s infrastructure. Our group met with Stadtwerk Winterthur to align our objectives with their own, in order to aid in bringing their visions, products, and projects to the public eye.
3.3 The Art of Gamification

Gamification is a trending phenomenon, being a member of the US Shortlist Word of the Year list in 2011 (Drell, 2011). Over the past decade, it has been regarded as a reputable business tool, with new research on how to best utilize gamification coming to light every day. So, what is gamification? In the words of Karl Kapp, the author of *The Gamification of Learning and Instruction*, “Gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems” (Kapp, 2012). Another interpretation of gamification comes from Gabe Zichermann, co-author of *Gamification by Design*, who defines it as “The process of game-thinking and game mechanics to engage users and solve problems” (Zichermann, 2011).

Game-thinking and game mechanics are two key concepts mentioned by these two authors. Game-based mechanics represent aspects of a game that make it tempting to play. This can include points, badges, levels, or any quantitative scoring system. Game-thinking can be characterized as the interface and competition within a game. The blend of these helps to immerse and motivate individuals to perform tasks in a desired manner in many separate applications.

3.3.1 Gamification Application

Gamification seeks to promote interest in the subjects to which it is applied. However, for gamification to be successful, participants need to have an interest to begin with. A simple way to foster interest in a game is to give the user a sense of accomplishment. Whether or not this gamified accomplishment translates to any real-world progress does not minimize the rush of satisfaction that is felt by the individual. The concepts of extrinsic and intrinsic motivation properly elaborate upon the impact of interest (see Figure 6).
In extrinsic motivation, the individual participates mainly due to external factors unrelated to the context of the game itself (Armstrong, 2013). In one example from Sweden, sound mats were placed on the stairs next to an escalator, transforming them into a giant piano keyboard with every mat emulating a different key. The results were positive, as stair usage was increased by 66% in the course of one day (Peeters, 2007). The intent of the “piano stairs” was to increase exercise through the stairs. Walkers, without knowledge of the intention, found themselves drawn to the stairs by the sounds they made rather than the benefits of exercise from taking the stairs.

Intrinsic motivation, on the other hand, consists of “the sense of enjoyment and progress [from playing the game] without the need for a specific reward” (Armstrong, 2013). Due to this natural desire, intrinsic motivation profoundly outweighs extrinsic in the long-term (Armstrong, 2013). This raises the question: how can you unlock people’s natural desires? In a 2009 interview, Colonel Casey Wardynski of the Office of Economic and Manpower Analysis (OEMA) asked the same question. Due to the success of the America’s Army game series, he had some concrete results. America’s Army is a game programmed and released by the United States Army Corp., with the purpose of generating interest in enlistment. The OEMA found that users had more native demand in the military than expected (Robertson, 2014). They tapped into a new audience, one that previously had little to no outlet for interest in the Army Corps. America’s
Army created a new means for citizens to gain knowledge and information about military service. It was then deduced that for the circumstances, increasing demand was not the foremost issue, but rather giving individuals the outlet for their native demand. For our project, finding an audience with native desire, like the people at the Nacht der Technik festival hosted by ZHAW’s School of Engineering on July 6, 2018, will yield heightened interest in ZHAW’s demonstration tool (Nacht Der Technik, 2017).

Gamification has a wide array of applications, including research and knowledge creation. Dr. Elisa Mekler from the University of Basel studied how to increase participation through a significant purpose and a point system. The primary objective was for participants to generate image annotation tags. Using control groups, the first group was informed that a point system was in place to judge their image annotation tags. The second was told that their production of image tags would help advance research and science. The final group was advised that they would be scored on their tags and that their image tags would advance science (Mekler, 2013). The study concluded that gamifying the meaningful frame of scientific advancement with a point system had the greatest impact on the quality and quantity of image annotation tags. This concept of incorporating both intrinsic motivation (scientific advancement) and extrinsic motivation (point system) creates a new avenue to pursue for gamification, lending itself to data collection, surveys, simple research, and education. The impact of intrinsic motivation can be applied to our project smoothly, with smart energy capturing the native interest of Swiss culture.

3.3.2 Game Elements and Techniques

Within a gamified concept, different elements have various effects upon the user. In a systematic review of 25 studies, researchers counted the number of times specific game concepts were employed in each study. It was found that the concepts of feedback (mentioned 17 times), challenges/goal-setting (15 times), social sharing (11 times), and rewards (10 times) were the most popular game elements utilized in studies (Johnson, 2017). These four game elements share a common goal: increased interactivity and immersion. As such, this project focuses on these elements in the further development of VEH. Comparative feedback, which involves knowledge of the performance of others, has been shown to be a helpful tool in managing energy consumption (Siero, 1996). This study concluded that in the workplace, receiving reports on a
coworker’s performance in addition to the employee’s own performance pushes employees to be more mindful of energy saving. This addition of comparative feedback thereby increased interactivity with energy usage in the workplace. This element of competition is a very powerful motivator, and needs to be highly considered.

Another example comes from a study where the concepts of feedback and goal-setting were combined and analyzed. Two goals were set for different groups: either reduce electricity use by 20% (difficult goal) or 2% (easy goal), as seen in Figure 7.

![Energy Reduction Chart](image)

**Figure 7: Energy Reduction Chart**

A control group was told to save an ambiguous amount of energy. This study was partnered with information on which appliances in each household used the most electricity. The laundry machine was targeted as the least efficient. Next, the difficult goal was combined with feedback (three times a week) and the easy goal did not involve any feedback. As seen in Figure 7, the combination of feedback and the difficult goal resulted in an average 15.1% reduction of energy usage, significantly differing from the control group. However, the easy goal had little to no effect, averaging 1% reduction. (Becker, 1978). Goal setting is an important element, but this study shows that it requires proper use. If the goal set is readily achievable, there is no motivation to strive for better. Since this study lies within the domain of energy consumption, its results provide further relevance to our own objectives. Without much extrapolation, we can see how effective setting goals and challenges are, with a supplement of feedback to go with it. The idea of giving individuals the ability to self-set difficult goals promotes a sense of control from
the user. This enhances the initiative, interaction, and participation of the participants, resulting in greater success and savings. Self-setting goals/challenges alongside feedback can prove to be very valuable suggestions for the continued development of VEH, as increased interaction is paramount.

Rewards and social sharing are less valuable to a demonstration game, according to Professor Lee Sheldon of Worcester Polytechnic Institute. Our interview with Professor Sheldon helped us gain valuable insight on the topics of game design, game elements, and serious games. Professor Sheldon viewed rewards as a beneficial concept, specifically when using intrinsic rewards. Section 2.2.3 elaborates Professor Sheldon’s ideas of extrinsic and intrinsic motivators and rewards. Professor Sheldon describes social sharing as the practice of sharing content from websites on a social media application or site. He then stressed that social sharing is a lackluster means of providing motivation, in the context of ZHAW’s game, stating that leaderboards throw away a sense of confidentiality and individualism (see Appendix C). However, if social sharing was performed in such a way as to maintain confidentiality, then subjects would be more willing to participate. Social sharing can provide an additional platform by which players can interact and learn. For our project, the elements of social sharing, comparative feedback paired with challenges/goal-setting, and intrinsic rewards are the techniques that will facilitate a well-received, interactive game.

3.3.3 Serious Games

Serious games take gamification to a deeper level. They include the fun, entertainment side that any naturally successful game holds. However, they hold an underlying complexity for the user to indulge in. Serious games can be defined as “any form of interactive computer-based game software for one or multiple players to be used on any platform and that has been developed with the intention to be more than entertainment” (Ritterfeld, 2009). The mission of these games is to enable change in the real world, whether it be education on nutrition, exercise tracking, or energy awareness. Although their intentions aren’t as enticing as their recreational game counterparts, serious games hinge their success on the emulation of the popularity and engaging nature of recreational games (Johnson, 2017).
Basic examples of gamification, similar to those listed in the above literature, rely on either simple point, level, or badge systems alongside primarily extrinsic motivational factors. In the short time frame these methods are conducted in, they are successful, but only in the short term. The motivation from participants subsides, resulting in a decline of success (Juul, 2011). In the interview with Professor Sheldon, he remarks that extrinsic rewards end up doing more harm than good. An example he gave was in a university setting. Students were given monetary incentives to increase study habits. After the time frame was up, they no longer received money for their study habits. As a result, they were demotivated and reverted back to previous habits, with some students adopting worse habits (see Appendix B). Serious games focus on long-term success. These games hope to embed their intentions into the user in a way that users will be able to reflect upon and apply for a long time. In the feedback study mentioned in section 2.2.2, the study came back after six months to find that comparative feedback was still maintaining its impact (Siero, 1996). Professor Sheldon worked with intrinsic motivators and rewards in the classroom. He found that establishing teams that rely on each partner for a particular set of skills was a very effective method. When these groups were put to work, each partner’s strengths had a chance to shine. They felt appreciated for their work, driving their motivation to produce quality outputs (see Appendix B). Alongside this idea, Professor Sheldon pointed out the need for a narrative. A narrative has a distinct effect on an audience, whether it be emotional or educational. The cause and effect style of most narratives lends itself to how the brain processes information (Hurme, 2016). These concepts provide a means to accomplish a serious game and educational tool with long term impacts.

One example of a serious game intended to increase awareness of energy consumption and improve energy-use habits in the home is the computer game EnerCities (Knol & De Vries, 2011). Designed for use in secondary school classrooms across Europe, the game’s creators found that to maintain the students’ attention, serious games “should be in the first place games for enjoyment containing explicit or even implicit specific content instead of specific content looking for or transformed into game formats” (Knol & De Vries, 2011). By designing the EnerCities game with the main goal being the creation of an entertaining game, without losing sight of the educational purpose, it was found that playing the game increased energy awareness and promoted positive attitudes towards saving energy in daily life (Knol & De Vries, 2011). VEH similarly aims to increase energy awareness, reduce energy consumption, and raise
awareness for the implementation of renewables. Instead of through a computer game that would last through a class period, ZHAW’s game is intended to be an exclusive brief demonstration, and makes use of the novelty of virtual reality.

3.4 Virtual Reality

Virtual reality (VR) is one of the newest concepts in the gaming industry, though its exact definition remains contested. One definition is that of virtual environments: “real-time interactive graphics with three-dimensional models, when combined with a display technology that gives the user immersion in the model world and direct manipulation” (Bishop, 1992). This definition takes a broader approach than most, in the name of accuracy. It encompasses any model that alters perceptions. VR is defined primarily as a technological hardware, a sort of goggles and gloves setup. However, it can be more aptly categorized and applied through the concept of presence versus telepresence. Presence is defined as the sense of being in an environment. This mainly applies to a physical setting. However, telepresence refers to the experience of presence in an environment by means of a communication medium (Steuer, 1993). For this project, we define virtual reality as an experience in which a communication medium alters the user’s perception of an environment, enhancing connection through interactive graphics and direct manipulation. A communication medium can be represented by the standard optical hardware system that alters your scenery, or even be a computer that synthesizes and creates the “world” that the game is set in.

3.4.1 Virtual Reality Systems

VR systems fall under two main categories: those for console or PC, and those for smartphones. The HTC Vive (seen in Figure 8) and the Oculus Rift are the two main PC systems, and the console-based Sony PlayStation VR is the most popular system, with over two million headsets sold (Lamkin, 2018). For mobile devices, Samsung Gear VR and Google Cardboard are two of the most popular headsets, with a large difference between the two. At around $130, the Gear VR comes with a handheld controller, and requires one of a few models of Samsung phones to provide the screen. Like the Gear VR, the Google Cardboard requires a
smartphone, though it is compatible with many models. It costs only $15 because the headset is made out of actual cardboard (seen in Figure 9) and comes with no additional components such as controllers (Lamkin, 2018). Due to its low cost and ease of use, the Google Cardboard is a very accessible introduction to VR. Systems for mobile devices have limited uses compared to those for console/PC, in part due to the frequent absence of a handheld controller. The main limitation is the lack of processing power in a smartphone, requiring VR applications to be simpler than those for console/PC. However, smartphone systems have the advantage of using a device most people already own, and are relatively cheap (Pierce, 2016). This mobile VR market can be used to share an application with a larger number of people than the console/PC user base.

Figure 8: The HTC Vive (BagoGames, 2016)

Figure 9: Google Cardboard (Lamkin, 2018)
VEH currently only uses the Vive. The main components of the system, which can be seen in Figure 8, are a headset, two controllers and two base stations. The base stations track motion of the headset and controllers in a space up to 15’ x 15’ (HTC Corporation, n.d.). The space required for VEH is approximately the size of a hot air balloon basket, which is well within this range. In addition to tracking motion, the two handheld controllers also have trackpads, triggers and other buttons, and provide haptic feedback to the user, allowing for more interaction with the virtual environment than would be possible with a controller-less system like the Google Cardboard. A gyroscope and G-sensor help accurately track headset motion, and the two AMOLED screens update in near-real time to reflect input from the base stations and controllers (HTC Corporation, n.d.). The high screen resolution with the image constantly updating in time with the user’s movements, combined with an adequate field of view, helps provide a sense of immersion and avoid feelings of sickness (Psotka, 1995), which will be discussed in further detail in the next section.

3.4.2 Virtual Reality Usability

It is essential to provide a comfortable experience to the many first-time VR users expected to try VEH. Due to the approximately ten minute time limit per game, it is vital that users can quickly understand and easily control the game to achieve as much as possible in the given time. A study of a VR game that taught students geography found that factors affecting a game’s usability include game user interface acquaintance, VR navigational effort, and VR environment distractions (Virvou & Katsionis, 2008). Another important factor to consider is the potential for simulator sickness, which can include headaches, nausea, or vomiting (Psotka, 1995).

Game user interface acquaintance refers to the user’s familiarity with and understanding of the game’s controls and functions. Users who are familiar with VR and/or gaming have been found to encounter fewer delays, leaving more time for progressing within the game (Virvou & Katsionis, 2008). As some participants for our project are expected to be novices at gaming, having simple controls and making the beginning tutorial as clear as possible should reduce time
lost due to confusion over the user interface. Fortunately, the controllers for the Vive have been described as “surprisingly intuitive” and should not take long to understand (Dempsey, 2016).

For the study by Virvou and Katsionis, VR navigational effort involved players moving within the game without becoming stuck or unable to move where they desired, while VR environment distractions meant the player lost sight of the educational purpose of the game. Instead, the player chose to wander around the game or interact with non-player characters (NPCs) for fun, while avoiding answering the geography questions required to progress in the game (Virvou & Katsionis, 2008). To apply these concepts to our project, we can combine the two into a single topic of environmental navigation.

The final factor in VR usability is ensuring that the risk of simulator sickness is minimized. Causes of simulator sickness include lag between a user’s movement and the game’s reaction, and when users view a simulation of strong self-motion while they are physically remaining still (Hettinger & Riccio, 1992). While recent headsets can update their displays without noticeable lag, motion sickness is still an issue, and it seems to affect women more frequently than men (Munafo, Diedrick, & Stoffregen, 2016). During testing of the VR demonstration, we will have to check for simulator sickness, potentially disproportionately affecting women. If it is prevalent the motion within the game may have to be altered. Despite these challenges, VR already has a multitude of applications.

3.4.3 Virtual Reality Applications

Although VR is regarded as the future of entertainment, it also holds many opportunities for businesses to excel. The ability to effectively catapult someone into a virtual circumstance proves beneficial in a multitude of ways (Waugh, 2017). It can be a useful training tool to immerse the subject into a situation they must solve. Oculus Rift headsets are used to train the likes of firefighters in Britain and even Arsenal Football Club players (Waugh, 2017). The ability to see exactly how a piece of furniture would look in a customer’s house greatly enhances marketability. In a 2017 interview with Mark Miles, managing director of VR agency RenderMedia, he remarks: “VR makes it possible for engineers and manufacturers to experience their creations before they are built.” This is quite enticing to engineering businesses, because they can directly market their goods and technology to potential clients. When it comes to
building airplanes, precision is a must. Boeing has invested generously in virtual reality, specifically the Microsoft HoloLens. Engineers are shown a 3D model of each piece of equipment, and step by step how to insert it into the assembly line. Training time is projected to be reduced by 75% through the Microsoft product (Kishore, 2017). VR’s applications within training and education are profound and growing with each year. For our project, we can extend its usefulness to encompass educational demonstration tools.

3.5 Knowledge Transfer

As an educational demonstration tool, ZHAW’s initial VR game is intended to increase people’s awareness of energy consumption and the implementation of renewables. In other words, ZHAW intends to communicate information on these topics to the public so that people will be engaged and remember what they have learned beyond the initial period of time when it is conveyed. This spread of information is officially referred to as “knowledge transfer.”

3.5.1 Defining Knowledge Transfer

Knowledge transfer is a term that can have many different interpretations, depending on the context in which it is used. The University of Cambridge takes a research-oriented approach, defining knowledge transfer as “the transfer of tangible and intellectual property, expertise, learning and skills between academia and the non-academic community” (Minshall, 2009). The business-oriented Institute of Industrial Relations at UC Berkeley defines knowledge transfer as “how to move good ideas from one part of an organization to others that can use the information” (Levine & Gilbert, 1999). A broader definition can be obtained from A Dictionary of Environment and Conservation, which considers both scientific and social aspects of issues and defines knowledge transfer as “the effective sharing of ideas, knowledge, or experience between people, companies, or organizations” (Park & Allaby, 2017). This is the definition of knowledge transfer which will be used in the remainder of this paper, since we will be mainly examining knowledge transfer between the public and ZHAW, Stadt Winterthur and Stadtwerk Winterthur. We will also consider the potential for VR-based knowledge transfer within the academic community to aid ZHAW’s research, or within a business for training purposes.
### 3.5.2 Stages of Knowledge Transfer

The process of knowledge transfer can be broken down into five stages, according to Levine and Gilbert (1999):

1. **Idea Creation**: The first step in knowledge transfer is selecting the specific information to be conveyed.

2. **Idea Sharing**: After the information to be conveyed is determined, others must be exposed to the idea, or no transfer will occur. There are numerous possible methods for sharing ideas, such as distributing pamphlets, speaking face-to-face, teaching classes, creating websites or downloadable applications, and providing public demonstrations.

3. **Idea Evaluation**: Those who receive the shared idea must assess its validity and relevance to themselves. An idea is not inherently correct or useful simply because it was shared; the recipient must use critical thinking to evaluate the information.

4. **Idea Dissemination**: Just as information that is shared may or may not be valid, the form in which an idea is shared and the audience it is shared with may be incompatible. The idea should be conveyed to an audience that can make use of it, and in a form that the audience can understand.

5. **Idea Adoption**: The difference between knowledge being transferred versus simply transmitted is if the communicated idea is adopted by its recipient(s). Even when people are aware of the benefits, they do not always adopt new ideas. Some obstacles include an inability to adopt the idea, or a lack of incentives to do so.

In order to transfer knowledge, one must determine what to convey, how to convey it, to whom it should be conveyed, and how to convince the recipients to act on that knowledge. For our project, we control and evaluate the first four steps. In step one, we determine which topics should be included in the initial game and in future versions, which is guided by ZHAW’s research and the desires of partner organizations. In step two, determining how to convey the information is addressed. Our sponsors have decided that this is done by means of a VR game. There is still much flexibility for presenting information within the field of VR, as seen by the number and variety of recent start-ups dedicated to VR (Wingfield, 2015). Steps three and four...
require the audience to feel motivated towards evaluating and understanding the information presented. In this area, VR games have an advantage over many other methods of knowledge transfer, such as sitting through a lecture. “The motivation and mindful engagement . . . that comes from this [VR] environment stems not only from the novelty but from the challenge, interactivity, realism, fantasy, cooperation, and immersion that are natural extensions to the benefits of games and simulation” states Joseph Psotka in a paper for the U.S. Army Research Institute (1995, p. 409). Presenting the information clearly and in a gamified fashion should facilitate successful knowledge transfer. Examining the fifth step, idea adoption, would be the best measure of successful knowledge transfer. However, to evaluate whether game users adopt the ideas presented and change their habits would require time and resources beyond the scope of this project. Therefore, the first four steps, which we can control and evaluate, are our focus.

3.5.3 Role of Knowledge Transfer

Organization make use of knowledge transfer techniques both internally and when engaging the public in their work. Universities such as ZHAW use it to recruit new students, volunteers or employees, and gain support for their research. Many businesses spread their name and products or services to gain new customers. For example, the National Grid Sustainability Hub engages the public for education on smart energy and a green economy (National Grid, n.d.). An industry partner we worked with, Stadtwerk Winterthur, can use knowledge transfer through VR for training, outreach, or other work. One target in particular is customers who are willing to become prosumers, who consume electricity but also produce their own through solar panels. They may be willing to adopt new smart energy services offered by Stadtwerk Winterthur or other utility and energy companies, which could be promoted through a personalized product-focused version of VEH.

In Switzerland, communication with the public is especially important because the country is a direct democracy - citizens vote directly on issues, including energy topics (Pauchard, 2010). Educating the public on energy issues allows them to make more informed decisions when voting, and may help boost voter turnout, which is frequently low (Pauchard, 2010). Greater energy awareness also allows people to be more energy conscientious in their day-to-day lives, reducing energy consumption and avoiding time of peak electricity demand.
The National Grid Sustainability Hub, mentioned in section 2.1.1, has plenty of experience with communicating with the public. Its employees and volunteers have hosted over 8,000 visitors and attended more than 300 outreach events (National Grid, n.d.). Techniques used to share information include interactive exhibits on smart grid technologies, hands-on demonstrations of smart meters for the home, and participation in the community through the use of student ambassadors from local universities (National Grid, n.d.). As its main goal is to raise energy awareness among customers, the Sustainability Hub’s techniques and experiences provide an excellent reference for fulfilling similar goals for ZHAW and Stadtwerk Winterthur.

3.6 Summary

Due to the traction that smart energy generates across the world, it is predominantly viewed in a positive setting. This makes transferring knowledge easier, as the individuals receiving are more accepting of the topic and willing to listen. However, the problem is having the same acceptance when the knowledge transfer method is not traditional.

In the words of Professor Sheldon, “virtual reality is a pizza box. It’s just a delivery system. The pizza has to smell, taste, and look good.” (see Appendix B). VR is just the platform on which the game is displayed. While virtual reality allows for increased immersion into a game experience, you still need that experience to be successful. Therefore, evaluating the success of both the game experience and educational experience for ZHAW’s VR game is the final goal.
Chapter 4: Methodology

This section details the methods by which we approached and completed our goals. Our schedule plan can be found in Appendix G. As stated previously, the goal of this project is the further development of the Virtual Energy Hero (VEH) game concept in accordance with Stadtwerk Winterthur, Cymmersion, and ZHAW initiatives. The purpose of this demonstration game is to increase people’s awareness of energy consumption and the implementation of smart technologies, advancing VR applications for beneficial research in smart energy and smart city technology as well as for our stakeholders. In order to achieve our goal, we have outlined three key objectives:

1. Implement a method to draw relevant statistical value from participant data in VEH, including alteration of the question script and story line.
2. Through VEH, raise participant awareness and motivations towards the implementation of smart energy, smart city, and renewable initiatives in Winterthur.
3. Demonstrate the use and versatility of virtual reality gamification for research, education, and entertainment through the applications and possibilities of VEH.

The final deliverable will be a written report including the following results:

1. Compiled stakeholder initiatives into concepts for VEH, ensuring that most needs and desires of industry partners and sponsors are met.
2. Provided a set of recommendations on how to apply VR gamification in energy and marketing research.
3. Provided a set of recommendations on how to improve player immersion and interactivity within VEH.
4. Provided a set of recommendations on how to optimize knowledge transfer of smart energy/city topics in VEH.

In addressing these deliverables, we decided surveys, interviews, and workshops would be the best avenues. The first step towards solidifying our methods was to identify an audience for them. After holding a comprehensive meeting with our sponsors at ZHAW, we found that the
target audience for surveys would be players of the game. The target audience for interviews was determined to be experts in the appropriate fields of our project, including VR, gamification, knowledge transfer, smart city, and smart energy technology. These experts came from both the United States and Switzerland. ZHAW’s primary focus is on expert opinions on the implementation of their VR tool. After gathering responses and data from our interviews and surveys, the next step was to compile them into a set of recommendations for the continued development of VEH. We determined workshops to be a key aspect in approaching this final set of deliverables. In various workshops conducted with our stakeholders our concepts, priorities, and therefore recommendations were further refined.

4.1 Stakeholder Goals

First, it was important to understand the goals of all organizations involved in further developing VEH. We held workshops in coordination with ZHAW and Cymmersion for Stadtwerk Winterthur, a utility company located close to ZHAW. In each workshop, they explained to us how they currently foresee the virtual reality demonstration benefiting their company, including where they hope for improvement. These results helped streamline the process of improving the game, as we gathered the suggestions of the developers, other organizations, and the results of our own investigations.

4.2 Research Application

VEH is a first-of-its-kind project in Switzerland. Therefore, the path this project takes paves the way for others to follow. In interviewing the head of the Institute for Sustainable Development at ZHAW, Dr. Silvia Ulli-Beer, it was apparent that a mission for ZHAW is to extend the game to be a platform for research, both internally and externally. Internally, the game can draw relevant data from player responses and analyze it to produce data on trends to apply towards ZHAW research. These trends and data can help approach an answer to research questions posed by our sponsors, as well as for milestones and deliverables of SCCER CREST, a collaborative research center in Switzerland (Appendix J). Externally, the game can be studied by energy companies (such as Stadtwerk Winterthur) and other organizations to better
comprehend the use of virtual reality for various topics. These ideas were then pitched to ZHAW and other stakeholders. Following this we met with our sponsors to recommend concrete extensions into research for VEH.

4.3 Gameplay Improvements and Engagement

As discussed in the background, to promote the comfort of users we had to consider VR navigational effort, VR environmental distractions, familiarity with the game user interface, and the potential for simulator sickness. Before arriving in Switzerland, we performed two separate interviews with WPI professors Lee Sheldon and Jeffrey Kesselman, specializing in the fields of serious games and virtual reality, respectively (see Appendix B). These interviews confirmed that simulator sickness, environmental distractions, and other concerns were valid considerations. We addressed these issues by conducting demonstrations of VEH at public events (Appendix H); we had the participants try the game and then answer our survey. Many of the questions focus on gameplay (Appendix F). Environmental distractions were judged by observing users as they played the game to see if they became sidetracked and had difficulty focusing on the purpose of the game. Supplementing this, we held meetings with Cymmersion to discuss further improvements and problems in VEH. Through these techniques, we were able to create a comprehensive set of recommendations outlining practical refinements to the gameplay.

4.4 Knowledge Transfer of Smart Technologies

The aim of VEH is to raise public awareness and improve perception of smart energy and city topics. We interviewed smart energy expert Dr. Silvia Ulli-Beer and smart city expert Vicente Carabias-Hüttter at ZHAW to learn what they considered the most important initiatives in Winterthur and how to reach the public. A later interview with knowledge transfer expert Pascal Kienast was conducted to help evaluate specific knowledge transfer methods proposed for VEH (Appendix B). We also evaluated the effect of the original VEH through surveys conducted at our game demonstrations. We used this information to propose specific ways that smart energy/city topics should be implemented in VEH.
4.5 Summary

Initial tests of ZHAW’s VEH allowed us to understand prominent areas for improvement, discussed in Chapter 5: Results. From our interviews and surveys, we gained valuable knowledge on the subjects of VR, gamification, and smart technologies through the well-informed opinions of experts as well as from a user experience standpoint. Focusing on player immersion (game experience, storyline improvements, increased interactivity, etc.), educational value, and the implementation of smart technologies to serve the interests of stakeholders, this collection of responses helped steer our development of the game concept into an immersive, comprehensive educational tool.

Finally, our research, workshops, surveys, and interviews culminated into a set of recommendations that we presented to ZHAW in our final week of work, which can be found in Chapter 6: Recommendations. We expect that our suggestions will be able to address every group’s concerns, from players to stakeholders and ZHAW itself, in order to deliver an optimized virtual reality demonstration that will be able to more effectively inform the public of smart energy and city initiatives, increasing positive motivation toward those initiatives in the city of Winterthur, Switzerland, and potentially beyond.
Chapter 5: Results

The final goals of this project include optimizing the knowledge transfer, interactivity, immersion, and extended applications for Virtual Energy Hero. During the attempted completion of these goals, priorities from stakeholders changed drastically. The consequence of this was a large amount of concepts that developed in various avenues. Many concepts overlap in content, such as the individual scenes and the overall storyline development. To better organize all the available information, these scenes were made into individual sections to make it easier to track their progress throughout our time here. The majority of these sections take the chronological format of initial concept and/or scene, current state of the game, concept development for Stadtwerk Winterthur, and finally concept development for the overall progression of the game. This project included major events for these developed concepts, and the results are also structured around their chronology. These events include the first meetings with ZHAW and Cymersion at the beginning of September, followed by a September 10th workshop with Stadt Winterthur and Stadtwerk Winterthur, and finished on September 27th with the final workshop and pitch to Stadtwerk Winterthur.

Stadtwerk Winterthur will be referred to as “SW” in this section.

5.1 Storyline

This section details the storyline of the game and the changes therein. General scene concepts are mentioned here but not in detail, in order to avoid overlap. From various sponsor meetings in Switzerland, it was decided that a large priority for the continued development of VEH was the storyline. The storyline provides the hook for the player to continue investing time and attention into the game, which dictates their retention of knowledge. Therefore, reevaluating the general structure of the game was paramount to achieving the deliverables and goals of this project.
5.1.1 Initial Game Storyboards

The initial concepts of the storyline were conceived with the stipulation that the game would serve as a small demonstration tool. This was explained during the conference calls with ZHAW in April (see Appendix B). The game idea was a quiz on energy topics. The player would be accompanied by a companion, a bird named Ibby. From the perspective of a hot air balloon, the user could pick one of ten “hotspots” (see Figure 10).

![Figure 10: VEH View of Winterthur with Hotspots Storyboard](image)

These hotspots represent key parts of the city of Winterthur, where the project is located. A 3D model of Winterthur was provided by Stadt Winterthur, meaning it is precise but does not have the textures of Google Earth. At these hotspots, players answer several questions on energy topics. The answers to the game questions would be tallied and scored at the end of the game, as seen in Figure 11, in order to give the player a sense of accomplishment.
It’s important to restate that this early stage storyline was created for the purpose of a small demonstration tool, the aim of which was intended only to raise awareness on energy usage. This was followed with a disclaimer from ZHAW, expressing that the full version would be ready in July and the direction it would take was unknown (see Appendix B).

5.1.2 Current Storyline

The current storyline is detailed in the first section of the background, 3.1. For this section, Figure 12 helps concisely depicts this storyline as a reminder to the reader.
After the first meeting with ZHAW, the first test of the game was conducted. The next step was to identify if there were prominent gaps and areas for improvement. After initial testing, the introduction Attic scene was found to be lacking a substantial hook for the player. In order to counteract this, the addition of another avatar was explored. Bettina, whose house the player visits in the game, could potentially become an overseeing figure to Oscar. Her purpose would be to help guide him and the player in a more fluid way. It was also discovered that the hotspots had specific energy topics attached to each. However, this was not clear to the player. Another area identified for improvement was the point system in the game. Based on arbitrary “energy points”, these had no real lasting effect on the user when they acquired them. The first meeting with ZHAW also yielded insight into a new aim for the game. The new purpose centered around increasing awareness and positive motivations towards smart energy and smart city topics. This had to be reflected in the storyline. There was a blatant lack of smart city technologies in the current storyline. To rectify this, a scene was proposed that focused on a smart district in Winterthur, where the player could view a larger scale of smart energy and smart city interactions. Then, it was decided that a new interior house scene would help directly promote smart energy products and services, showing the player specifically what can be improved in a typical home. Furthermore, at the end of VEH, the player is flown up over the city of Winterthur to receive their certificate with their score. Oscar the Owl then concludes by telling the player to take their part in the energy revolution and bids them farewell. This is often mistaken as the end
of the game, but the hot air balloon then rises and transports the player to space to see the credits of the game, seen in Figure 13. This was sudden and awkward, yet ZHAW was keen to keep the scene due to the amount of work required to produce this scene.

Figure 13: VEH Space Scene

5.1.3 Stadtwerk Winterthur Intern Storyline

After the initial gaps were identified, they were reported to the sponsors and the programmers of the game, Cymmersion. Cymmersion quoted the hours it would take for each addition of the game to be implemented, effectively ranking the practicality of each (see Appendix E). This is also when SW, a utility company interested in VEH, was concretely mentioned. After these ideas were reviewed, ZHAW explained that the continued development of the storyline concepts would be best geared towards SW, in order to best advertise the game to them. However, due to a recent push towards the Swiss energy transition by city officials, the game had also gained interest from Stadt Winterthur, meaning the concepts had to be flexible enough to apply to both parties, even though SW would remain the focus. This, alongside the time quotes from Cymmersion, resulted in a consolidation of the previous ideas: The second avatar was dropped and replaced with a concept for a new avatar altogether and the storyline
would include implementation of the SW logo and products where available. Figure 14 elaborates the initial storyline that was developed and presented to Stadt Winterthur and SW at a workshop.

![Diagram of VEH Stadtwerk Storyline First Edition](image)

*Figure 14: VEH Stadtwerk Storyline First Edition*

After the workshop, feedback was received from SW, Cymmersion, and ZHAW. SW was concerned that for the money they would be contributing, the current concepts did not justify buying into the game, as there was a lack of their own version. The company felt that the game was being developed in a direction that would not have changed had their money been added to the pile. They were also concerned about time limitations. Their preferred purpose for VEH would be to use it as a marketing tool at exhibitions, and the 10-15 minute updated time limit did not suit their needs. Ideally, they wanted the game to play for 5 minutes, but they received pushback from Cymmersion, who argued that compromising the storyline of a game is never an option and that the lowest time limit the game could have in its current state was 8-10 minutes. During the workshop, we presented the smart district scene and received negative feedback from Cymmersion, who stated that a dynamic location of that magnitude would require serious labor (see Appendix C). They were not impressed that it would be non-interactive, and made a compromise that they would be willing to do it if the scene was changed to include interaction. After much debate, it was decided that the smart district section would be scrapped in order to focus on the more concrete concepts. The smart city concepts would be transferred into the House scene instead. At the end of the workshop with Stadt Winterthur and SW, ZHAW
mentioned a storyline focused on a relationship between the player and SW (see Appendix C). This idea was heavily weighed and investigated, as it seemed to solve and address major gaps that needed filling: there would be a strong connection from the player to SW, making it easier to direct them towards their real life smart energy services and products. This would also help give a sense of real purpose to the player.

![Figure 15: VEH Initial Intern Storyline Diagram](image)

Referring to Figure 15, the storyline would begin with the player in the Attic scene again, and the new avatar would introduce themself as an employee for SW. The player is then told that they are an intern on their first day of work and it is their training week. This sets a firm reasoning behind the introduction of SW products and services in the game. The player takes the SW hot air balloon (seen in Figure 15) above Winterthur, utilizing the Hotspot scene once again. This time, the specific energy topics here would be available for the intern’s choosing. They would pick the option they found most appealing to them and the avatar would help teach them at this location. The next scene brought the player to the outside of a house with neighboring houses surrounding it. The center house would be that of a customer of SW who requested consultation on their energy efficiency. While making changes to the outside of the house, the player would be able to view how the decentralization of energy and increase of efficiency affected the neighboring houses. After these changes, the player then can go into the customer’s house and begin to make more direct smart energy changes as mentioned before. This
is where SW products would be introduced. Finally, the player would go back outside the house where the avatar would present them with their “grade” for the day. They would then be encouraged to “research” on SW’s website and look at their products and energy consulting services.

This full storyline was pitched to ZHAW, and reworked to address the needs of SW. Due to time constraints, the Hotspot scene (highlighted in red in Figure 15) had to be completely removed. Next, it was decided that instead of neighboring houses, a flat complex would be seen in the background of the House scene. This is due to the fact that the majority of people live in flat style apartments, so showing them the changes they could make would be most beneficial. Finally, it was decided that the indoor house scene would be changed to an indoor flat scene, where the flat is provided to the intern by SW. This helps justify the real energy changes the intern makes inside the house, whereas previously the player made decisions in an unknown customer’s house, who was not present. For the full script of the Intern storyline, see Appendix K.

After another few days of establishing these changes, ZHAW took another turn. They decided it would be best to make a final version for SW that was completely different from the general storyline progression. This included cutting out the Attic scene and Hotspot scene, and reintroducing the Smart Living scene, named “Smartes Quartier”. These changes can be viewed in Figure 16. This version kept the player as an intern for SW. However, the story begins at the Smartes Quartier, where the same introduction is given to the player, but they begin making changes more immediately. The main focus of this storyline was to reduce the time limit on the game. The mission here was to help address SW’s concern over having an effective marketing tool that felt exclusive to them.
The day before the final workshop with SW, ZHAW learned that the concept presentation should be focused around the general progression of the game, instead of the specific and exclusive storyline. This was a complete shift in priority from SW, and resulted in these storylines never being properly explained to them.

**5.1.4 Save Winterthur Storyline**

Due to the heightened interest from Stadt Winterthur (mentioned in section 5.1.3), a second storyline was developed concurrently. The Swiss Federal Office of Energy grants funding to various energy projects throughout Switzerland. Through Stadt Winterthur, funding is awarded to various projects that aim to hold Winterthur’s status as “Energiestadt Gold”. This title means that Winterthur is among the most energy efficient cities in Switzerland. The funding for this ranges from 20,000-60,000 Swiss Francs per year. This was very attractive to ZHAW, so priorities were once again shifted to address this. The general storyline would progress in a direction to fulfill Stadt Winterthur’s wishes, since they were helping to provide the largest amount of funding. The initial version of this storyline can be seen in Figure 17.
The story begins once again at the attic of the Technikum, the main university building for ZHAW. While Oscar sets the scene for the player, he encourages them to look at the crystal ball that is before them. In this crystal ball, the player sees a dark, smoggy city. This is the city of Winterthur in the future. Oscar explains that if global energy consumption stays the same, this future is inescapable. This helps motivate the player to save the day, be the hero, and change the global energy future. Next, the hero flies over what is the current 3D model of Winterthur, providing a stark contrast to the horrid crystal ball city. They are once again encouraged to pick a hotspot to learn from specifically. The subsequent scene is of the smart living scene, where the hero changes highlighted smart city and energy areas to be more efficient. They then move into the interior of one of these buildings to make more concrete and direct energy changes. These are easy-to-grasp changes, such as installing high efficiency smart appliances, or switching over to eat local organic food. The player is brought back in the hot air balloon over Winterthur and is congratulated by Oscar. The hero is then shown through the crystal ball that the future of Winterthur has been saved. Once this was drafted, a meeting with ZHAW was held. The meeting concluded with only one change to the storyline: the hotspot scene would be taken out and replaced with a “Winterthur by Balloon” scene (see Figure 18). The player would be able to see the energy breakdown of the city of Winterthur, with the hope of piquing their interests.
5.2 Introduction (Attic) Scene

This section describes the changes involved with the introduction Attic scene of the game. In terms of the storyline, the introduction and end scenes are the most important in selling the message within the game. It was decided that the Attic scene would be kept due to positive survey results on it (see Appendix D).
5.2.1 Current Version

The player begins the game in the attic of the Technikum (see Figure 19). The player hears the shrill voice of Oscar the Owl, who explains the energy research he has been conducting here. He then gives context, mentioning the Energy Strategy 2050 and 2000-Watt-Society, which are two important energy initiatives in Switzerland. Oscar admits that while these are interesting, he needs some real-life experiences to fully comprehend them. He then concludes the introduction by encouraging the player to go on a “voyage of discovery” with him.

On first glance, the scene had various faults. There was no sense of urgency or need for the player to go along with Oscar and learn more about the energy transition. Furthermore, the initiatives mentioned were never elaborated on, meaning that an uninformed player would gain nothing from hearing them. These were the first areas that needed reworking. After back and forth communication with ZHAW, it seemed the progression of the game had a bigger picture than initially thought. The game would be displayed at various events outside of Winterthur. Therefore, the attic being located in the Technikum had less relevance to the game and needed to be shifted.

5.2.2 Stadtwerk Winterthur Version

As mentioned in the storyline for SW, it was decided that a new avatar would be the best avenue to pursue. ZHAW was keen to keep Oscar the Owl for themselves, due to sentimental reasons. Through brainstorming sessions, Battina the Bat was drafted as an idea. This would be a play on words from the initial storyline’s Bettina, whose house the player visits. This would shift the attic scene to be in Battina’s house. Battina would be the newest employee at SW and the player would be her friend. Due to her excitement of being hired, Battina brags to the player about how much SW helps the current energy status of the city. She would then ask the player to follow her around the city in an SW hot air balloon, once again solidifying the relationship with the utility company. While the new introduction was well-received at the workshop, the concept of Battina was questioned. This was put into a survey and players were asked to rate the concept
of replacing Oscar the Owl with Battina the Bat (see Appendix D). The results showed that a bat was not a good avatar, due to negative connotations attributed to them.

The intern storyline was conceived at the conclusion of the first SW workshop. This required another reworking of the attic scene. The player would begin VEH at the SW headquarters, where Ollie the Owl (Oscar’s cousin), would introduce himself as an employee. Ollie’s color scheme would match that of SW: orange and white. Ollie’s job would be to train the player, who is the newest intern at SW. This creates a very direct and strong relationship for the player and the utility company. Ollie then explains what SW’s mission is and how the intern themself can help. It is concluded by the player once again departing in the SW balloon.

5.2.3 Save Winterthur Version

The Stadt Winterthur storyline involved the player becoming a proper hero in the game. This storyline would return the attic to the Technikum. However, it would be referred to as the “ZHAW Technikum” instead of just Technikum. This way, players would understand it is involved with the creators of the game. Oscar the Owl would begin speaking to the player, explaining the dire situation that global energy is in. To further explain, he will hand a crystal ball to the player. As Oscar continues to explain energy consumption problems, the player is transported to a hot air balloon overlooking a dark, glum cityscape. There is smog running throughout the scene. Oscar explains that this is the future of Winterthur, if nothing is changed. As the player glimpses around for a last few times, Oscar begins to explain the Swiss initiatives currently in place and how they can help alter this future, with your help. The crystal ball is taken back by Oscar, and the player is returned to the attic scene. He then asks for their help to alter this future and set out on a journey through Winterthur.

5.3 Hotspot Scene

In this section, the progression of ideas for the original game’s hotspots is explained. The initial storyline, as mentioned in section 5.1.1, centered around the idea of these hotspots, where the player would see ten locations, or “hotspots”, which they could visit and answer questions. Within an undefined time limit, the player would be free to answer as many questions at one
hotspot as they wished, or visit other hotspots. The game that was tested upon arrival in Switzerland was already significantly different, with the hotspots only one part of the game. This is also the current version of the game that is used at events.

5.3.1 Current Hotspot Scene

As described in section 3.1, in the current hotspots scene the player only sees four possible hotspots. From these, they can only visit a single hotspot per playthrough of the game. At each hotspot the player answers four questions targeted at the topic of that particular hotspot, with 30 seconds per question. Questions at the Bahnhof (train station) focus on transportation; questions at the KVA (a waste burning facility) are about the KVA; questions at Technopark (a location of ZHAW offices) focus on solar power; and questions at the Technikum (large ZHAW academic building) are about general energy topics.

5.3.2 Initial Stadtwerk Winterthur Hotspots

The initial plan for the hotspots was to alter the locations to be as directly relevant to smart city and smart energy topics as possible, as ZHAW expressed a desire to incorporate these topics better into VEH, especially smart city topics that were mostly lacking in the current game. In a smart city interview with ZHAW’s Vicente Carabias-Hütter, he also recommended adding smart city topics to the hotspots (see Appendix B). Examining the existing hotspots, the Bahnhof’s focus on transport already made it smart city and smart energy relevant. The Technopark and Technikum were included due to their relevance to ZHAW rather than to the energy transition, so they seemed the best to remove. Removing the KVA was also considered, but a meeting with ZHAW revealed that they wished to keep the KVA because waste burning facilities are uncommon and it is something that makes Winterthur special. In the first meeting held with SW, a general change of hotspot locations was proposed, with a few suggestions for new locations. A solar farm could replace the Technopark, still focusing on solar power but making this focus more obvious to players. An electrical substation would feature questions on the electrical grid and the importance of flexibility. The SW headquarters would use questions on
the relationship between customers and utilities companies and serve as a method of incorporating SW into the game.

Two more hotspot changes were presented to SW. One was to reduce the number of questions at a hotspot. Reducing the questions from four to three would buy a little time for the rest of the game as in the same meeting we also proposed new scenes - a Smartes Quartier and Indoor House scene, discussed in sections 5.4 and 5.6, respectively. To reach more people, the game could not be made too long. The other change involved detaching the point system from the Hotspot scene. This was due to a proposed new point system that held more meaning than “energy points”. In the proposed point system discussed in section 5.9, points would be based on CO2 emission reductions which would be very difficult to attach to many of the hotspot questions.

5.3.3 Final Stadtwerk Winterthur Hotspots

The changes proposed to the hotspot scenes were relatively minor compared to those for other scenes. After the first meeting with SW, the hotspots received little attention in regard to further development. Following a meeting with a master’s student at ZHAW who studied VR and was considering working on a mobile app to supplement VEH, the hotspots seemed even less important. In this meeting, the student expressed a desire to better utilize the strengths of VR in VEH, such as the ability to directly interact with one’s surroundings. The hotspot scene’s quiz format could also be used in a plain 2D computer game and failed to make proper use of VR. With this feedback and the need to remove a scene for the sake of time, it was decided to remove the hotspot scene altogether for the final presentation to SW. Removal of the hotspots allows time to be spent on more interactive scenes (such as a smart city scene), but it also removes the scene that used the majority of the existing question script, and which had the greatest freedom in what questions could be asked.

5.4 Smart City: Balloon Over Winterthur Scene

This section details the work involved with the development of a new smart city focused scene. For the purpose of raising awareness and positive motivations towards smart city topics,
implementing more visually appealing smart city technology in VEH is a necessity. It was after the interview with Vicente Carabias-Hütter, head of ZHAW Platform Smart Cities and Regions (see Appendix B), that the first recommendation was contemplated. This took the form of an overhead view of a smart region of Winterthur. In this idea as it was presented to Cymmersion, the player would zoom in from the hot air balloon close enough to see city activity. From there, the player would see a showcase of various smart city technologies, such as smart lighting, smart parking, decentralized energy storage solutions, etc. There was also a brief discussion on adding limited interactivity features such as a ride-along in a BICAR (see Appendix C) or applying some changes to the energy consumption of the area similar to the current game’s House scene. At this point, the scene was referred to as the “Smartes Quartier” (translates to “Smart District”) scene.

5.4.1 Smartes Quartier

In further developing the Smartes Quartier for the first presentation to SW, the issue of time constraints proved difficult to circumvent. With the addition of interactivity came an unavoidably substantial increase to the total game time, whereas ZHAW wanted to limit the game’s length to around 10-12 minutes. It was decided to present the idea to SW as a non-interactive scene that the player would be able to watch for between one and two minutes. It would be similar to an animated hotspot where no quiz questions are asked. This way, the scene could interrupt the monotony of the quiz format with a more tangible visualization of Winterthur’s potential as a smart city. Feedback from Cymmersion and SW on this version of the scene was skeptical. It was not feasible to spend dozens or even hundreds of hours animating such a complicated scene in exchange for only a minute of viewing with no (or even limited) interactivity.

After receiving feedback from the first SW presentation, the team was faced with the options of either abandoning the Smartes Quartier, or making considerable cuts to other parts of the game to devote more time to the highly expensive scene. One decision to remove one question from the current hotspot scene would save up to 30 seconds. There was also the possibility to shorten the Attic scene, but it would be difficult to preserve the narrative with any substantial cut to the opening monologue. Thus, the idea of a Smartes Quartier scene was
consolidated with the new Smart Living scene (see section 5.5); implementing smart city technologies on a more residential level. This still allowed for a wide variety of technologies and was considered an effective compromise.

5.4.2 Balloon Over Winterthur

In preparation for the second SW presentation, it was decided to remove the Hotspot scene entirely. However, due to the popularity of the Hot Air Balloon scene as well as its great utilization of VR, there was no sense in removing it with the Hotspot scene, so it was decided to expand upon the Hot Air Balloon scene in a way that optimizes knowledge transfer of smart energy and smart city topics, as well as taking advantage of the visual appeal of the scene in VR. This was done by incorporating a more engaging and educational scene focusing on the energy breakdown of Winterthur. Players would now see Winterthur through multiple filters, showing the energy distribution, photovoltaic (PV) potential, and infrastructure connectivity of Winterthur (see Figure 20). To make use of the question script (see Appendix K), the different filters would now be revealed by answering a question for each filter. The category of the question would be dependent on the filter, and so the current question script can be recategorized accordingly. For example, the player may answer a question such as “How much of Switzerland is powered by solar energy?” to reveal the energy breakdown filter. By incorporating this more visual and engaging version of the first question scene, the player will gain more knowledge on smart energy and smart city topics than in the trivia-oriented Hotspot scene while also gaining a more immersive game experience.

![Figure 20: Map filters for new VEH Hot Air Balloon Scene](image)
5.5 Smart Living Scene

This section describes the creation and expansion of a “Smart Living” scene integrating smart energy and smart city topics. The purpose of the Smart Living scene is to engage the player by enabling them to make concrete energy consumption changes in their virtual environment. The current game’s version of this scene is called the House scene, where the player answers four questions on changing the power-consumption, heating, mobility, and nutrition of a single-family residence (see Figure 21). The player would be given three options to change consumption in each of these categories and be awarded one, two, or three points per question based on the effectiveness of the change. After the first playthrough of the game, it was difficult to notice the changes to the House scene environment as most of the changes were not particularly visible or emphasized. Thus, the first recommendation for the House scene, as presented at our Cymmersion meeting was to add a visual highlight to each change at the House scene to make the player more aware of their influence on their virtual surroundings. Cymmersion agreed that this change would be necessary and easily implemented once funding came through (see Appendix C).

5.5.1 Initial Version

For the first SW presentation, the House scene was expanded to include multiple houses around it, renaming it to the ‘Smart Living’ scene. By including more houses, the scene gained the potential to learn about smart city topics on a residential scale (see Figure 21). This would include a comparison of the interactions of each residence with the electric grid, and potentially implementing smart grid and smart metering technology in a section of the scene. The Smart Living scene further allows the opportunity to introduce the player to energy flexibility concepts (see section 3.2.3), which are of critical importance to consumer awareness as Winterthur’s prosumers continue to grow in number. Finally, our group tackled the redundancy of the quiz format, where players must answer questions that are projected in front of them, by granting the player more “control” over which questions are prompted and how they are prompted. Rather than projecting questions in front of the player in sequential order, objects would be highlighted
for the player to click on and answer questions on various topics. This would allow the player to follow their interests and takes greater advantage of the potential of VR to engage and immerse the player.

![Image](image.png)

*Figure 21: Current House Scene*

### 5.5.2 Final Version

For the second SW presentation, further adjustments were made to the Smart Living scene to better engage the player and to increase the scene’s capabilities as a marketing tool. First, a flat complex was included in this scene to allow for the potential to show players how smart energy technologies (in this case, SW products) work in apartment-style buildings, as well as to better represent the living situation of most Winterthur residents. The flat complex was also added for storyline purposes (see section 5.1), as the second SW presentation had a focus on improvements to the storyline (in addition to the game’s marketing applications). It was also decided to completely change the format of the questions in Smart Living to challenge the player in a more gamified, and thus engaging, manner. The change was also made to address the complications of consolidating the point system of the current House scene with the new Smart Living scene (see section 5.8.2). In the final version of Smart Living, instead of having the player select highlighted objects to make changes, Oscar would challenge the player to make a change...
within a category of energy consumption such as public lighting, building heating, mobility, etc. The player will then search and select where to make the change from the highlighted items (selecting a street light to change public lighting, the wall of a building for building insulation, or a car for mobility, as seen in Figure 22). There would be a 15-second time limit to make each change. After each question, the player will be presented with a brief explanation of the impact of each change they made, e.g. “Switching to smart LED public lighting can save up to 35% on city lighting!” This way, the challenge is straightforward enough to complete quickly while allowing the player to gain important knowledge. The game becomes more engaging and fast-paced while maintaining educational value.

5.6 Smart Home Scene

The Smart Home scene is an entirely new scene that is not present in the current VEH. This section covers the smart house scene from its initial, rather vague formation to a fleshed-out and concrete concept for implementation.
5.6.1 Initial Version

In the second week on-site, a meeting was held with Cymmersion to discuss ideas thus far and gain an idea of their feasibility (see Appendix C). During this meeting, the idea of a scene inside of Bettina’s house was presented, where the player could interact with items to change energy use - for example, turning off the television or switching appliances to energy-efficient versions. This scene was proposed to reach people at a personal level, at home. This is also the easiest place for them to start making changes in real life. This is addressed somewhat in the existing scene at Bettina’s house, but an indoor scene would strengthen the message further and provide players with even more ways to improve their energy use. This includes easier methods than buying and installing a photovoltaic system or selling a car and relying on public transportation (both presented in the current scene outside Bettina’s home).

To present the idea of an indoor scene to SW for the first meeting, this idea was elaborated on once Cymmersion had confirmed the scene was feasible. The Indoor House scene presented to SW placed the player in the middle of a home, where they could see into multiple rooms without having to move (see Figure 23). This stationary setting was decided upon to avoid issues with motion sickness if the player had to move between rooms. Since the player couldn’t move closer to objects, each change had to cover a large enough area to be easily selected. For example, rather than selecting food within a refrigerator to make multiple changes, the entire refrigerator would have to be selected for a single change. This limited the number of changes that could be made. These changes would be grouped into categories such as energy use, diet, heating, and new technologies. For each category, the player would have 30 seconds to make as many changes as possible related to that category. After selecting each object that could be changed, a text bubble would show up to explain the change that was made. The time limit and categorization of choices provided parallels to the existing scene at Bettina’s home, where there are four questions, each asking which of three choices is the best change to make in a specific category such as transportation. This way, the new scene would be familiar to players and more easily understood, but it would still be different enough to maintain interest.
5.6.2 Final Version

Following the first meeting with SW, the Indoor House scene was renamed to “Indoor Flat scene” to reflect the storyline in development for SW, where the player is an intern temporarily staying in Winterthur and the home they make changes to is their new flat. The idea of sorting choices into categories was abandoned in favor of a shorter time limit of 30-60 seconds to make as many changes as possible. This was in part due to feedback from the SW representative at the first meeting. They expressed a strong desire to keep the game very brief, and this change would cut down the time required for the scene while still covering multiple topics. This also avoided the potential issue of some categories having too few possible changes. This would make selecting all changes within the time limit too easy. If the game is not challenging enough for players, there is less of a sense of accomplishment. The short time limit with many changes also had the goal of making people think quickly and critically about which changes had the greatest positive effect, as not all changes could be made within the time given. This meant that selecting better choices first would result in a higher final score (see section 5.9 for scoring).

The iteration that was finally presented to SW was renamed to the Smart Home scene, since this name encompassed either a flat or a single-family home depending on the storyline used. The number of possible changes was narrowed to approximately 15, and rather than having the player select as many changes as possible within a time limit, the player would be instructed to select the 5 best options within that time limit. The exact time needed for this can be
determined through tests after the scene is created within the game. The switch to selecting only the best few changes was suggested to prevent an aimless point-and-click by players to earn points without learning, a risk in the previously suggested iteration. This scene also contains the potential to display products and services for SW or another energy company. One example is switching from e-Strom.Grau to e-Strom.Gold, both grades of electricity offered by SW, with the latter consisting of more sustainably sourced electricity.

5.7 End Scene

This section describes the process of developing the ending scene of the game. As the last scene players see, this scene is the one they will remember most. Therefore, we want to ensure that it motivates players to act on what they have learned and make real-life changes towards the energy transition.

5.7.1 Current End Scene

As described in section 5.1, in the current storyline the player returns to the hot air balloon at the end of VEH. There, they receive a certificate with their final score in energy points, and depending on their score Oscar either encourages them to learn more or share their knowledge (see Appendix K for full script). He also reminds the player that every person can make a difference in the energy revolution, before flying away over Winterthur as the ending music begins to play. The balloon with the player continues to rise before transitioning into space with a view of the Earth and credits, seen in Figure 24.
After personally testing VEH, the first impression was that the scene in space seemed sudden and out of place, even if the experience itself was enjoyable. However, ZHAW preferred to keep this scene, citing the work involved in its creation. Instead, avenues were explored to make the scene more useful. In order to reach people after the short time frame of the game and to make learning as easy for players as possible, the team proposed including the names of websites that players could use as resources for further learning, such as the website of SW. These websites could be listed in the credits scene to give it an educational purpose. The website names would also be hyperlinks in the then-proposed ideas of a downloadable VR version of VEH, online non-VR version, and/or a mobile app (for more information, see section 5.12). These websites would also be included on a physical copy of the certificate Oscar presents, to be handed out after completing the game.

5.7.2 Stadtwerk Winterthur End Scene

For SW, the initial plan was to claim that the hot air balloon belonged to them, so in the end scene the player would return the balloon and receive their score at the SW headquarters. This would replace the space scene for a more realistic and expected ending. The names of other
informational websites also did not have to be displayed for an SW demonstration, as the game’s purpose would be marketing SW. Instead, dialogue in the final scene would direct players to the SW website and services of theirs such as energy consultations. A separate website, specifically for VEH, could also be mentioned (more on this website in section 5.12).

For the final meeting with SW, the Intern storyline removed the hotspots and created the opportunity for a balloon-free version of VEH for SW, which would make the demonstration easier to transport and set up. Either way, the ending scene would have the player stand on the ground back where the Smart Living scene was set, and receive their final score from the avatar, with similar dialogue to that previously described. Depending on whether the balloon was included in the demonstration or not, the avatar would either take the balloon with them and leave, or simply leave the player. Either way, the player would remain on the ground and not see the space scene, keeping the demonstration more realistic.

5.7.3 Save Winterthur End Scene

In the Save Winterthur storyline, as in the current storyline, the player will return to the balloon for their final score. However, for this storyline it became possible to incorporate the space scene more smoothly. In the current VEH, the space scene is not only sudden, but also a point of confusion for players. During the public events where we demonstrated VEH and conducted surveys, many players were observed removing the headset after Oscar flew away from the balloon and before the space scene began, mistakenly believing the game to have ended. ZHAW made the same observation at the event they solely attended, Nacht der Technik. With the addition of a crystal ball (used in the attic scene to show a potential future Winterthur, as described in section 5.2.3), the player can be shown space through this crystal ball instead of relying on their own suspension of disbelief to explain how a hot air balloon entered space.

After the Smart Home scene is completed, Oscar would again bring out his crystal ball to show the player the new future of Winterthur reflecting the changes they have made. The player would once again find themselves in a balloon over Winterthur, viewing a bright and clean city with some new technologies added, such as solar panels and wind turbines. The player would receive their score while viewing this scene. Then, rather than having Oscar fly away as the balloon rises to the space scene, Oscar tells the player to hold on while he shows them another
scene in the crystal ball, and the scene will transition to space. This should prevent players from mistakenly removing the headset early. While in space, Oscar would remark on the beauty of the Earth, and remind the player to keep it that way, again calling back to the dark potential future shown at the start of the game and ending the game with a call to action.

5.8 Question Changes and Quiz Format

This section details the development of our recommendations to improve the game questions and quiz format of VEH within the context of optimizing knowledge transfer and increasing player engagement. The questions in VEH are the only means by which knowledge is transferred in the current version of the game. The question script, in the interest of optimizing knowledge transfer, contains several examples of trivialities that are able to be replaced with more valuable questions. The presentation of the questions is additionally lacking in engagement and could do much more in making use of VR’s immersive capabilities.

5.8.1 Current Format

The current question script is used at the Hotspot scene (see section 5.3) and the House scene (see section 5.5). At the Hotspot scene, four questions are picked randomly from a set of 67, based on which category they fall into. The questions are categorized according to their hotspot. The Technikum asks questions about general smart energy topics, the Technopark asks questions about solar energy, the KVA asks questions about waste energy, and the Bahnhof asks questions about Swiss mobility and public transportation. The current distribution of questions into these categories is seen in Figure 25. The four questions asked at the Hotspot scene are each worth two points.

![Figure 25: VEH Current Question Distribution](image)
At the House scene, four more questions are asked. These questions, however, are the same in every playthrough of the game. The questions asked here focus on four categories of energy consumption: electricity usage, heating, mobility, and nutrition. The player has three options to increase sustainability and is scored from one to three based on the quality of the change. Each question at this scene is worth up to three points.

The script, while mostly comprised of relevant questions, contains several Hotspot questions recommended for removal (see Appendix L). These questions were recommended for removal because the knowledge transferred to the consumer is of marginal relevance toward the objective of energy awareness (e.g. “which room of the KVA are you currently in?”). A solution to replace these questions is recommended later in this section.

The quiz format of the current game is a large two-dimensional projection of the question in front of the player. The player points the controller at one of the answers and selects it using the rear trigger. This method of presenting information turns the game into a “glorified quiz”, doing little to utilize the VR environment according to a local masters student.

5.8.2 First Format Changes

At the first SW presentation, it was recommended that trivial questions should be replaced with questions more focused on consumer awareness. These questions could be determined by an interested research team or utilities company looking to collect consumer data via an extractable data system (see section 5.11). In addition, there would be more questions added concerning the important topic of energy flexibility, as the interview with Dr. Silvia Ulli-Beer suggested (see Appendix B). At this point in the development of the game, time constraints associated with adding a new scene had to be considered (see section 5.6), and it was thus decided to reduce the number of questions at the Hotspot scene to three, which would save up to 30 seconds of game time to divert to more engaging scenes.
5.8.3 Final Format Changes

For the second SW presentation, numerous changes were made to the questions and quiz format, encompassing the Balloon Over Winterthur scene (see section 5.4.3), the Smart Living scene (see section 5.5.2), and the Smart Home scene (see section 5.6.2).

In the Balloon Over Winterthur scene, the question script would largely remain the same and be answered before showing each of the different filters over the city of Winterthur. These questions would also be reorganized according to their respective filters and displayed via a word bubble from Oscar, and answered using the directional pad on the Vive controller. The change of environment and utilization of the controller makes further use of the functionalities of the Vive, further increasing player engagement.

In the Smart Living Scene, the questions and quiz format had to be changed significantly to help consolidate the format of the current House scene. The new Smart Living scene would implement smart city topics, but many of the necessary questions could not be asked in such a way that three options could be offered (smart lighting, smart metering, PV systems and batteries, etc.). It was therefore decided to ask different questions in a new format. These questions would be randomly selected from a set of possible changes and would be asked from a word bubble in the form: “Find a way to become more sustainable in ____!” The player would then search for and select the object relating to the appropriate change. If the player tries to make the incorrect change, they will be stopped by Oscar and move on. The question must be correctly answered within 15 seconds. After selecting the correct answer, the player will receive a brief informational text to learn more about the impact of the change (e.g. “Switching to smart LED public lighting can save up to 35% on city lighting!”) The number of questions to be selected from has great potential to be expanded upon, being able to pull from residential options (installing a PV system, insulation, mobility, etc.) as well as smart city topics (smart public lighting, smart metering, decentralized energy storage, etc.).

5.9 Point System

In the current VEH, players earn “energy points” as they answer questions. For each correct answer at the hotspots they earn 2 energy points, while in the current Home scene each
question has answers worth 1, 2, and 3 points. There is a total of 20 points available and a player receives the title of “Energy Hero” for earning 10 or more points.

From the first week, a concept was developed to take these relatively arbitrary energy points and give them more meaning, to turn them from extrinsic to intrinsic motivators. The first idea was to display the cost or energy savings resulting from a player’s choices. However, some choices (such as installing a PV system) would not necessarily reduce a player’s energy use, and could even cost them more money. In an interview with Dr. Silvia Ulli-Beer, she recommended using CO₂ savings instead. In further meetings with sponsors and advisors, this idea was explored, and the idea of visually representing scores was investigated. Some possible visual representations included renewables introduced (adding wind turbines and solar panels) or trees planted (a number approximately equivalent to CO₂ reductions). However, without a scale showing the maximum points, players may find it difficult to gauge their performance.

From these options a decision was made to focus on replacing energy points with CO₂ savings, looking for ways to reduce the complexity and constraints that such a system involved. The points would have to be detached entirely from the Hotspot or Hot Air Balloon scenes as most of those questions could not be calculated in CO₂ savings. For actions the player takes in the Smart Living and Smart Home scenes, it is easier to calculate CO₂ savings but still comes with many issues. For example, if the player switches their electricity to a CO₂ emissions-free source in the Smart Home scene, they will no longer reduce CO₂ emissions by using energy-efficient appliances. In the Smart Living scene, installing a smart meter will not necessarily reduce energy use, merely inform residents of their usage. Making compromises and researching averages may make this possible, especially if there is a reliance on existing CO₂ calculators like the World Wildlife Fund’s footprint calculator, as suggested by our sponsor. Ultimately, the format of the game and its questions dictate whether this point system is viable or not. Rather than limiting the entire gameplay and questions based on the point system, it is better to limit the point system based on the game - using energy points if necessary.

5.10 Variable Time Modes

A constraint on the current version of VEH is the amount of time each playthrough takes. Without including setup (putting the headset on and learning the controls), the game currently
takes around ten minutes to finish. This puts a limit on the number of potential players at each demonstration. For example, at a five-hour exhibition there can only be a maximum of 30 players if the game is being played nonstop. To address this, ideas were developed to maximize the amount of information delivered in the shortest amount of time, while still developing the narrative well enough to keep the player engaged and interested.

At the first SW presentation, long and short time mode variants for VEH were presented. The long mode would take the player through the full story while the short mode would be reserved for busy events, showing only the most engaging and interactive scenes to pique the player’s interest in smart energy and city topics, and then directing them to further resources (see section 5.12). The scenes cut for the short mode included the Attic scene and the Hotspot scene. The outcome of this was a reduction in playtime by up to three minutes, allowing for 30% more potential players at demonstrations. The introduction could additionally be compensated for with a screen playing the introduction on loop for the players in line. However, after the storyline changes leading up to the second SW presentation (see section 5.1), this plan was revised completely to better serve the purposes of each version of the storyline.

At the second SW presentation, the Intern version of the game with only two scenes was presented: the Smart Living and Smart Home scenes (see section 5.1.3). This way, SW’s version would be used strictly for marketing and product design and could be made as long or short as necessary to sufficiently showcase SW products. This offers a suitable model for other utilities companies that show interest in their own marketing version of VEH. Conversely, the Save Winterthur storyline is offered in only the full version to maximize the quality of the game experience. The gameplay is projected on a larger screen for players waiting in line or walking by the exhibit. Here, it is more important to maximize the quality of each player’s experience rather than rushing more people through a minimally developed story. With the branching of VEH into two versions, this concept was developed to minimize the length of the marketing version to reach as many potential customers as possible, while building up and refining the full version of the game with a more concrete narrative, interactive environment, and engaging playthrough.
5.11 Extractable Data System

This section provides an explanation for the concept of an extractable data system in the game. This system would tie into the game and survey platform in order to create a database of actions and responses in and out of the game. This was identified as an important way to boost the games possible applications and extensions, and thus became a concrete priority in this project.

5.11.1 Data for Research

In an interview with Dr. Silvia Ulli-Beer, she revealed that she would like VEH to be able to be utilized for research. When asked to elaborate, she explained that this project is a first-of-its-kind in Switzerland, and will be looked at closely. Furthermore, the current game has no system to extract player answers to questions or even their total score. She went on to state that some of this data could go towards answering energy research questions posed by ZHAW and various organizations, such as SCCER CREST (see Appendix J). As a result, a concept was drafted that would include an extractable data system in the game. This system would log data such as total game time per playthrough, player response time, and player response choices. For the initial version of the game, this would serve mainly as a way to identify where players spend the most time and what responses they are drawn to. If players are consistently drawn to the wrong answers, that can yield insight into the misconceptions surrounding energy consumption. This was presented to Cymmersion and ZHAW, with the hopes of finding other avenues to pursue with the system as well as ways to establish the concept even further into the game. It was decided here that the data system was important, but needed to wait until other concepts were fully developed.

After the storyline and new scenes were properly developed, the group reacquainted itself with the concept of an extractable data system. The addition of the Smart Living and Smart Home scenes provided further relevance. In the Smart Living scene, smart city concepts would be introduced to the player, and their responses would be tracked. The same process would apply to the Smart Home scene, where smart energy concepts are directly instituted. This player information could help discern the level of knowledge the average person in the community has about smart city and smart energy topics. If gaps in knowledge were identified, then proper
education could be pursued by organizations, in order to fill these gaps and reduce misconceptions.

5.11.2 Data for Marketing

After pitching the extractable data system to ZHAW, the next task was to find an application for SW. With an emphasis on products and services embedded in the game, it was clear that data gathering would have a focal point in the Smart Living and Smart Home scenes for SW. These scenes would include specific products and services from SW. Therefore, player responses could help indicate a consumer mindset around SW products, helping the utility company to alter their marketing according to the data. This data could manifest into trends that rank the products and services introduced in the game. Furthermore, a lack of interaction with a product in the game could represent a need for improved product design.

5.12 Game Accessibility

This section details the works involved with improving the capacity of the game’s accessibility to the public. As VEH continued to gain popularity and potential for funding, the outreach for the game had to concurrently rise. The development of a multilingual script, supplemental mobile app, as well as a web-based version of the game help extend the game to reach other audiences.

5.12.1 Multilingual Expansion

Upon arrival in Switzerland, the game was tested. The entire game is in German and does not include any other language alternatives. ZHAW explained that during the Nacht der Technik demonstration in July, a few of the 50 game participants needed the employees to help translate the game for them. Expanding the game’s language system would help attract larger crowds and increase the number of events it could be displayed at. In Basel, at the SCCER CREST Energy Future Conference, energy experts from all across Europe came to share their knowledge. The language for the business conference was English. VEH was also demonstrated here and required
translations. Due to the multilingual basis of Switzerland, it was proposed that the languages of Italian, French, and English be added to the game.

5.12.2 Mobile Application

After the initial meeting with ZHAW, the project goals called for the pursuit of extended applications for VEH. There are currently no other resources available to the player if they wanted to learn more about the game or its topics. It was determined that a mobile application would be the best way to alleviate this hole in the project. A member of the ZHAW IT department was interested in electing some of his master students towards developing a mobile application for the game. Through concept development, two separate avenues were found: either add an informational platform onto the already existing Stadt Winterthur app or develop a separate application that functioned as a mobile-VR game. When Cymmersion was questioned about the latter, they shared their concerns by stating the processing power of phones would render the game much less enjoyable (see Appendix C). This resulted in a focus on an informational side to the application. However, without attaching this to an already existing app, there was no substantial difference between this concept and that of a website. As a consequence, the mobile application concept was suspended until more information came forth.

5.12.3 Game Website

VEH offers no current information or outlets for the player to visit in order to learn more about the energy transition in Switzerland and the concepts therein. Initially, it was suggested that links to ZHAW, Stadt Winterthur, and SW be made available in the space scene of VEH. This would at the very least subject the player to the links with the hopes that they would have the initiative to visit the sites. Through rigorous meetings with ZHAW, a standalone website concept emerged. This website would be directly referred to at the end of the game. The website would be very accessible, as it shares the same name as the game. Upon visiting the website, players would see the same game art displayed on the cover of this paper, along with a neighboring panel of text explaining the mission statement of the game and its overall goal. Next, the reader could explore the full content that the game has to offer, this time with no time
limit. They would be able to view the full information the current storyline has to offer, since you can only visit one of the four hotspots. To further enhance this experience, whenever important energy topics are mentioned in these scenes, Oscar would pop up and direct the player to a proper outlet of information to learn more. For example, in the Technopark, the player would answer questions about PV systems and be prompted to visit a site where these systems are available for purchase and research. Links to ZHAW, Stadt Winterthur, and SW’s websites would be made available on the web page as well.

This concept was pitched to ZHAW and SW. Within their suggestions, an idea was unearthed that involved strengthening the storyline even further. The web page would serve as a “Chapter Two” for VEH, for both the Save Winterthur and Intern storylines. This would strongly encourage the player to finish the storyline on the website. Instead of being an exploration of the current game, the web version of VEH would be an information heavy game. This would teach the player more on smart city concepts and potentially include the smart district scene, which was taken out of the fully developed storylines.

5.13 Game Mechanics

This section lists the various minute concept changes to the game to improve its usability and reduce its discomfort. Features such as a reticle, improved balloon movement, and the introduction of time of day and/or season modes further enhance the experience in the game. One of these small concepts allowed for day and night modes along with winter and summer modes in the game. This would add a sense of realism for the player and allow them to learn how energy changes during day/night and summer/winter. However, due to the small impact this would have on the game in comparison to the amount of work required to implement it, this concept was suspended.

5.13.1 Reticle and Avatar Movement

From background research, it was clear that virtual reality systems create a plethora of problems for players. Post-game surveys show that 32% of the players experienced some sort of discomfort during their game experience (see Appendix D). In an interview with Professor
Jeffrey Kesselman, he pointed out a need for a reticle (see Appendix B). While VR doesn’t support traditional heads-up displays, a reticle helps give a frame of reference for the player, fixing their depth perception and therefore reducing negative feelings such as nausea. This is especially relevant when considering that the game takes place in a hot air balloon high above the ground. When presented to the game developers, Cymmersion, there was pushback due to the difficulties involved with adding a two-dimensional constant reticle in a virtual reality experience. Another idea to improve dizziness involved reducing the degree of movement the current avatar undergoes while standing in front of the player (the idle animation). Oscar gyrates his body in an unnatural movement whilst standing in front of the player, which creates a lack of realism and is generally unsettling to the player. When presented to ZHAW and Cymmersion, all parties were in agreement that an improvement was needed.

5.13.2 Balloon Basket and Movement

The initial version of VEH allowed for the player to dictate balloon movement with the Vive controller. However, the controls were difficult and took too much time out of the game, as players would spend time wandering around with the balloon instead of picking a hotspot or taking the quiz. Introducing movement also raised the chance that players would experience simulator sickness. The wandering is also true for the physical balloon basket that was made for the game. Whenever the game was demonstrated without the use of this real-life basket, players felt comfortable walking around in game, despite the virtual balloon boundaries being violated. This resulted in many awkward occurrences where the base station, which help to center the player in the game, would be bumped and almost knocked over by the player. Thus, the balloon movement idea was scrapped to save time and reduce simulator sickness and it was evident that the basket (or some other form of a physical boundary) must remain in all demonstrations in order for the players to not wander around the game too much.
Chapter 6: Recommendations and Conclusion

During the course of this project, Virtual Energy Hero acquired substantial interest from many different directions, resulting in a necessity to revise project goals. Previously, they were focused only on the game and ways to improve its entertainment factor and educational value. The primary goal was then refined to focus on how to extend the applications of Virtual Energy Hero in accordance with ZHAW and stakeholder initiatives. This manifested in recommendations centered around increasing research and marketing value, increasing player immersion and interactivity, and optimizing knowledge transfer to better introduce the topics of smart city and smart energy technology.

6.1 Research and Market Value

In order for ZHAW to justify the funding used for the development of Virtual Energy Hero, it must demonstrate its value to current research. Being a pioneering project, Virtual Energy Hero can be used as a model for future projects of similar nature. ZHAW is also interested in determining a means by which Virtual Energy Hero can generate revenue. This section presents our final recommendations to increase Virtual Energy Hero’s research value and potential as a marketing tool.

1. **Implement an extractable data system.** By implementing a method to collect player data to the game, Virtual Energy Hero gains significant research value. Player responses, playtime, and preferences can be used to build a clearer picture of the consumer mindset. Questions can be introduced to research consumer awareness, playtime data can be used to determine where players are wasting time and optimize the efficiency of knowledge transfer, and player preferences can be used to determine product marketability as well as public opinion towards smart city projects.

2. **Using our Stadtwerk Winterthur model, dedicate a second version of the game to product marketing.** The storyline we developed for Stadtwerk Winterthur serves as a model for an effective marketing tool. The shortened version of the game aids in
maximizing the potential number of players and minimizing wait time. By developing the Smart Living and Smart Home scenes to implement smart energy and smart city products, utilities companies and other organizations dedicated to marketing more energy efficient products can purchase advertising space in Virtual Energy Hero to be shown at various demonstrations, or even for the organization’s own use.

3. Use the player survey to ask questions related to the products and services implemented in Virtual Energy Hero. The survey can be used to continue to collect data on player enjoyment and attitude toward smart energy and smart city technologies. Its use can be further extended in a commercialized version of the game to determine consumer opinion on stakeholder products and services. By asking players to rank their interest in the products presented in the game, the survey data can aid in refining product design and development.

6.2 Player Immersion and Interactivity

Player immersion and the interactivity within Virtual Energy Hero serve to engage the player and ensure their attention is held. An engaged player is less likely to leave the game before it is finished, and is expected to better remember what they did during the game. This would raise the amount of information they learn on smart energy and smart city topics and encourage them to take real-life actions contributing to the Swiss energy transition, which is the main goal of the further development of Virtual Energy Hero. This section presents our final recommendations to raise player immersion and interactivity and craft an overall enjoyable game experience.

1. Implement game mechanics to minimize player discomfort. To prevent simulator sickness and improve player focus, we recommend the introduction of a reticle and a less pronounced idle animation for the avatar. A reticle is expected to provide a frame of reference and improve eye focus to prevent a blurry view and eye strain. Reduction of the avatar’s motion while standing in front of the player will increase realism and avoid a distracting, even unsettling, quality in the avatar. For the player’s safety, we also
recommend keeping the hot air balloon basket to protect the player from wandering outside of the designated play area. If any version of the game is created without a balloon, some other physical boundary should be used.

2. **Replace the current storyline with the Save Winterthur storyline.** The storyline provides the hook for the player to continue investing time and attention into the game. To increase player engagement through a more concrete narrative, an antagonist should be introduced in the form of a potential negative energy future. Therefore, we recommend replacing the current storyline with the Save Winterthur storyline detailed in section 5.1.4, where the player is shown a version of the future using a crystal ball, and must take actions to prevent this future.

3. **Rework Attic scene according to the new storyline.** The current attic scene can appear to drag on, as the player waits for Oscar to finish speaking. Implementing the Save Winterthur storyline would make better use of this time, with Oscar’s dialogue mostly occurring while the player looks out over a darkened Winterthur. This would make the first scene players experience more interesting and engaging.

4. **Remove Hotspot scene.** The format of the current hotspots scene is essentially a multiple-choice quiz and fails to properly utilize the VR aspect of Virtual Energy Hero. Due to the need for a short game, a scene needs to be removed. Therefore, we recommend removing the Hotspot scene so time can be spent on more interactive scenes, such as a new Smart City scene.

5. **Implement a new Smart City scene via hot air balloon.** To expand the subject matter of Virtual Energy Hero to further include smart city topics, we recommend the introduction of a new scene focusing on smart cities. This scene, detailed in section 5.4.2, shows various filters over the city of Winterthur, showing the city’s interconnectivity. Filters would be revealed after answering a related question, resulting in a more visually engaging and interactive scene than the Hotspot scene, which this scene essentially replaces.
6. **Change Bettina’s House scene to a more interactive Smart Living scene.** Adding an apartment complex next to the existing single-family home covers the most common Swiss housing options, so people can feel familiarity with the setting regardless of which they live in. Changing the gameplay of the scene from answering questions that appear in front of the player to one that requires the player to look around for changes and think about their surroundings would greatly increase the scene’s interactivity (see section 5.5.2 for details). It also makes use of the 360-degree view and immersion for which VR is uniquely capable.

7. **Implement a new Smart Home scene indoors.** The second new scene would set players in the familiar and immersive setting of a home. As described at the end of section 5.6.2, players would have to interact with their surroundings to pick the five changes that have the greatest positive effect on a home’s energy use. Like the proposed changes to the Smart Living scene, this makes better use of the VR platform of Virtual Energy Hero.

8. **Rework End scene according to the new storyline.** To incorporate the new Save Winterthur storyline into the end scene, the crystal ball would make a return to show the player Winterthur by balloon after the changes made in the Smart Living and Smart Home scenes created a more positive future. This also allows for more fluidity in the transition to space for the credits, which avoids breaking immersion. The game would also end with a final call to action, encouraging the player to not only interact with the game, but also the real world to work towards a positive energy future.

### 6.3 Optimizing Knowledge Transfer

ZHAW’s primary objective in developing Virtual Energy Hero is to raise public awareness and positive motivations toward smart energy and smart city topics. Optimizing knowledge transfer is therefore critical to ZHAW’s objective. This is to be achieved by developing the game to communicate as much information as possible to the player in each playthrough, and also by implementing methods to expand the potential audience of the game as
much as possible. This section presents our final recommendations to optimize knowledge transfer in Virtual Energy Hero.

1. **Implement more engaging and impactful player challenges.** By implementing the changes recommended for each scene (see section 6.2), the player will be more engaged via a more interactive environment and a more fast-paced challenge. By engaging the player through a greater variety of challenges, they will be more likely to retain their knowledge of the content of the game beyond the ten minutes spent playing it. Furthermore, the new Smart Living and Smart Home scenes offer much more versatility in communicating a greater variety of smart energy and city topics, which will go further to aid in improving consumer decision-making.

2. **Implement a point system focusing on sustainability.** A point system focused on sustainability will give meaning to the game’s reward system, as opposed to the current “energy points” which are more arbitrary. The change in point system will go further in making use of the player’s intrinsic reward system. This will better motivate the player to answer and learn to the best of their ability. Based on our interviews and workshops, our group arrived at the conclusion that quantifying the point system based on reduction of CO₂ emissions is the most feasible method. However, many broad assumptions must be made which sacrifice the accuracy of some measurements, in addition to other difficulties in calculating the impact of each action (see section 5.9). We offer a sample point system (see appendix #), but encourage our sponsor to pursue a more developed model for the point system.

3. **Implement an accessible digital version of Virtual Energy Hero.** By offering a web-based or mobile version of Virtual Energy Hero, whether as an added functionality on an existing platform or as a standalone product, the potential audience for Virtual Energy Hero would be significantly expanded. Reaching as many people as possible is critical to optimizing knowledge transfer. This mobile or web version can potentially be developed by ZHAW masters and bachelor students.
4. **Translate the game into different languages.** Offering Virtual Energy Hero in different languages expands the potential audience as well as the potential utility of the game. By first translating Virtual Energy Hero to English, the game will be playable in almost any country immediately. Furthermore, as a pioneering project in the VR gamification of smart energy and smart city topics, Virtual Energy Hero will serve as a model for future similar projects. With other projects aiming to achieve the same goal as Virtual Energy Hero, knowledge transfer of the information in Virtual Energy Hero will be further optimized.

6.4 Conclusion

The implementation of these recommendations is expected to build the existing VEH into a game that better accomplishes its current purpose as an entertaining and educational tool on the Swiss energy transition. In addition, value for both research and marketing can be introduced, expanding VEH’s sphere of influence. As VR has only recently become widely available, a pioneering VR game like VEH stands to serve as a model for future VR applications in research, gaming, and education most of all. Winterthur is not the only city undergoing the Swiss energy transition, and Switzerland is not the only nation that plans to change its energy infrastructure. A more sustainable energy future is required worldwide, and projects such as VEH play an important part in ensuring this future is met.
References


Kapp, K. (2012). The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education. Pfeiffer.


Appendix A: Sponsor Description

The School of Engineering for the Zürcher Hochschule für Angewandte Wissenschaften, also known as the Zürich University of Applied Sciences or ZHAW, was originally founded in 1874 as the Technikum Winterthur. This became the Technikum Winterthur Ingenieurschule (TWI) in 1964. In the 1990s, the Swiss educational system underwent a reform that increased the number of applied science universities, combining aspects from both vocational schools and traditional universities. In 1998 as part of this reform, the TWI joined with other existing institutions to form the Zürcher Fachhochschule (ZFH). In 2007, these loosely associated institutes became reconstructed into three different universities: the Zurich University of the Arts (ZHdK), the Zurich University of Teacher Education (PHZH), and ZHAW (Roumois, Girsberger, Buomberger, & Meister, 2011).

Since then, ZHAW has continued to be a leader in applied sciences. In 2009, ZHAW decided upon their university strategy: social embedding, interdisciplinary, internationality, personality development, selectivity, and economic efficiency (ZHAW, n.d.-b). Currently, there are over 12,000 students enrolled in ZHAW. Approximately 2,000 of these students are in the School of Engineering, which is one of the eight schools of ZHAW (ZHAW, n.d.-f). Modern day School of Engineering graduates have the privilege of studying at a leading institution in the advancement and development of Swiss engineering. This inherently makes them highly sought after in the workforce. The remaining seven schools benefit in similar manners, due to ZHAW’s collaboration with numerous firms and institutions to keep themselves at the forefront of research and development.

In 2015, ZHAW partnered up with the Zurich Cantonal Bank (ZKB), the purpose being to promote start-ups from within the university. Currently ZHAW has partnership agreements with over 420 universities in 57 different countries, providing its students with international perspectives (ZHAW, n.d.-f). With a total investment of 116 million Swiss francs in applied research and development and conducting several hundred projects yearly, ZHAW is a rapidly growing institution that matches its expansion with its ambition (ZHAW, n.d.-f).

With the gamification program largely focused on smart energy and smart city technologies, the Institute of Sustainable Development (INE) is the institute most relevant to our
project. Our on-site mentors, Dr. Silvia Ulli-Beer, Dr. Juliana Victoria Zapata Riveros, and Mirjam West, belong to INE. The mission statement from the ZHAW INE website is as follows:

“The Institute of Sustainable Development (INE) observes technological, economic and social changes and their complex interactions from a sustainability perspective. Using applied research, we identify future demands on technologies and their future-compatible integration into systems. We concentrate on the following three subject areas: sustainable energy systems, sustainable transport systems, risk management and technology assessment” (ZHAW, n.d.-a).

Their mission is to improve sustainability, with a particularly vested interest in how society can be influenced by their mission as well as how society can impact INE’s goal. A few critical points that the INE must confront in order to move forward with their research include identifying the needs and behaviors of individuals, the anticipation of the development and acceptance of new technologies, evaluating the social acceptability of infrastructure projects, and, perhaps most important with regard to our sponsor’s mission for us, analyzing the potential of participative approaches (ZHAW, n.d.-d).

In regard to the gamification of smart energy and smart city technology, INE has a vision of informing citizens through a focus on energy consumption in the virtual reality game. In order to make advancements in these areas, INE researchers seek to predict future trends, make use of available and new technologies and consider the interests of stakeholders to develop business models and Smart Regions promoting sustainability, as can be seen in Figure 26 (ZHAW, n.d.-a).

![Figure 26: Figure from ZHAW Institute of Sustainable Development (INE) indicating their research strategies (n.d.-a)](image-url)
Appendix B: Interviews

Interview Format:

Conductors of the Interview:
These persons were responsible for the interview

Date, Location, City, Country:

Introduction:
This was read to the interviewee prior to the interview to give context to our work.
We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, smart city, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:
The information contained in this interview is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. Questions
   a. Responses
      i. Explanation and/or Sub Response

2. Questions
   a. Responses
      i. Explanation and/or Sub Response
Appendix B.1: Interview with WPI Professor Sheldon

Conductors of the Interview:

These persons were responsible for the interview
Nicholas Fleury, Aislinn Harte

Date, Location, City, Country:
April 18th, 2018; Worcester Polytechnic Institute; Worcester, USA

Introduction:

This was read to the interviewee prior to the interview to give context to our work.

We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:

The information contained in this appendix is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. Can we identify you in our IQP?
   a. Yes, you can.

2. What is the greatest challenge for serious games?
   a. People not understanding what makes a good game.
      
      i. Rather than just adding game element rewards, extrinsic rewards can cause more harm than good. Like giving students money to study and it
works, but when you stop it, it ends up at previous levels or worse. Not really leveling up.

ii. Prefer intrinsic rewards. Like put people into “guilds”, and make sure each has a chance to shine, get high-fives. People love to be appreciated.

b. Balancing gameplay and teaching.

i. Prefers the term applied games instead of serious games. Too often people focus on the gameplay and have a fun game, but they lose the academic side all together. Universities and professors tend to focus only on the academic side and make a horrifically boring game.

ii. Example: Equations were just taken straight from the textbook, and it looked horrendous.

iii. Also a statistical game. A drug going to come out but has an issue, you have to find the issue which is a mystery. You had to go into the library and look at a book, but they basically just copied a textbook there.

3. **Serious games have a solid impact upon initial implementation. However, over time the impact drops severely. In your opinion, what are solid avenues to have a long-term impact with serious games?**

a. Rewards have to be intrinsic. Like having a diverse team where each member has their turn to shine (as said earlier).

   i. Likes giving his team a test where some questions count for the whole team if one person gets it. So people try for the team.

   ii. Rewards can come from relationships with NPCs.

b. Need to find some narrative to the experience. Like looking around, but maybe you have a connection between the sites to have an underlying story. Like in Civilization, you learn about the towns with something at stake.

c. “VR is a pizza box. The pizza has to smell, taste, and look good” A delivery system, and you need the product/game to be good “pizza has to be edible.” You don’t want just a travelogue.

   i. It’s immersive which is good. But nausea is an issue, want fast frame rate and careful with motion over the town, etc.

   ii. But cuts down on number of people who can play
d. Like saying somebody “Nefaria” is competing with the Swiss towns and messing with old technology. So you have to try and get smart energy to fix it.

e. Personalizing it and having scenarios in order to surprise people.

4. **In the literature review, the concepts of feedback, challenges, social sharing, and rewards are cited as the most effective methods of motivation. Do you agree or disagree, and why?**

   a. Comparative feedback-agree
   
   b. Challenges-agree
   
   c. Social Sharing- sharing content on a social media medium. Could have a leaderboard, but people won’t want to identify themselves. Just people saying “hey, cool game over here.”
   
   d. Rewards- Intrinsic motivators mentioned before.

5. **Have you had any experience with VR in serious games?**

   a. Taught a class of grad students where they were teaching electrical engineering on a spaceship. You wake from cryosleep and have to make sure systems work properly. Discover someone else woke up earlier and is sabotaging the ship. But the cargo of the ship is children who will be enslaved. So you have to decide what to do, stop the saboteur or not. So a whole moral dilemma in a game to teach electrical engineering. Ran out of time for VR, people underestimate time needed for a VR game.

6. **Any other considerations?**

   a. Put the testing invisibly inside the game. A lot more work.
   
   b. You can have fail states, but be gentle. (No power, you missed a tv show).
      
      i. You want them to want to play again.
      
      ii. Maybe make rules like “get 3 attempts” and then you have to let next person try. Just for time consideration.
   
   c. Firewatch is a ‘walker’ game
   
   d. He’s done math games, easy for computer to understand. Also a business ethics game, which is harder for the computer to understand.
   
   e. Did a cybersecurity game for Cal Polytech. Created a hacker who was a threat to the school, seeking revenge. Cal Polytech is near last nuclear plant in California,
hacker may have infiltrated the plant. Had TA kidnapped, created a fake dark web for students to hack. Had recorded videos of hacker taunting students. Had another game where hacker erased student’s grades.

i. Willing suspension of disbelief

f. Can be a really simple setup, like brief text introduction about a threat.

i. Like saying if we don’t change, some company will overcharge people.

Ambit is a company that starts with low rates and then charges more after 6 months?

g. Wouldn’t make the game much longer than 10-15 minutes.

h. Happy to advise long distance if we need help.
Appendix B.2: Interview with National Grid Sustainability Hub’s Monica Costillo

Conductors of the Interview:

These persons were responsible for the interview
Adam Ramram, Aislinn Harte

Date, Location, City, Country:
April 16th, 2018; National Grid Sustainability Hub; Worcester, USA

Introduction:
We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:
The information contained in this appendix is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. How would you describe the work of the National Grid Sustainability Hub?
   a. Determined areas of Worcester/Auburn for smart meters based on existing feeders
   b. Send out monthly to quarterly newsletters and weekly updates
   c. Smart energy for them means their AMI meters
   d. AMI is different from AMR, which sends usage info out in drive-bys, as opposed to connecting to the cloud and if a meter goes down they hop to another one. A grid formation has the meters hop.
e. Meters update every 15 minutes.
   i. *Better awareness of energy consumption, time of day/personal curves for your energy use. Based on that usage, provide tips on how to reduce energy usage during those times.*
   
   ii. *Much more helpful than a monthly usage*

f. People can come and visit and get pulls of their 15 minute intervals over a period of a month or two.

g. Started with energy saving days, extended to little bits of energy saving every day

h. Navigant is an external company, government required program for a year

2. **How do you encourage people to visit/talk to you? How do people find out about you?**

   a. Information pamphlets
   b. Some customers call for questions, take smart grid calls right away
   c. Sent advertising to customers saying anyone interested in the pilot can come visit.
      Limited to the customers in their smart grid

3. **What kinds of outreach events have you attended? What do you do there? (We especially want to know about educational outreach and local festivals)**

   a. Q&A sessions
   b. Table at Farmers’ Markets
   c. Human powered generators
   d. Show people energy usage
   e. Ecotarium Earth Day event
      i. *Table, have coloring book with energy saving reminders to kids like turning off lights. Push the small things when teaching kids.*
   
   f. Proposed a game on energy usage patterns, but would have been too big for a farmers’ market, the audience would be uncertain. Easier to have people come to them.

4. **What are some demonstration tools that you use to aid in public outreach? Have you ever used games of any sort in your demonstration? If so, how were those games structured?**

   a. Gamification. Change to gain points to redeem for gift cards.
i. One family has kid track peak events and such to earn the points, then he gets the gift card. (Amazon, Apple, restaurants, etc.)

ii. Hub doesn’t actually verify, customer can click in on their points. Can get 10-100 points per day.

iii. 5,000 points = $5 gift card

iv. Also says how customers do compared to neighbors. And they gain points for answering questions for a better “neighbor” comparison based on square footage, appliances, etc. to help categorize homes (inefficient vs. efficient)

5. Do you provide any kind of incentive in your demonstrations?
   a. Coloring books for kids
   b. Key chains
   c. Seed pack

6. Do you use any specific teaching methods to get your message across? Examples being visuals (diagrams and charts), passive vs. active learning, etc?
   a. Compare energy usage to others
   b. Suggest replacements to current technologies/appliances (smart plug/thermostat, smart frame that flashes tips/notifications for peak events), peak load reduction
   c. Tiered pricing: energy is more expensive during peak events, off-peak is less, third and most expensive tier is conservation days
      i. Normal (daytime): 12.11 cents/kWh
      ii. Nights/weekends: 9.91 cents/kWh
      iii. Peak events: 61.39 cents/kWh
   d. Also offer rebates for people who can’t reduce. Pay a basic rate and don’t have to pay more during peak events. If bills are higher due to peak events, they can get rebates at the end of the year.
   e. Rates picked to be revenue-neutral. Have up to 30 events, but last year only had 8 events so customers weren’t affected much.
   f. Haven’t had any winter peak events - shoulder months

7. What have you found most effective in raising awareness?
a. Send a welcome pack to people when they join the smart grid. It was an opt-out program.
   i. *When someone moves in, they are told the home has a meter, they’re automatically opted in and can choose to opt out.*
   ii. *They don’t know how many people are unaware they’re in the program. Only about a 5% opt-out rate.*

8. **How do you evaluate the success of a demonstration or event? Do you make use of any surveys during public outreach events or in general?**
   a. Got calls complaining about robo-calls, have to use a real voice to remind about peak events and other information
   b. Initially default was call, email, about peak events the day-of and day-before. It was overwhelming, gave customers the chance to opt-out of some of the calls, only get day-before calls.
   c. Issue with leaderboard due to seniority giving an advantage.
   d. Monthly prizes, but people didn’t really believe it. Top 25 (percent?) savers for a peak event could go into a drawing for an iPad.
   e. Coming in to the hub can also allow chances for winning prizes. Issue is not many customers are aware of these rewards.
Appendix B.3: Interview with WPI Professor Jeffrey Kesselman

Conductors of the Interview:
These persons were responsible for the interview
Nicholas Fleury

Date, Location, City, Country:
May 12th, 2018; Worcester Polytechnic Institute; Worcester, USA

Introduction:
This was read to the interviewee prior to the interview to give context to our work.
We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, smart city, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:
The information contained in this interview is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. Can we identify you in our IQP?
   a. Yes

2. What are some VR demonstration tools you have worked on and what makes them unique?
   a. I worked on a game that teaches kids about poverty issues. Resource management game. Making family decisions as if you are the family in poverty.
i. Self-discovery is a must!

3. For the User Interface, can you provide examples of successful and unsuccessful UI?
   a. Yes, some things to be aware of:
      i. Mismatched queues.
      ii. Things moving in your peripheral.
      iii. Women are more susceptible! Make sure to include a significant number of women in your demonstrations.

4. Are there ways to foster a successful and intuitive UI?
   a. Successful UI focus on the least amount of strain on the user:
      i. Having a tutorial introduction.
      ii. Classic Heads Up Displays (HUDs) do not work in VR, as they block the view.
      iii. Avoid overlays, as they cause depth perception issues and therefore eye strain.
      iv. If you have a menu, try to attach it to the body: keep things close in!

5. After hearing the basics of our game, can you give any potential UI improvements?
   a. Make the static parts of the game more pronounced.
      i. The hot air balloon basket and the ropes attached.
   b. Add a centered reticle for the user to reference.
      i. Helps with scaling from large heights.
   c. Straight shoot into scenes instead of swooping motion.
   d. For your project, you could play with a zoom feature using a telescope.

6. In our email chain, you mentioned that increasing environmental awareness was key. Can you elaborate?
   a. That means you have to have focal and reference points for the user.
   b. Include glowing/highlighted/spotlighted objects to clue the user in.
Appendix B.4: Interview Call with Sponsors: Mirjam & Juliana

Conductors of the Interview:

These persons were responsible for the interview
Adam Ramram, Aislinn Harte, and Nicholas Fleury

Date, Location, City, Country:

April 19th, 2018; Worcester Polytechnic Institute; Worcester, USA

Point of Information:

The information contained in this interview is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. Good morning! You mentioned a test group in your emails to us, can you explain?
   a. First test round with a couple of teens/kids on Friday, see how they react to the model of Winterthur and avatar
      i. Have a bird accompany them
      ii. Precise 3d model of Winterthur, but without the textures of Google Earth.

2. Can we see what the game will look like? Do you have a first version you can share?
   a. Can send pictures next Friday, probably.
   b. Did storyboards a couple months ago. Have changed a little since then.

3. Is there anything you see as potential issues with the current game?
   a. Game is in German, can maybe set up to translate into English, time allowing.
   b. Probably not enough narrative, something that could be improved later.
   c. About making Winterthur more sustainable, no villain or anything.
d. Working on the questions at the moment, can send them to you so you can suggest other questions.

4. You have mentioned that there is a focus on “Hotspots”. What are these?
   a. Hot air balloon, hotspots over Winterthur to select and go to that place.
      i. Have 360 degree footage of places, like a train station. Questions will be related to each location.
      ii. So someone could go to the back of the line, play again, have a different experience.
   b. Maybe around 10 hotspots.
   c. Will test how long it takes people to get used to the hardware. Expect around a 5 minute game.
   d. Transition to a location shouldn’t be a problem. Hot air balloon will be at a fixed height, and can move slowly around at that height.

5. What are your plans for our arrival to Switzerland?
   a. Plan to have another test group while you are around, all depends on how our work goes.
   b. You guys will conduct Swiss expert interviews.
      i. We have people here.
Appendix B.5: Interview with ZHAW Dr. Silvia Ulli-Beer

Conductors of the Interview:
These persons were responsible for the interview
Adam Ramram, Aislinn Harte, Nicholas Fleury

Date, Location, City, Country:
August 29th, 2018; Technoparkstrasse 2; Winterthur, Switzerland

Introduction:
This was read to the interviewee prior to the interview to give context to our work.
We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, smart city, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:
The information contained in this interview is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. What is ZHAW’s stance on smart energy? Silvia, what do you focus on?
   a. ZHAW: focus on flexibilization of decentralized energy systems.
   b. Silvia: Load management and shaping load.
      i. GridSense is a product at the lowest grid level (works in homes). A smart energy product to shape loads, make sure companies don’t use more
energy than allowed or they pay money. Can postpone energy consumption to avoid too large a load.

ii. From Alpiq, an energy company.

c. Smart grid not implemented in Winterthur (smart metering)
   i. Self-consumption communities to know how much feeds back into the grid.
   ii. Go a step further from smart metering at households. Another, higher level is with companies. Want a grid-friendly load shaping approach considering both companies and the state of the grid, how much generation is in the grid.
   iii. Multi-energy system approach: Power-to-gas and gas-to-power with hydrogen as a storage solution, gas or electricity to heat, various energy systems that can come together, mobility connected to electricity, heat pumps, etc. Various interconnected systems. This is flexibility again.
   iv. Batteries for energy storage also flexible.
   v. Can take overproduced energy to store energy in hydrogen

2. Can you give concrete examples of what you mean?
   a. Example of flexibility: Don’t charge all cars at same time after work. If energy company can control loading of battery and charge various ones overnight, more flexibility in grid. Control appliances without interrupting its utility (use).
   b. Producers can have feed-in tariff, or newer is house batteries
      i. Payment to households generating own electricity.
   c. Using energy you pay for energy and transport. Transport about half the cost. With a battery you can use that energy without paying transport fee again.

3. Can you describe some of your short-term/long-term goals in developing Swiss Smart energy initiatives?
   a. In moving Switzerland closer towards the first milestones of the ES2050 and the 2000-watt society?
      i. Pooling approach, based on digital platform. Have to know who is using energy, put thousands of customers together. People know how much they can sell. Seeing if this business model is viable.
ii. Swarm photovoltaic or batteries. See if batteries can be combined, when to use your battery or to sell the battery energy.

iii. Look for less local (district instead of individual homes) battery/energy storage systems. Use it for local consumption? For grid stability?

iv. Less about the impact, more about the problems. Problems on the household level with PV and fluctuating production/use.

4. In your research experience, what have you found to be most effective in changing people’s attitudes towards Smart energy/city initiatives?
   a. Incentives? Education?
      i. Want people to use less energy or use renewable energy. PV production especially brings more local renewable energy. Want to foster more PV introduction.
      ii. Have feed-in tariffs, paying a bit per energy to the grid. These are being phased out.
      iii. Gov’t offers financial incentives you buy a PV plan
      iv. People should be aware of the importance of flexibility.
      v. Many people use fossil fuels for heating, need to decarbonize this. Look at solutions to provide flexibility and decarbonize.

5. In your opinion, what makes virtual reality a good means of transferring knowledge? Why did you choose it over a conventional gaming system/demonstration?
   a. Energy seems intangible, it’s just here. Doesn’t get much attention. We need a marketing tool that attracts attention and can show the energy systems around you. Related to energy technologies.
      i. All the energy service you get, AND how they are provided.
      ii. See ecological and cost impact. Raise awareness for both energy services and energy technologies.
      iii. Can show stuff like huge warm water storage system. Show various levels of focus, local to greater.

6. What would you like to see from this game in its final stages?
a. Want to add more research, outside of it being fun and somewhat educational. Want to add research value, see what research questions it can address.

b. Helps connect energy services with energy tech, increase understanding. Could influence people’s decisions, what energy products/services they prefer.
   
i. *If people become aware of stuff, they might learn more about their needs.*
   
   *Speak with their utilities, what services they prefer.*

7. **Rework point system to money?**
   
a. More focused on conversion to renewables, rather than energy savings.
   
i. Maybe if they make the right choices, they contribute to renewable energy. Show CO2 they save.

b. Be aware this might cost more, but provides other benefits of helping on larger scales.

8. **How can we prepare for further development with Stadtwerk Winterthur?**
   
c. Look for their research interest

d. Suggestions on concepts, present these thoughts. Use this to get their feedback.

e. Digital lives research proposal can be sent to use for some idea about ongoing issues.

9. **Further Information and Papers?**
   
f. Mera Kubli. Study on flexibilities. Can be sent to Mirjam and then to us.
Appendix B.6: Interview with ZHAW Vicente Carabias-Hütter

Conductors of the Interview:

_These persons were responsible for the interview_

Adam Ramram, Aislinn Harte, Nicholas Fleury

Date, Location, City, Country:

August 30th, 2018; Technoparkstrasse 2; Winterthur, Switzerland

Introduction:

_This was read to the interviewee prior to the interview to give context to our work._

We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, smart city, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:

_The information contained in this interview is not verbatim. Instead, what we learned has been paraphrased and organized._

Interview Questions and Responses:

1. **What is ZHAW’s stance on smart city?**
   a. **ZHAW’s aims:**
      i. *Increase energy/resource efficiency, use of renewables, quality of life*
      ii. *Backbone infrastructure with ICT (information communication technology)*
iii. Smart grids, more information communication (smart meters), how to affect energy consumption

iv. Research mobility (electric vehicles, can use vehicles as storage systems with batteries)

b. Stakeholder processes and government systems need to be more connected. City officials/policymakers need to connect with scientists, citizens, industries, etc.
c. Cities are already built, so the focus is more about transformation of existing infrastructure
e. What do you focus on?
   i. There’s the city level down to district or building level.
   ii. Matching public energy supply and demand, connect buildings to see what buildings have more demand at what times. “Microgrids”
   iii. In reality, everything is connected. The city grid.
   iv. Treat it like borrowing a drill from a neighbor, you don’t need it all the time. Borrow/share energy. This works in an ideal world, in reality it’s more difficult.
   v. Have to try stuff out to move forward.

2. In your opinion, what makes virtual reality a good means of transferring knowledge? Why did you choose it over a conventional gaming system/demonstration?

3. How involved have you been in the development of VEH?
   a. Involved in some conceptual game bits. Like which hotspots and which questions.

4. We would like to incorporate more smart city topics into the game. What would you like to see from this game in its final stages?
   a. Game seems more energy-based so far. Can add smart city hotspots. Stuff like smart lighting, keeping lights dimmed if there isn’t movement/cars.
      i. Parking
         1. Hills around Winterthur, lots of valleys. Recreation areas on the hills, but there’s only a few parking spots. You might not have a spot, so you’d drive up and return. You could have a
dashboard/app saying if spots are open, or a barrier if the lots are all full.

ii. **BICAR (bike-car)** is an electric vehicle from ZHAW center for product and process engineering. 3 wheels, small, one-person, weather protection and good to use in urban areas. Mobility. Seen most cars used by one person and move <5km (from urban areas mobility research), so it doesn’t make sense to use a full car. Use this 70kg electric vehicle instead.

iii. **Share your bicar. Make a system to reduce the number of vehicles by sharing a fleet of BICARs.**

b. We should demonstrate that saving small amounts add up in the long run.

5. **How informed do you think Swiss citizens are on smart cities?**

a. This is really at the beginning of smart city, etc. Most citizens aren’t very aware yet.

b. Thinks VEH can help inform people

   i. The questions have a function to raise awareness. People see facts they didn’t know, and think they should look up more.

6. **Are there any other issues/ideas that you would like to see addressed in VEH?**

a. Could show bicars, smart lighting, smart parking, etc. in a model idea city

7. **Other stuff/ideas**

a. Suggests leaving links at the end, to smart city Winterthur, etc.

   i. Or on the points certificate at the end

b. How about touring the city while seated in a virtual bicar?

c. Want clients/sponsors to develop stuff. Local utility can be this client. Mostly interested in energy, then. But also open to smart city topics.

d. Stadt Winterthur app, will be expanded for districts (sharing function, etc). Can report faulty lights, etc. Shows waste collection information. Powered by company Anthrazit

e. Pronounce ZHAW as [German] Z-H-A-W
Appendix B.7: Interview with ZHAW Pascal Kienast

Conductors of the Interview:

These persons were responsible for the interview

Aislinn Harte
Adam Ramram

Date, Location, City, Country:

September 20th, 2018; Technoparkstrasse 2; Winterthur, Switzerland

Introduction:

This was read to the interviewee prior to the interview to give context to our work.

We are a project team of three students from Worcester Polytechnic Institute. Our group is studying in Switzerland in order to complete a required research project for our degree. The project focuses on the topics of smart energy, smart city, virtual reality, knowledge transfer, and gamification. Our goal is to evaluate a virtual reality demonstration tool aimed at increasing the awareness of smart energy topics in Winterthur, Switzerland.

Point of Information:

The information contained in this interview is not verbatim. Instead, what we learned has been paraphrased and organized.

Interview Questions and Responses:

1. What experience do you have with knowledge transfer to the general public?
   a. We organize events like workshops specific to a topic like energy (usually focused towards experts).
   b. We have recently been doing more work focused towards the general public.
c. We usually talk to experts with access to the general public or to certain industries/sectors, and support them in their activities.
d. We also release publications and papers aimed towards raising public awareness.
e. The type of channel and language used needs to be considered, also the target audience.
   i. We target experts and interested members of the public
   ii. Non-interested members of the public are a challenge, so we often communicate with experts.
   iii. VR seems promising as another channel to get people into the energy topic.
   iv. Heard that for climate change, rather than using a scientist to share about climate change, have a doctor talk about health issues or military talk about flooding causing issues for them (make the issue more personal by talking about the consequences).
   v. This is something VEH does well, trying a new approach to reach people with less interest in science to begin with.

2. Do you have any ways to evaluate the success of knowledge transfer? In other words, how can you tell that people learned what you wanted them to learn?
   a. That is a very difficult question. Simple answer is no. We have discussed with other knowledge transfer experts how to evaluate impact of their work, and it is an issue they don’t have a clear answer to.
   b. When you publish a paper, you don’t know where it will end; what channel will it take and who will read it. Will the people who read it share the info in talks/speeches and such?
   c. Can have smaller feedback loops with workshops, for example. Like energy startup days, see if startups get engaged in collaborations.

3. What methods have you found most effective in knowledge transfer (to the public)? Which do you envision working best in the context of VEH?
   a. What about our survey? What questions can we ask?
i. A short-term, easily applicable method. But you don’t see the long-term effects. Like if someone says after a game that they’re interested, but later backs out. Would have to take a survey later instead.

ii. Educational aspect of a kid going home and telling their parents stuff like “let’s take the train instead of the car, save the world”. Probably the biggest impact is through kids, but using a survey for the educational impact is tough. He doesn’t have experience in surveys with kids.

b. Pamphlets/leaflets?

i. Those usually end up in a drawer. Maybe ask for emails instead, let people know if there’s an app/downloadable version available later. Could build up a database of people with an interest.

ii. Considering the game’s ~95% enjoyment rate, people might give the pamphlet to someone else and tell them to try the game. Have info on the pamphlet on future places to show the game. Use it to capture new people, rather than affecting people who already played.

c. The Swiss population has an interesting characteristic. Direct democracy votes, so everyone has an idea and it matters. You really need to engage people in discussions and get them to vote. Talk to people who are in line, give them pamphlets to read while in line, etc.

4. What are your thoughts on including a webpage for VEH? What sort of functionality should be included in the webpage? How can we best market the webpage?

   a. In general, a webpage needs to continue to be maintained after it is corrected. Don’t let it fizzle out.

   b. Should make a webpage that builds on the storyline.

   c. Could include a teaser about playing the real game.

5. How do you recommend marketing the game? Posters in the city? Social media?

   a. You could build this up with no limit, depending on your capacity. The question is who will maintain this, make sure there’s engagement. He doubts there is enough resources available to do this.
i. Keep it to a reasonable level. Looking forward, VEH needs to move
towards a financially self-sustaining model. Best to go to events, show up
and show the game off.

6. How would one go about making the game financially sustainable?
   a. Could use it for marketing, let energy providers insert their products to sell them
      through VEH. (So we’d want to leave room in the game for this to be an option)
      i. Could put links in a game, you can place products and logos and click on
         stuff to get more information. Could charge companies to pay for adding
         more stuff to the game like parts of scenes. Or keep it simple with just
         adding/changing logos. See with energy providers what they want most.
   b. Could use it at an energy provider’s booth to draw people to them
   c. An app would be free to download, people aren’t going to pay for an app.

7. Any other comments on the development of VEH?
   a. Idea of top score list on the webpage, use the score and build up more points on
      the next storyline.
   b. How about a set time limit for the hotspot, see how many questions you can
      answer. People in line can also compete with each other for questions.
      i. Reaching a more competitive group, but risk narrowing down the target
         group (such as older players who are not interested in a competitive
         version).
      ii. If it’s very competitive, you should have a relaxed mode and a competitive
          mode.
   c. Idea of adding a villain.
      i. In my experience, it’s better to focus on the positives of action rather than
         the negatives of inaction. Don’t want to get too depressing, show how easy
         the positives are instead.
      ii. Could work because it’s a game, but goes against how they usually do it.
         If we want to consider it, should do an investigation between a villain
         game and a non-villain game.
      iii. Currently, flying over Winterthur doesn’t give a sense of action, it all
          looks lovely already so why change it?
iv. But don’t want people to associate climate change with a bat, one single individual. Make the potential issues themselves the villain.

d. To many people, climate change seems abstract and far away. We could use the game to make it more real, show that the issues affect first world countries as well.

i. Could show stuff like woods/rivers drying out, stuff that is forecasted to happen here in Switzerland specifically. More floods, going further up to reach ski areas, lower air quality.

ii. Activities you do reduce the negative effects, return to a positive landscape.
Appendix C: Meetings

Meeting Format:

Attendance:

*These people were present and actively involved in the meeting*

- Adam Ramram
- Aislinn Harte
- Nicholas Fleury

Date, Location:

Point of Information:

These meetings were conducted with the purpose of brainstorming ideas and concepts in cooperation with the attendees.

Meeting Notes:

1. Key Finding
   a. Explanation and/or notes about
      i. Group comments

2. Key Finding
   a. Explanation and/or notes about
      i. Group comments
Appendix C.1: First Meeting with Sponsors

Attendance:
These people were present and actively involved in the meeting
- Adam Ramram
- Aislinn Harte
- Nicholas Fleury
- Sponsor: Mirjam West
- Sponsor: Juliana Zapata

Date, Location:
August 23, 2018; Technoparkstrasse 2; Winterthur, Switzerland

Point of Information:
These meetings were conducted with the purpose of brainstorming ideas and concepts in cooperation with the attendees.

Meeting Notes:

1. Set dates
   a. 9/10 First Stadtwerk Winterthur meeting.
      i. The workshop, where we present ideas and Stadtwerk Winterthur discusses their ideas/wishes.
   b. 9/27 Second Stadtwerk Winterthur meeting.
      i. Present more concrete plans to the board.
   c. 10/5 Startup Night.

2. Interviews
   a. Silvia Ulli-Beer: Smart Energy.
   b. Vicente Carabias: Smart City.
   c. Oliver Christ: Head of FHNW Virtual Tech and Innovation Lab (optional).
d. Peter Hug/Reto Knaack: ZHAW VR experts (optional).
e. John Rice: Innovation Management SwissCom (optional).

3. What ZHAW wants from us
   a. Concrete ideas for adding smart energy and smart city to the game.
   b. Further develop concept with Stadtwerk Winterthur, cymmersion and ZHAW INE.
   c. Good to put down a recommendations section in our paper summarizing applications for VR gamification that we learned through our lit review/expert interviews. Especially where it can be used for research.

4. Next steps
   a. Start with the first two interviews this Tuesday.
   b. Prepare for workshop with Stadtwerk Winterthur.

5. Weekly meetings
   a. Probably on Tuesdays, may have to be flexible.
      i. Next Tuesday we could hold interviews as well as the meeting.
   b. Would be best to also have the advisor meeting on this day.
   c. For urgent situations, Mirjam said she is somewhat available on Mondays and will be working nearby.

6. Initial testing of the game
   a. Plays smoothly.
   b. Avatar voice is very frightening.
      i. Hard to understand for novice German speakers.
   c. Avatar moves around too much when standing.
      i. Gyrates his body, which can confuse the player.
Appendix C.2: Second Meeting with Sponsors

**Attendance:**

*These people were present and actively involved in the meeting*

- Adam Ramram
- Aislinn Harte
- Nicholas Fleury
- Sponsor: Mirjam West
- Sponsor: Juliana Zapata

**Date, Location:**

August 28, 2018; Technoparkstrasse 2; Winterthur, Switzerland

**Point of Information:**

These meetings were conducted with the purpose of brainstorming ideas and concepts in cooperation with the attendees.

**Meeting Notes:**

1. Don’t really give us boundaries, suggest whatever. In the end, it can usually be done for a price.
   a. Don’t want just a demonstration. Have big ideas!

2. **Preparation for Stadtwerk Workshop.**
   a. For workshop, probably will have a list of ideas, suggestions, fragments, etc.
      i. *Could meet with Cymmersion a few days beforehand to learn cost/difficulty of various ideas.*
   b. Probably 2 people from Stadtwerk Winterthur. Let one in charge play the game first. Review of Nacht der Technik. Then we try to guide them a bit by proposing ideas/suggestions, then brainstorming.
      i. *Perhaps split into 2 groups to have more participation.*
c. Groups could draw some storyboards to picture the idea. Could draw a little sketch, show them a storyboard first to give them some ideas to start.

d. See what’s important to them, because that’s what they want to finance.

e. Look for similarities between different people’s suggestions for hints of importance.

f. Don’t want to drag storyboards on too long, avoid boredom. And don’t want too many ideas if we can develop some further (but don’t go too far on an idea that ends up not being feasible).

3. **ZHAW IT department expressed interest in the game.**

   a. Could pursue accessibility of the game with a person here. He has master’s students who work for him who could be enlisted for an app for the game or such.

   b. Mirjam can send us contact info, and if we contact him let her know and let him know how we heard of him.

4. Adam mentions potential visual appeal of smart city topics, more noticeable than smart energy.

   a. And could make a difference through companies following smart city initiatives rather than individuals, compared to the current game targeting actions at the level of the individual.

5. **Want to extract results from the game in the future to understand public’s current view/knowledge.**

   a. What they believe is best vs. what is actually best.

      i. *Could apply to most of our ideas.*

6. **Can reach out to SwissCom and try that if we have time.**

7. **Try small/medium/large ideas. Small being data collection, medium being point system changes, large being adding smart city.**

   a. Can be dramatic enough to cut off small house, for example (just to show the scale of changes).

   b. Careful of making players move around, space constraints and safety.
Appendix C.3: Meeting with Cymmersion

Attendance:

*These people were present and actively involved in the meeting*

- Adam Ramram
- Aislinn Harte
- Nicholas Fleury
- Cymmersion: Mario Ravasio
- Cymmersion: Manuel Loth

Date, Location:

September 4, 2018; Technoparkstrasse 2; Winterthur, Switzerland

Point of Information:

These meetings were conducted with the purpose of brainstorming ideas and concepts in cooperation with the attendees.

Meeting Notes:

1. **Cymmersion agrees with highlighting house changes.**
   
   a. The house scene is still being worked on.
      
      i. *Could select highlighted areas to pull the questions up in the first place.*

2. **Oscar is budget lbby.**
   
   a. Oscar was a model purchased by Cymmersion because animating an avatar from scratch is labor and cost intensive.

3. **Worry about quiz getting boring towards the end.**
   
   a. Many people at the Swiss Green Energy Symposium were in a hurry to see other exhibits and felt the game quizzes dragged on, so they stopped at the second quiz because it was too similar to the first one.
      
      i. *Change format of different quiz scenes to be more engaging.*
   
   b. One solution is to allow the player to move within the different scenes.
i. Various locomotion methods like fixed steps you can take (like in google maps).

4. **The hot air balloon scene was made using a 3d model of the city.**
   a. Player feedback indicates that it is difficult to see.

5. **The game can be transferred across different platforms**
   a. VEH should work for Vive or Rift out of the box.
   b. Mobile VR has performance issues, like the large city model.
      i. *The house scene already has some framerate issues on the Vive.*
      ii. *Would require reworking, could make areas small or such.*

6. **Language additions have issues with budget, time constraints, voice actors, etc.**
   a. Captions would be possible in theory, but difficult in VR.
   b. Could potentially add speech bubbles for Oscar for a short-term solution, but a voice actor is best.

7. **Leaderboard/high scores could work for some events.**
   a. Players could enter name/email address for a leaderboard.
   b. This will show people they can improve.

8. **3d models vs 360 degree photos are required to add items to the models.**
   a. Cymmersion would have to investigate the costs and difficulties.

9. **Could potentially add winter mode to the game.**
   a. Seasons have an impact on energy use. Could make reducing an energy use bar harder, like a hard mode.
   b. Also proposed differences from time of day

10. **Could expand game potential by using different city models.**
    a. Gives a more global feeling and could work with a home version of the game.
    b. Or could give a random name when displayed outside of Winterthur “Energyville”.
       i. *This makes the game useable in any country.*
       ii. *But, there is a high appeal in seeing one’s own city from above.*

11. **The game originally had movement controls for the balloon over the city and could reintroduce it, but it was removed due to time issues.**
    a. While testing it, people just flew around for 3-4 minutes.
i. We could introduce a time limit for reducing energy use in the house.

ii. We could also introduce various modes for at-home vs demo usage. Explore, multiple hotspots, etc. Or questions for different ages.

12. Could use steering wheel to control the balloon.
   a. Most people were confused with the movement with the controller, need a tutorial from Oscar. Not very intuitive.
      i. We’ll try to use stuff in VR that behaves as in reality.
      ii. Could introduce reticle to help the player focus: Cymmersion finds it interesting but haven’t heard of it before.

13. Website could show how the various house answers have different effects.
   a. This allows the player to expand their knowledge beyond what they saw in their playthrough.

   a. Ex: feed Oscar snacks, knock him off the balloon, etc.
   b. An Easter egg, but more for fun so this is low-priority.

15. In theory, devices recommend not being used with children under 12.
   a. May be some long-term playing issues
      i. Probably want to stay with older ages for legal reasons
      ii. Ask ZHAW why there are age restrictions

16. Lightning round: select highlights, answer questions, get as many as possible in time limit.

17. Not many changes planned before Stadtwerk meeting, don’t want to go away from their plans.
   a. Depends on time/budget

18. Need to know Stadtwerk priorities
   a. Connect fun with Stadtwerk?
   b. Research?
   c. Learning/education?
Appendix C.4: Meeting with Mirjam

Attendance:

_These people were present and actively involved in the meeting_

Adam Ramram
Aislinn Harte
Nicholas Fleury
ZHAW: Mirjam West

Date, Location:

September 5, 2018; Technoparkstrasse 2; Winterthur, Switzerland

Point of Information:

These meetings were conducted with the purpose of brainstorming ideas and concepts in cooperation with the attendees.

Meeting Notes:

1. **We will put a hold on pursuing app development with a SwissCom sponsor.**
   a. Possibility to submit proposal with current game improvement concepts.
   b. Stadt Winterthur seems like they’ve basically already agreed to contribute, just have to see how much.
   c. Have to get Stadtwerk to move quickly to submit the proposal.

2. **Adam has permission to wear a suit.**

3. **One potential game feature: drive around in BICAR.**
   a. Issues with motion sickness if you move too fast.
      i. **Involve in presentation**

4. **Winterthur is EnergieStadt Gold.**
   a. Energiestadt is an energy city, kind of a certificate.
b. The proposal we want to have is for the funding that gives the most to Energiestadt gold cities.

5. Could address further development of VEH contributing to various goals, like the one for cooperation and communication. Could show it in schools, etc.
   a. Show/emphasize that the ideas match what they have in mind for being an energy city, follow the guidelines from the call.
      i. If we suggest changing the house scene, probably don’t include the highlighting changes bubble.

6. MAKE GENERAL SUGGESTIONS (but also CONCRETE IDEAS to work fast for the proposal).
   a. Probably calculate work that can be done in a year (even 6 months).
   b. Consider idea to add additional character (Bettina).
   c. Changes to the story?
   d. Structure as what we already have vs what do we want to change?
      i. Stuff like “keep Oscar? yes/no” and “add Bettina? yes/no”.

7. Assume we have an uninformed audience. They’ve just played the game, but they don’t know the original intents very much. Refer to parts of the game more clearly.
   a. First goal is to be an “eye catcher”, do we want to keep this?
      i. We have to evaluate if the goals will change.

8. Need to show stakeholders a simplified and concrete storyline, like the one Mirjam showed us. Like: “attic scene” and photo, then suggestions. Highlight new stuff.

9. Stadtwerk Winterthur is concerned with EXACTLY what we need from them.
   a. They want their footprint on it.
   b. They don’t want to give out information on knowing what specific houses have what energy consumption. And for average stuff, we can just google it.
      i. Info for a district in Winterthur?
      ii. Ask for data that ZHAW can use to do calculations?
   c. The more concrete, the better.

10. Like point system idea, but we’d have to work out all the technical details.
    a. How to calculate max number of points?
    b. How to make a CO₂ reduction point system fit in with hotspot scene?
11. Smart city is cool, would be good with a storyline.

12. Pick an idea and develop where it fits in the story, show what’s optional. Send to Cymersion to see info about costs.

13. The Workshop will go as follows (location not decided yet):
   
   a. Introductions
   b. Melanie (Stadtwerk employee) plays the game, maybe someone else
   c. Presentation(s) [20-30 minutes?]
      
      i. *We might share the presentation with Mirjam (change “Before Switzerland” to work done so far, what we’ve researched and interviewed)*
      
      ii. *Nacht der Technik throwback*
      
      iii. *Ideas/storyline*
      
      iv. *Save questions for the end*
   
   d. Really getting down to business with ideas and the proposal.
      
      i. Show a draft of the proposal.
   
   e. Talk stuff over to come to an agreement for the proposal.

14. Stadtmuur for food!
   
   a. 9 CHF for student lunch.
   
   b. Across from Technikum.
Appendix C.5: Stadtwerk Winterthur Workshop

Attendance:

*These people were present and actively involved in the meeting*

ZHAW
Cymmersion
Stadtwerk Winterthur
Stadt Winterthur
Nicholas Fleury
Aislinn Harte
Adam Ramram

Date, Location:

September 10, 2018
ZHAW Technikum, Winterthur

Point of Information:

This meeting was conducted as a presentation of WPI’s initial Virtual Energy Hero (VEH) recommendations

Meeting Notes:

1. Cymmersion feels that the work involved in a Smart City scene would not be warranted if the player will only be passively watching it for less than a minute.
   a. Interactivity and more time spent at the scene would make the work more justified.
      i. Need to see what Stadtwerk values, push smart city?
   b. Controls can make it difficult to click on small items.
2. We need to show Stadtwerk concrete changes that can be feasibly made, not just possibilities.
   a. However, work hours, costs, and resources are still unclear.
3. Cymmersion never really got below 10 minutes with the various game versions.
a. Lowest is probably 7-8 minutes.
b. Players need to know why they’re in the world, how to use controls, etc.

4. **The purpose of the house scene is to show how people can benefit from various smart energy measures.**

5. **What value is there in adding different seasons to the game (Summer, Winter)?**
   a. Fit the real seasons.
   b. Different energy uses in different seasons (heating, daylight hours).

6. **Smart district and smart living good concepts, but they’re too long for an exhibition.**
   a. Have to be very short for marketing.
   b. We want a lot of people to play the game.
   c. At an exhibition, people don’t want to spend too long at one spot.
      i. *We could perhaps put the start and end into a verbal explanation for people in line.*

7. **10 minutes a lot longer to those in line than to players.**
   a. At Nacht der Technik, ZHAW gave tickets for people to return later, which avoided a massive line.
   b. Also had a screen for those in line to watch while waiting.

8. **Make sure game is fun, don’t bore the player or it may have the opposite of the desired effect.**

9. **Website with the game to supplement could be good/makes sense, but you have to decide if it’s worth the money.**

10. **What kind of avatar should be given to Stadtwerk?**
    a. Need it to be appealing to players.
    b. Animals are more relatable than a battery that can move, or something, and can mimic humanoid gestures.
    c. Ideally, the avatar should be related to smart energy topics, but it’s difficult to find a model for such a thing.

11. **Besides VR, what else does the game have to attract people?**
    a. Seeing Winterthur from above in the hot air balloon scene is a huge eye-catcher.
    b. Interactivity: it’s exciting to click on something and see the change.

12. **Stadtwerk will send their ideas over to us**
13. Could have funding to develop a second, separate project specifically for Stadtwerk.
   a. Could reduce costs by using some similarities between both projects.
Appendix D: Surveys & Results

Version 1.0: First Survey

VR Based Gamification of Smart Energy/City Topics
Sample Survey Questions

This survey is to be handed out after playing ZHAW’s virtual reality game.

1. Rate your enjoyment of the game.

1 2 3 4 5
Disliked Neutral Greatly Enjoyed

2. How informed were you on smart energy topics and initiatives prior to this demonstration?

1 2 3 4 5
Little to No Knowledge Some Knowledge Highly Knowledgeable

3. Rate the educational value of the game.

1 2 3 4 5
Learned Nothing Learned Some New Info Learned Substantial Info

4. How did the game alter your views on smart energy, if at all? (Multiple Choice)
   a. My views became more negative toward smart energy.
   b. My views became more positive toward smart energy.
   c. No effect.
   d. Other ____________________
5. How did the game alter your feelings towards reducing energy consumption, if at all?
(Multiple Choice)
a. I care more about energy reduction.
b. I care less about energy reduction.
c. No effect.
d. Other ____________________

6. How much experience do you have with the following? Scale 1-5, 1 meaning you have no experience, 3 meaning you have moderate experience, and 5 meaning you consider yourself an expert.
a. Video Gaming:
   
   1  2  3  4  5
   No Experience  Moderate Experience  Expert Experience
b. Virtual Reality:
   
   1  2  3  4  5
   No Experience  Moderate Experience  Expert Experience
c. The HTC Vive:
   
   1  2  3  4  5
   No Experience  Moderate Experience  Expert Experience

7. Did you have trouble with any of the following while playing the game? If no, leave the space blank. If yes, please elaborate.
a. Objectives to be completed_______________________________________
b. Using the controllers____________________________________________
c. Moving around within the game___________________________________
d. Following the storyline__________________________________________
e. Reading the text________________________________________________
f. Awkward disruptions____________________________________________
g. Other ________________________________________________________

8. Did you experience any of the following while playing the game? (Select all that apply)
a. Dizziness/Vertigo  
b. Nausea  
c. Eye strain  
d. Headache  
e. Claustrophobia  
Other discomfort (please explain) ________________________________

Version 2.0: ZHAW Survey (translated into English)
*This survey was conducted online, so the formatting shown here is not exactly the same as what participants viewed.*

1. How many points did you score? ________________________________

2. How old are you? ________________________________

3. Did you experience any of the following during the game?  
   a. Dizziness  
   b. Nausea  
   c. Eye pain  
   d. Difficulty focusing (with the eyes)  
   e. Headache  
   f. Fear of heights  
   g. None of these, I felt good

4. How did you like the game in general?  
   a. Very good  
   b. Good  
   c. Mediocre  
   d. Bad
5. Which scene/environment did you like the most?
   a. Attic
   b. Hot air balloon
   c. a) Technikum
   d. b) Technopark
   e. c) KVA
   f. d) Train station
   g. Single-family home
   h. Space
   i. (Own answer) __________________________

6. Did you learn something in this game?
   a. Yes, very much.
   b. Yes, a little.
   c. No, nothing.

7. How has the game influenced your attitudes towards energy issues or the Energy Strategy?
   a. I want to deal with it more.
   b. I’m less interested in energy issues now.
   c. No effect.
   d. (Own answer) __________________________

8. What else would you wish for? _______________________________________________

9. Other remarks: ____________________________________________________________
**Version 3.0: Rating Concepts**

*This version is the same as version 2.0, with the addition of one new question. In the online version, participants could select one answer for each suggestion.*

We want to develop the game further. What do you think of the following suggestions?

<table>
<thead>
<tr>
<th>Suggestion</th>
<th>Not Interesting</th>
<th>Maybe</th>
<th>I like it</th>
<th>Cool!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insight into a “smart neighborhood” including smart technologies</td>
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<tr>
<td>Replace Oscar the Owl with a bat</td>
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<tr>
<td>More interaction at the house scene</td>
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<tr>
<td>Additional “indoor” house scene</td>
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<tr>
<td>Saved CO₂ emissions instead of “energy points”</td>
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<tr>
<td>Supplementary website with background information</td>
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<tr>
<td>Online version of the game</td>
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</tbody>
</table>
Survey Results:

Figure 27: Survey Results from the First Two Events

Figure 28: Concept Ranking Results
Appendix E: Emails

Cymmersion Feedback and Priorities:
Date: September 13th

Hi guys,

First of all, we would like to thank you for the exciting discussion and your great work. You have presented some good ideas for further development and improvement on which we can build.

We also discussed the ideas together with Marcus and are now happy to give you feedback on our five (six) favorites:

1. **Improving learning effect**: It is important that the participants receive more background information. This could be background information on questions. Or we could extend VEH as a platform for future technologies. For example, BICAR: we can have a virtual reality scene dedicated to the BICAR with questions.

   Another point which is very closely related to the learning effect strategy is the "Point system change": energy points to carbon emissions saved/renewables introduced or trees grown. => more meaning and motivation

2. **More interactivity in the game**: especially in the house scene: addition of an explorable interior to the house => clicking on a leaking faucet to completely shut it, or turning off the lights after leaving a room, or even making lighting changes such as new light bulbs or motion sensors for smart lighting (smart thermostat, heat pump, smart appliances, etc.).

3. **Analysis system /Extractable Data System**: gather information from player answers and actions, which will allow us to form an idea of the public’s view on Smart Energy topics. The analysis system could be individually adapted for different events: For example: There are different questions for each event => Each event could have a different target audience or objectives.
4. **Multilanguage support**: Of course the game should be available in different languages: At least in English in addition to German.

5. **Downloadable Version**: A version that can be played at home could have its own longer story, because the user has much more time at home than at a public event. For example, the user might be able to visit several hotspots or travel to other cities.

6. **Different modes**: An additional feature closely related to point 5 would be different modes: Day / Night, Summer/ Winter, Sunny / Rainy / Snowfall etc.

I think you made some more notes on Tuesday with our ideas, which arose from the discussion (in a Google Docs)?

Could you send us these notes as well?

We are very much looking forward to the workshop on Monday and are sure that more interesting ideas and inputs will come.

---

**Mirjam West (Sponsor) Priorities:**
**Date: September 17th**

Dear all,

Thank you for your concept organization! It looks pretty good so far.

I have the following suggestions:

- The story we want to tell in the game (including the take away messages we want to give the player) is a key element of the game. Therefore, I suggest not to separate the new scenes from the storyline. As for now, we’d like to focus the game / the story more on smart city / smart energy topics à I’d make all the new scenes “Smartes Quartier”, “Smart Living” and “Interior House” sub-ideas of the story change one and thereby also first priority
- I’d change the webpage to medium priority as it is an additional product and not part of the game. Let’s make the VR game first priority.
- Regarding the point system: If we keep the quiz part, I’d not change the point system to saved CO2 there. Regarding the ecological footprint of WWF: it has nothing to do with CO2, but measures human demand on nature, i.e., the quantity of nature it takes to support people or an economy. You should give that one a closer look. I’m not sure if we could implement it, as it is a very comprehensive calculation.
- Downloadable version: VR or non-VR?
- Hotspot Scene changes: Is also very much depending on the new storyline. I’d make it a subtopic of the storyline and therefore first priority.

Also, what are your thoughts on a new character? It’s also part of the story.

We can discuss the edited version of your concept organization tomorrow at the meeting. Will your supervisors be there, too?

Kind regards,
Mirjam

**Stadt Winterthur Feedback Email:**
**Date: September 18th**

Dear all,

The visit at the «Vermessungsamt» of the city of Winterthur today went really well. Four people played the game and they all really loved it. They would happily contribute with any available data / material (for example the PV potential of buildings in Winterthur). Maybe we should think about it.
Also, they came up with some suggestions on how to improve the game in their opinions. I wrote it down for you:

- **Hotspots: Questions more specific to Winterthur**
- **Shorter beginning (less talking) in the attic scene**
- **At the house scene: show the impact (CO2 / energy savings) of the measures** (or what I think would be even better: ecological footprint à talk with Nick about what we were discussing this afternoon à https://www.wwf.ch/de/nachhaltig-leben/footprintrechner à we could show the number of earths the player would need in the end and could still use the space scene)
- **At the house scene: when you click on a measure and the points appear, the measures should still be visible.**
- **At the end, Oscar could give specific recommendation to the player on what he could do better (based on his “wrong” measures / answers)**

**Juliana Zapata (Sponsor) Priorities:**

*Date: September 19th*

Dear all

Thanks for your concept :-) I see there are lots of new ideas around and as time ticks we should start focusing.

First, I totally agree with Mirjam, we have to focus on the story line, and the interactivity, hotspots, new scenes and points are all largely dependent on the story you want to tell and the message you want to give. So, I think it is very important to have a clear story that we can further use when you go home. For that, it is also important to keep things simple and realistic, for example, with the pointing system as Mirjam mentioned you can get inspired with the WWF calculator or even, I think that google maps offer some similar app but don’t get lost on these topics.
Regarding online version, web page multilingualism and all other factors, I think they are very important but we have to do things step by step and if we don’t focus we risk ending up with just good ideas.

I won’t be today at the meeting but please keep me posted and have a nice week :-)  
Greets

**Stadtwerk Winterthur Feedback & Priorities:**  
**Date: September 20th**

Hello,

I have not yet had the opportunity to finalize how Stadtwerk Winterthur can participate in the project.  
However, in order for the students to receive feedback/further input to prepare for the common date in September, or to have a task, you will receive feedback on the suggestions as well as a consideration towards the delivery object for our next date in September.  
For the improvement of a game it is important from which perspective something can/should be improved.  
Therefore, the proposed functionalities are based on a benefit - this can be on a scale (User experience, From the point of view of Stadtwerk).  
We had addressed this point in the discussion. To what extent is an intrinsic motivation triggered by a certain suggestion/functionality?  
Furthermore, a first prioritization would be useful, preferably an example. One idea was several languages.  
But once the product is played in Switzerland - the question is cost/benefit - how many more people can be reached.  
(Synchronization, texts / care is then also more complex...) perhaps this is meaningful in a further development stage.
Then the following tasks would be a good idea - how could the following products or services be integrated into the game?
Information about the product or services can be found on the website or in the flyers.
Are there any suggestions? Possibly also here different ideas/options and evaluations:
- e-Solarroof.single (https://stadtwerk.winterthur.ch/privatkundschaft/dienstleistung/fotovoltaik)
- Energy consulting products (https://stadtwerk.winterthur.ch/privatkundschaft/dienstleistung/energieberatung)
- Building services (https://stadtwerk.winterthur.ch/privatkundschaft/dienstleistung/haustechnik)

And how could the following graphic (attached) - overview of the Stadtwerk Winterthur services be integrated?

This is already possible in advance in terms of content feedback - gladly for forwarding or for your discussion with the students.

Further feedback will follow shortly...

Friendly greetings

**Official Project Description:**

**Date: September 23\textsuperscript{rd}**

Hi there

I’ve just finished a first draft of the project description for the proposal which we’ll discuss on Monday:

Project Title: XXX (to be discussed on Monday!!)
Project description: As an energy city of gold, the City of Winterthur strives to implement measures on the way to a 2000-watt society. This also includes the promotion of renewable energies and the development of a Smart City. Participation by the population is essential if these goals are to be achieved. Various studies show that individual prior knowledge of the respective forms of energy has an influence on attitudes. People who know more about renewable energies tend to evaluate them as positive or to choose renewable energy products.

This project involves the development and testing of Smart City elements in a virtual reality environment. The ZHAW "Virtual Energy Hero" VR game, which has already been developed and used on various occasions, is to be improved and further developed for this purpose. The "Virtual Energy Hero", which was developed for a high-end VR system (e.g. for an HTC Vive), aims to raise public awareness of energy strategy issues at public events. A physical hot-air balloon basket is the connecting element between the real and virtual worlds and an eye-catcher. The survey results with 32 players from all age categories of the "Virtual Energy Hero" show that 90% of the players liked the game well to very well and that they learned something new. Although the game only lasts about 10 minutes, a quarter of the respondents also indicated that they would like to focus more on energy topics (short summary of the results in the appendix).

The City of Winterthur's "Smart City Hero" is to include Smart City topics even more strongly, for example with an additional module of a virtual insight into a smart neighborhood or a virtual association of different households to form a private consumption community. The VR environment gives the operator a new perspective on complex topics. The basis for the game is a 3D city model, which was created by the surveying office in Winterthur. The accompanying avatar "Ibby", the owl, guides the player through the game, flies with him in a hot-air balloon over Winterthur, lets him solve tricky questions on energy topics and take concrete measures and shows him what a smart neighborhood could look like. The player gets a feeling for life in a Smart City, then knows the advantages of renewable energies and what he can contribute to a life with a high quality of life in the energy city of Winterthur. At the end of the game, the player is referred to already existing websites / mobile apps of the city and the municipal utility.
The game will be presented in different difficulty levels, in the national languages German, French and Italian as well as in English at public events and in schools. During the project, ZHAW students will also develop a concept for an app development within the framework of master's and bachelor's theses, which could then be integrated into the city of Winterthur, for example.

Let me know what you think! I’ve also replaced Osky by Ibby because I feel that Oscar is our baby and we should come up with a new avatar for Stadtwerk / the city of Winterthur. It doesn’t have to be an owl, either. It’s also something we should discuss on Monday. Please include these discussion points in a slide, so we won’t forget them.

Thanks a lot and see you later!

Mirjam
Appendix F: Contact Information

The following is a list of contact information for the advisors and sponsors on our project:

**ZHAW (sponsor):**

*Mirjam West*: INE Department of Sustainability Assistant  
mirjam.west@zhaw.ch

*Juliana V Zapata*: INE Department of Sustainability Assistant  
zapt@zhaw.ch

**WPI Advisors:**

*Professor John Orr*: Adjunct Teaching Professor  
orr@wpi.edu

*Professor Dirk Albrecht*: Assistant Professor of Biomedical Engineering  
dalbrecht@wpi.edu

*Professor Alex Sphar*: IGSD Assistant Professor  
jasphar@wpi.edu

**Expert Interviewees:**

*Professor Lee Sheldon*: Professor of Practice, Interactive Media & Game Development  
clsheldon@wpi.edu

*Professor Jeffrey Kesselman*: Computer Science Instructor  
jpkesselman@wpi.edu
Appendix G: Schedule

A tentative day-by-day schedule can be found below, with tasks we plan to complete each week. Overlap in the tasks allows for flexibility in the schedule.

<table>
<thead>
<tr>
<th>Objectives/tasks</th>
<th>Week 0</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
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<tbody>
<tr>
<td>Claritying Stakeholder Needs</td>
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<tr>
<td>Meet with ZHAW</td>
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<tr>
<td>First Look/Test of Game</td>
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<tr>
<td>Interviews at ZHAW</td>
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<tr>
<td>Stadtwerken Winterthur Workshop</td>
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<tr>
<td>Schedule Other Interviews</td>
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<td>Conduct Other Interviews</td>
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<tr>
<td>Testing the Game</td>
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<td>Analyze Participant Data</td>
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<td>Refine Participant Survey</td>
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<td>Developing/Expanding VEH Uses</td>
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<td>Gather VEH Concepts/Ideas</td>
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<td>Evaluate Recommendations</td>
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<td>Final Deliverable</td>
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<td>Other</td>
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<td>Misc. Syllabus Deadlines</td>
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Dates

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Appendix H: Events and Demonstrations

Nacht Der Technik:

This event invited interested citizens from the Winterthur area to come and try out new and exciting technologies. The audience for VEH here was uninformed and had a natural curiosity towards virtual reality. This was conducted by our sponsors prior to our arrival in Switzerland.

**Date; Location:**

July 6\textsuperscript{th}, ZHAW Technikum

**VEH Players:**

50

**Age Range:**

12-87 years

**Survey Participants:**

31

*Figure 29: Nacht der Technik Demonstration*
SCCER CREST Annual Conference 2018 & Energiezukunft Schweiz:

This was a two-day conference in Basel for energy experts across Europe. This was an exact opposite audience from Nacht der Technik. The individuals here were well versed in certain energy topics and were naturally interested in the game for its energy efficient theme. We were in charge of running the stand for the full two days. We debuted our new survey with concept ranking here in order to gather the opinion of experts.

**Date; Location:**

September 11\textsuperscript{th}-12\textsuperscript{th}, University of Basel

**VEH Players:**

25

**Age Range:**

27-83 years

**Survey Participants:**

13

*Figure 30: Our Group Conducting the Demonstrations in Basel*
VRDAYS Zürich Festival:

This was an event, where the participants were specifically interested in virtual reality systems, rather than education or energy. The festival hosted many virtual reality companies that had their own games to play with a large variance of theme. Once again this was a full two-day event, but we received help from the programmers of the game. VEH held up well again other VR demonstrations, drawing a constant stream of players.

Date; Location:
September 29th-30th, Halle 622 Zurich

VEH Players:
50

Age Range:
12-75 years

Survey Participants:
11

Figure 31: Adam on the First Day at VR DAYS
Startup Night:

This nighttime event featured many startups in Winterthur. Speeches were given to promote each startup concept, and innovators and investors tested exhibits to see if they were worth exchanging information. VEH won an award for 1,000 CHF for the most aesthetic stand in the event.

Date; Location:
October 5th, Technoparkstrasse 2

VEH Players:
12

Age Range:
25-60 years

Survey Participants:
0

Figure 32: Our Sponsors Onur and Mirjam holding the 1000 CHF Award!
Appendix I: Additional Background Information

Smart Grid Background:

The critical elements of a smart grid that must be examined in implementing a smart grid to replace today’s electric grid, according to Capgemini (2010), include:

1. The utilization of the Geographic Information System: The Geographic Information System (GIS) is a data sharing system used for gathering and synthesizing data according to geographic location, and using that data to create more communicative maps (ESRI, 2018).

2. Existing WAN (Wide Area Network)/LAN (Local Area Network): Current WAN/LAN infrastructure is analyzed with regard to data security, bandwidth (smart grid technologies will require multiple terabytes worth of worth of data transfers at a time), robustness/resilience, connectivity (will the entire WAN need to be replaced?), and time synchronization.

3. Energy Delivery Network Topography: The Energy Delivery Network (EDN) is the core of utility distribution operations, and is the final stage between energy provider and individual consumer.

4. Integration Architecture: The integration architecture must be a secure platform upon which information can be transferred between systems almost instantly.

5. Legacy Information Technology (IT) Systems: Older IT systems should be utilized to avoid replacing all involved information systems. Their security, utility, and ability to integrate into a smart grid system must be analyzed (Capgemini, 2010).

VR Applications in Asia:

The United States filed many of the early patents of VR technologies and as of 2016, 41 percent of VR technology patent applications originated there. Patents from China, Japan, and South Korea accounted for another 42 percent. In recent years, the majority of patents originate in these Asian countries, especially China (China Academy of Information and Communications Technology (CAICT), & Huawei Technologies Co., Ltd., 2017). As these nations make advances
in VR, countries such as Switzerland can expect the best of those technologies to arrive in a few years. To prepare, it is beneficial to examine the emerging VR applications in nations like China.

Chinese VR applications covers areas such as industry, medicine, education, games, and live broadcasts. One example in the medical field is the introduction of live VR operations. In 2016, Shanghai Ruijin Hospital broadcast a laparoscopic operation live so doctors could observe and learn from the difficult operation even if they could not be physically present (CAICT, & Huawei, 2017). Live VR broadcasting has also been used to display sporting events such as the Chinese Super League and concerts such as one by famous Chinese singer/songwriter Faye Wong, where 90 thousand people paid for the live VR (CAICT, & Huawei, 2017). These fields are all important and interesting, but the topic that interests us and our sponsor the most for this project is how VR is used for education.

VR education is a major VR field in China. Education is a considerable concern for the Chinese government, and receives large amounts of funding that makes it an attractive market for VR companies. In 2016, RMB 600 million was invested into VR education projects in public schools, and in 2017 the amount doubled to RMB 1.2 billion (Huawei Technologies Co., Ltd., 2018). This is approximately equivalent to USD 90 million and USD 178 million, respectively, when using yearly average exchange rates for 2016 and 2017 (OECD, 2018).

One area where VR technology can make a large difference is in addressing the disparity between rural and urban students. To help rural students, the government is encouraging the creation of “MOOCs” (Massive Open Online Courses) so students can learn at a distance from their teachers. An unfortunate side effect of this is that many students may never meet their teachers face-to-face (Huawei, 2018). Through the use of VR classrooms, students and teachers can experience the feeling of being in the same room and observing each other’s gestures with their heads and hands, providing the currently-missing context of body language in communication. FLY VR is one company involved in VR classrooms in China. They provide headsets, software to manage classes, and even a content subscription service. The content focuses on science and vocational topics, but also covers school life topics such as fire and earthquake drills (Huawei, 2018). As VR is still new, its applications in education and other fields are expected to only grow and develop further, especially in the nations that make the greatest investments, such as China.
## Appendix J: SCCER Crest Research Questions

### SCCER CREST Milestones and Deliverables 2017ff.

#### Research Questions and Subquestions

**Q1: Which measures and conditions promote renewables and facilitate their inclusion in the Swiss energy system?**
- SQ1.1: How can innovations for a large-scale expansion of (decentralized) supply from RES be fostered?
- SQ1.2: How can the shares of renewable energy used by households be increased?
- SQ1.3: Which policies/market designs can facilitate the promotion and integration of RES in the Swiss electricity system while maintaining security of supply?
- SQ1.4: Which obstacles in the governance structure impede an RES expansion and how can they be overcome?

**Q2: Which measures and conditions facilitate a substantial reduction of energy consumption?**
- SQ2.1: How do socio-economic (e.g. age, gender), psychological (e.g. emotions) and societal (e.g. habits) determinants impact individual and household energy consumer behavior and decisions as well as the drivers of change of behavior?
- SQ2.2: Which policy instruments and civil society measures can help to overcome the efficiency gap in households and bring about a substantial reduction of individual energy consumption?
- SQ2.3: Which policy instruments are effective and efficient on the aggregate level?

**Q3: What are feasible pathways for the Swiss energy transition?**
- SQ3.1: How does the interplay of policies, firms and other stakeholders create feasible pathways to reach the goals of the Swiss energy transition?
- SQ3.2: Which transition pathways are achievable under which policies and market conditions?
- SQ3.3: How can Switzerland decarbonize its energy sector?

**Q4: Which governance structures are conducive for the energy transition in the Swiss context (legal, social, and political)?**
- SQ4.1: What are favorable conditions that foster societal, political, technological and business model innovations to create transformation pathways?
- SQ4.2: Which changes in policies, regulations and processes could facilitate the transformation of the Swiss energy system?
Appendix K: Game and Question Script

Script of Virtual Energy Hero:

Authors: Mirjam West & Onur Yildirim
Voice of Oscar: Jörg Reichlin

IN THE ATTIC (OF THE TECHNIKUM). START OF THE GAME.

Oscar sits hidden in a dark corner.

Oscar:

"There you are at last! My name is Oscar and for many many years I have been living here, in the attic of the Technikum. I learned a lot about science and technology. For nights on end I poured through countless books and teaching aids. Climate change is not a new issue. But now with the Energy Strategy, Switzerland has apparently committed itself to phasing out nuclear power, reducing our energy consumption and expanding renewable energies. Winterthur has also taken this to heart. We want to become a "2000-Watt Society" by 2050. But what does this mean in concrete terms? Sleepless days have been bothering me for a while. What does our energy future look like? Let's leave my cozy home and go on a voyage of discovery!"

SCENE CHANGE. IN A HOT AIR BALLOON OVER WINTERTHUR. DAY.
The player flies out of the attic, through the clouds and is then in a hot-air balloon approaching Winterthur.

Background music. From the clouds comes Oscar and spins a few laps around the hot air balloon basket.

Oscar (in flight):

"Hey, wait for me! Ooh, it's bright! - So, how do you like Winterthur from above? Oh, what am I talking about. There's no time to lose. Let's get on the trail of the energy transition!"

IN A HOT AIR BALLOON OVER WINTERTHUR. OSCAR SITS ON A BASKET.
“Take a look around. Seems there are some interesting places to explore. Choose where to start our research.

In your hands you hold ***two controllers. With them you can bring us to the desired places. Select the location with the laser and press the trigger on the bottom of the controller with your index finger. We'll fly there together.

All right, here we go. Just where to? You decide!"

If the player doesn't make up his mind for a while:

Oscar:

"We gotta go, pick a place!"

Or

"Show us the way, we still have a lot to learn!"

**ABOVE HOTSPOT IN A HOT AIR BALLOON. OSCAR SITS ON THE BASKET.**

Oscar:
1 (above the Technikum): "Aaah, Home Sweet Home. But let's go inside! This time we'll use the main entrance."

2: "The waste incineration plant! Exciting! Shall we go in there?"

Alternative [Note: Pictures are not yet definitive, please include both versions!]:

2: "We seem to have landed directly in the control room of the recycling plant. Exciting! Can we go any further?"

3: "The station. Interesting. What can be discovered here?"

4: "We are directly above the Technopark Winterthur. What can be discovered here?"

If the player does not go to the next scene or the quiz does not start:

Oscar:

"We shouldn't lose much time here. There's more to discover here!"

QUIZ STARTS WHEN YOU CLICK ON THE QUIZ SYMBOL. OSCAR IS IN THE PLAYER'S FIELD OF VISION.
Oscar:

"Oh, there's something to learn here. You collect two energy points for each correct answer. ***The more points you collect, the more sustainable you make our city. But you only have 30 seconds per question!"

*If the player answers a question correctly (a total of 5 questions):*

Oscar:

"Way to go!"
"That's it, keep it up!"
"Bravo!"
"Clever!"
"Yes, that's right!"

*If the player answers a question incorrectly (a total of 5 questions):*

Oscar:

"Unfortunately not..."
"Try the next question!"
"That was tricky too..."
"Too bad!"
"I'm sorry!"

*If the player takes a lot of time to answer (he has 30 seconds per question):*

Oscar:
"Watch the time!"
"Time is running out!"
"Hurry up, we don't have much time!"

The player answers 5 questions on energy topics in Switzerland / Winterthur in succession.

Oscar:

"Very good! That was exciting. It seems like you're already one step closer to the energy transition. But somehow I don't quite understand all this yet. What does that mean in concrete terms?

I have a friend, Bettina, who lives with her family in a nice little house in the countryside. They already use photovoltaics - i.e. solar power systems - to produce electricity on the roof. Is there anything more to do? Let's go help her!"

SCENE CHANGE. IN FRONT OF A DETACHED HOUSE IN THE GREEN. OSCAR SITS IN THE FRONT YARD.

Oscar:

"Here we are! The family, however, seems to have flown out. "Never mind, I'm sure Bettina will be happy when I tell her about your suggestions."

"Let's get started right away! What could the family do with electricity?"
Three measures appear in the quiz format for selection.

Oscar:

"Attention, not all measures give the same number of points. And we don't have much time!"

Depending on the measure taken, the house changes visually (e.g. battery appears).

After the player has selected an action:

Oscar:

"Good choice."

Three further topics and measures will follow one after the other for selection in quiz format.

Oscar:

"How could the family be more sustainable in heating?"

"What could the family change in terms of mobility?"

"Did you know that nutrition also plays an important role here?"

The player selects a measure and sees the visualizations.

Oscar:

"Aha!"
"Ooh!"
"Aah!"

After the player has taken all measures, Oscar flies a round around the house.

Oscar:

"That looks great! I'm sure Bettina will be thrilled! You've accomplished your mission. Let's go!"

SCENE CHANGE. IN A HOT AIR BALLOON OVER WINTERTHUR. OSCAR IS SITTING ON THE BASKET.

Oscar:

"Now I know what our sustainable energy future could look like. Thanks for your help! But before I hit the sack, here's your score."

Oscar gives the player an Energy Hero diploma showing the number of points collected.

A: If the player has scored more than half of the points:

Oscar (cheers):

"Congratulations! You really deserve the title of Energy Hero! Share your knowledge and make changes. Each and every one of us can play his or her part in the energy revolution."***

B: If the player has scored less than half the points/thaler:

Oscar:
"You scored less than half the possible points. But I think you're on your way to winning the Energy Hero title! Get smart on energy issues and make changes. Each and every one of us can play his or her part in the energy revolution."

Oscar flies away.

Oscar:

"Goodbye and see you next time!"

Music. Player flies away from Winterthur in a hot air balloon.

SCENE CHANGE. Space. View of Earth.

Player lands in space. End of the game and credits.
Intern Script of Virtual Energy Hero:

*You are in the attic of Stadtwerk Winterthur.*

*The Avatar introduces themself as an employee and states how excited they are that they get to train you as the newest intern.*

"Welcome to your first day at Stadtwerk Winterthur! My name is XXXX and I will be guiding you through your first week here as an intern! In my time here, I have learned a lot about science and technology. For nights on end I poured through the countless books and teaching aids in this room, and began grasping the concept of climate change. Climate change is not a new issue. But now with the Energy Strategy 2050, Switzerland has apparently committed itself to phasing out nuclear power, reducing our energy consumption and expanding renewable energies. Winterthur has also taken this to heart. We want to become a "2000-Watt Society" by year 2050. But what does this mean in concrete terms? Maybe it is best to show you in person! Let's leave this cozy attic and go on a voyage of discovery!"

**First View of Winterthur Scene:**

*The player approaches Winterthur in a hot air balloon. The Avatar flies up to meet the player and explain the next course of action*
"Hey, wait for me! Ooh, it's bright! - So, how do you like Winterthur from above? Oh, what am I talking about. There's no time to lose. Let's get on the trail of the energy transition!"

“Take a look around. There are some interesting places to explore. It seems each spot is specific to a certain energy topic! Choose where to start our research. We'll fly there together.

All right, here we go. Just where to? You decide!"

**Hot Spot Scene:**

*The player has flown through the clouds and is in the hot air balloon above their selected location.*

1 (above the Technikum): "Aaah, Home Sweet Home. There is much to learn here. But let's go inside! This time we'll use the main entrance."

2: "The waste incineration plant! It is quite a unique place! Shall we go in there?"

3: "The train station. Interesting. Transportation is a big consumer of energy. What can be discovered here?"
4: "We are directly above the Technopark Winterthur. And look at all the PV systems on the roof! What can be discovered here?"

"Oh, there's something to learn here. You collect two energy points for each correct answer. ***The more points you collect, the more sustainable you make our city. But you only have 30 seconds per question!"

"Very good! That was exciting. It seems like you're already one step closer to understanding the energy transition. But there is much more to take in.

**Transition to Smart Living Scene:**

“As you are living in Winterthur for your new job, Stadtwerk Winterthur has provided you a flat to stay in. The neighboring house is that of a Stadtwerk Winterthur customer, and it is already equipped with photovoltaics - i.e. solar power systems - to produce electricity on the roof. Is there anything more to do? Let's go see!"

**Arrival at House:**

_You arrive by hot air balloon on the end of the driveway. You can see a family house to the left and a flat complex to the right of it._
"Here we are! Your flat is right next to a small family house. The customer wants our help to make them more energy efficient, so let’s explore what changes you could make to each style of housing! I’ll be taking notes and rating your decisions!”

"Let's get started right away! What could you do with electricity?"

"How could each type of living be more sustainable in heating?"

"What could people change in terms of mobility?"

“Now that you have a general idea of how to reduce energy consumption and decentralize our energy, let’s explore your flat and make some real changes!”

**Transition to Indoor Flat Scene:**

*Player clicks on the entrance to their flat and the next scene is in the flat, standing in the living room.*
“Okay, now for a quick test on your knowledge! You only have 30 seconds to make the most impactful changes you can. Remember, this will go towards your final score for the day!”

“Ready, set, go!!!”

“Time’s up. Good work!”

**End Scene Transition:**

*Fades out and you are back outside in front of the flats and the house.*

“Great job, you have made some real progress on your journey today! However, there is still much to learn. As I mentioned, I was scoring your performance for the day and here are your results! There is always room for improvement in terms of energy efficiency, and we will learn more about that in the coming days. I need to return this hot air balloon back to Stadtwerk Winterthur. Enjoy your flat and get some rest: we have another big day tomorrow!”

*You watch as the Avatar floats away into the sky and the credits begin to fade in around you. There is a banner that details where Chapter Two can be visited.*
<table>
<thead>
<tr>
<th>Hotspot</th>
<th>Degree of Difficulty</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Currently, fossil fuels cover most of the world's energy needs. Which energy source comes first?</td>
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<tr>
<td>1</td>
<td>1</td>
<td>For what percent of Switzerland's energy consumption are buildings responsible?</td>
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<tr>
<td>1</td>
<td>1</td>
<td>How many buildings are still heated today with fossil fuels (heating oil and gas)?</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>How many hydropower plants are there in Switzerland?</td>
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<td>1</td>
<td>1</td>
<td>How much heating energy can be saved with a room temperature that is one degree lower?</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>What are fossil fuels?</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>What are plastics mainly made of?</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>What are the main research topics of the ZHAW School of Engineering?</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>What does &quot;gray energy&quot; mean?</td>
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<tr>
<td>1</td>
<td>1</td>
<td>What is counted as biomass?</td>
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<tr>
<td>1</td>
<td>1</td>
<td>What is geothermal energy?</td>
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<tr>
<td>1</td>
<td>1</td>
<td>What is meant by renewable energies?</td>
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<td>1</td>
<td>1</td>
<td>What is one of the goals of the Energy Strategy 2050?</td>
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<td>1</td>
<td>2</td>
<td>What is one of the key goals of a Smart City?</td>
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<td>1</td>
<td>1</td>
<td>What is special about renewable energy?</td>
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<td>1</td>
<td>1</td>
<td>What is the main cause of the CO2 increase in the atmosphere?</td>
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<td>1</td>
<td>1</td>
<td>Which factor influences, among others, your ecological footprint?</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Are solar cells recyclable?</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Do you know what the current power mix in Switzerland looks like?</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Guess how high is Switzerland's total electricity consumption?</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>How many soccer field sized solar farms would it take to power the whole city of Winterthur?</td>
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<td>2</td>
<td>1</td>
<td>If all suitable roofs in Winterthur were covered by solar power systems, how much electricity could be produced per year?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>Over a longer period of time, what is usually cheaper? To produce your own solar power or to purchase electricity from the energy provider?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>Some homeowners have mounted so-called PV collectors on their roofs. What can they do?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>What does &quot;self-consumption&quot; mean?</td>
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<td>2</td>
<td>1</td>
<td>What is a &quot;prosumer&quot;?</td>
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<td>2</td>
<td>2</td>
<td>What is meant by &quot;flexibility&quot; (in the energy sector)?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>What is meant by a &quot;decentralized energy supply&quot;?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>What is the main source of electricity in Switzerland?</td>
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<td>2</td>
<td>1</td>
<td>What is the typical lifetime of a solar power system?</td>
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<td>2</td>
<td>1</td>
<td>What material are the most solar cells made from?</td>
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<td>2</td>
<td>2</td>
<td>What was the share of solar power in the Swiss electricity mix (2016)?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>When does a solar power system make the most sense?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>When does a solar power system usually produce the most electricity?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>Which idea is not so outlandish?</td>
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<tr>
<td>2</td>
<td>1</td>
<td>Which of these statements regarding the performance of solar systems is wrong?</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Which three countries worldwide have installed the most photovoltaic power?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Does waste heat from KVA count as fossil or renewable energy?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>How many buildings are still heated today with fossil fuels (heating oil and gas)?</td>
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<tr>
<td>3</td>
<td>1</td>
<td>How many liters of fuel oil equals 1 ton of waste?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>How many tons of waste does KVA Winterthur use every year?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>What percent of Winterthur's electricity needs does the KVA cover?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>What percent of Winterthur's heating needs does the KVA cover?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>In which room of the KVA are you currently in?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>What does &quot;gray energy&quot; mean?</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>What does the abbreviation &quot;KVA&quot; stand for here in Winterthur?</td>
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<tr>
<td>3</td>
<td>1</td>
<td>What is a virtual power plant?</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>What is meant by demand side management?</td>
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<tr>
<td>3</td>
<td>1</td>
<td>Which factor influences, among others, your ecological footprint?</td>
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<td></td>
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<td>Question</td>
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</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Why does this facility mean KehrrichtVERWERTUNGsanlage?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Already there are so-called electricity petrol stations. What is charged with it?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Are electric cars or E-bikes an environmentally friendly alternative?</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>How big is the share of renewable energy in the railway’s power?</td>
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<tr>
<td>4</td>
<td>1</td>
<td>How many households in Switzerland own at least 1 car?</td>
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<tr>
<td>4</td>
<td>1</td>
<td>How many hydropower plants produce energy for rail operations?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>How many kilometers are covered in Switzerland per day by car (per person)?</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>How many kilometers in Switzerland are covered per day by public transport (per person)?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>How many minutes a day is a person traveling in Switzerland on average?</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>How many of the many commuters travel to work every day by train?</td>
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<tr>
<td>4</td>
<td>2</td>
<td>How many passenger trips does SBB handle each day?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>How many train tickets are sold per year?</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>How much electricity does the train use per year?</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>What is the market share of electric cars in Switzerland?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>What is the share of goods transported by train?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>What is the share of the Swiss population with an extra charge?</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Which factor influences, among others, your ecological footprint?</td>
</tr>
</tbody>
</table>
Appendix L: Questions for Removal and Replacement

The current game question script is comprised of 67 questions. The vast majority of these questions are relevant to the knowledge transfer of important smart energy and city information, but six questions were selected for removal. These six questions were determined to be relatively trivial and able to be replaced with more effective questions concerning consumer awareness and smart city topics. These questions are listed below.

1. Questions for removal (translated)
   a. What are the main research topics of the ZHAW School of Engineering?
   b. How many soccer field sized solar farms would it take to power the whole city of Winterthur?
   c. How many tonnes of waste does KVA Winterthur use every year?
   d. In which room of the KVA are you currently in?
   e. Why does this facility mean KehrrichtVERWERTUNGSanlage?
   f. What is the share of goods transported by train?

2. Candidate replacements:
   a. Consumer Awareness
      1. How much can you be paid for each kWh of electricity your PV system produces? (Ans. ~8 cents per kWh)
      2. How much energy does Switzerland consume per capita? (ans. 6000 Watts)
      3. How much of the cost of electricity is devoted to transmission and delivery? (ans. about half)

   b. Smart City Questions
      1. How much does public lighting contribute to the city’s electricity bill? (Ans. 10-20%)
2. How much energy can be saved with smart building initiatives such as smart heating/cooling and improved insulation? (Ans. about 40%)

Appendix M: Sample Point System

This point system makes generalizations on the impact of different changes to energy consumption, and consequently CO₂ emissions (1 kWh of electricity = 1 kg of CO₂ emissions). It groups them into three tiers worth 1, 2, and 3 points based on their “quality”. This is similar to the scoring of the current House Scene, differing in its separation from the points acquired in previous scenes. We encourage our sponsor to further refine this point system by calculating the individual contributions of each source of consumption and assigning scores more accurately. In this way, each change may have its own point value based on its impact. The challenges in this lie in maintaining a relative fairness in the scene’s scoring (e.g. heating/cooling alone account for about half of home energy consumption, and it would be unfair to place half of the scene’s points in a single option), as well as changes that don’t necessarily change energy consumption but are still necessary changes (e.g. switching to a CO₂ neutral energy delivery option, or installing a smart meter).

1. **The Smart Home scene will be scored individually of the Smart City and Smart Living scenes rather than having one cumulative score.**

2. **Smart Home:** Find max amount of CO₂ emissions that can be saved and apply point value to each change based on its contribution to savings.
   a. Most impactful changes (Heating/cooling system, Water heating, switching to smart washer/dryer, switching to CO₂ neutral sources): 3 points
   b. Moderately impactful changes (LED Lighting, switching to smart kitchen appliances, reducing thermostat by 1-2 degrees C): 2 points
   c. Least impactful changes (Fixing leaky faucet, turning off appliances after use, etc.): 1 point

   d. **Point of Information:** The Smart Home scene score will be given as a percentage of the maximum amount of CO₂ emissions able to be saved

3. **Smart City/Smart Living:** Scored using points: 2 for a correct answer and 0 for an incorrect answer
The scoring of the Smart Home scene is separated from the other scenes to emphasize the importance of going beyond awareness and taking action in the player’s own home. Due to time constraints and our focus on the development of the game’s storyline and its components, the point system could not be developed to a high degree of completeness. It was decided that the format of the game and its questions dictate whether a point system is viable or not. It is better to limit the point system based on the game, and not vice-versa.
Appendix N: IQP Images

Figure 33: Smart Parking Example

Figure 34: Smartes Quartier Storyboard
Figure 3: Smart Living Storyboard