MSc Program
Environmental Technology & International Affairs

Opportunities for Photovoltaic– and Wind Energy Systems – Austria vs. China – a Case Study

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

supervised by
Dipl.-Ing. Dr. Mario Ortner

Ing. Lukas Hainzl, BSc

0854296

Vienna, 15.06.2017

Affidavit

I, **LUKAS HAINZL**, hereby declare

1. that I am the sole author of the present Master's Thesis, "OPPORTUNITIES OF PHOTOVOLTAIC- AND WIND ENERGY SYSTEMS - AUSTRIA VS: CHINA - A CASE STUDY", 63 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 15.06.2017

____
Signature

Abstract

The investigation was conducted to explore the opportunities of wind- and photovoltaic energy systems in Austria and People's Republic of China. In this study, a technical report about the state of the art of the mentioned technologies was made. Moreover, the Austrian and Chinese market opportunities were reviewed. Finally, four case studies were conducted, one for each technology and market. The paper is investigated by two methodologies. The first two parts are described by the means of a literature review. The third part is investigated via case studies. This thesis presents an exhaustive review of these research fields. The results reveal that in recent years the cost of wind- and photovoltaic systems dropped in Austria as well as China. However, the market review and the calculations of the case studies suggest that the Chinese market offers more opportunities than the Austrian market. It was found that if policy makers would like to push the technologies and the markets forward there is still some room for improvements in both countries investigated. Implications of the results and future research directions are also presented.

Keywords: Renewable Energy; Wind Energy; Photovoltaics; Austria; China, Case Study; Market Analyses

Table of Contents:

1. Introduction

For decades, and with increasing certainty, scientific knowledge has shown the danger of a serious global climate change. The World Council of the United Nations recently presented its fifth report: If climate change is to be stabilized at 2° C, emissions must reach their maximum as quickly as possible and then fall by one to two thirds by 2050. A further delay in global protective measures is increasingly jeopardizing the goal of limiting global warming to a maximum of 2° C. In addition, a delay reduces the scope for action and considerably increases the costs for climate protection (Mechler, et al., 2014). In addition, resources on oil and natural gas are becoming scarcer, and the uranium deposits could be exhausted in the course of the 21st century. Moreover, the concentration of fossil fuel reserves in the Middle East and Russia are an increasing threat to the security of energy supply in Europe. These problems make a technological change necessary whose main elements should be the saving and the more efficient use of energy as well as the increase in the share of renewable energies in the energy mix (Schönberger, 2016). This will be especially important because of emerging markets such as China, India and the Middle East because these countries are expected to account for more than half of the projected increase in energy demand by 2030. The aspirations of their growing middle classes determine the pace of global growth in demand, with a number of African countries just behind them. In fact, countries that are not members of the Organization for Economic Cooperation and Development (OECD) will account for over 90% of future growth in demand. At the same time, over the next two decades, we are facing a global trend towards more electrification in the economy, as demand for electricity is growing faster than the demand for other forms of energy. It is expected that electricity consumption will grow by 2.5% per year by 2030, almost twice as fast as total energy consumption (Kratena, et al., 2014).

The list why a rethinking in the energy production must take place quickly can be continued. However, this is not the goal of this master thesis. The aim is to address two technologies that have the potential to counteract the effects of the last decades, in particular wind energy and energy from photovoltaics.

The Austrian energy policy promotes the principle of sustainability. In addition to increasing energy efficiency, the increased use of renewable energies is one of the two most important strategies to best meet this principle. In general, renewable energy sources are regarded as particularly environmentally friendly. Due to its favourable topographical situation, Austria has two resources that are traditionally used to a high degree for energy production: hydropower and biomass. However, the use of and wind energy and especially photovoltaics is less in the focus. This thesis attempts to show that that there actually is much potential in the market of these energy sources in Austria. On the other hand extensive research has shown that China is the new power horse when speaking about these two technologies. The central thesis of this study is to compare these two different markets and disclose the business opportunities for photovoltaic and wind energy projects in Austria and China. There has been no detailed investigation of the comparison of these two countries regarding energy from wind and photovoltaic.

1.1. Problem Definition and Objective of the Thesis

As mentioned in the introduction, a rethinking of renewable energy is essential to safeguard the energy security of the future. The thesis deals with two of the most important renewable energy sources, photovoltaic and wind energy. In the focus of the thesis will be business opportunities in the Austrian market and the Chinese market regarding the mentioned technologies. Of course, the circumstances in China are very different from those in Austria. This is due too many factors, including the economic power, the size and the different geography and topography of the two countries. However, Austria has long been committed to renewable energy, China has only recently put the topic on its agenda. The question is how China is pushing its market forward and has accomplished to become the global market leader in such a short time. Another exciting question arises in the implementation of subsidies for the two energy sources in these very different countries.

The master thesis should be conducted in a way to provide an overview of recent developments in the markets and the used technology. Moreover, groundwork for investment decisions should be one of the outcomes. Finally, potential gaps and improvements for policy makers should be identified.

To reach these objectives the thesis will try to answer the following research question:

How do business opportunities of photovoltaic and wind energy projects in Austria and China differ from each other and what is the financial impact of these differences when setting up photovoltaic and wind energy projects?

1.2.Methodology

The master thesis combines several different methodologies to cover the objective of the thesis defined in section 1.1. as best as possible. The first part of the master thesis consists of a literature review on the current state of the art of photovoltaics and wind technologies. Especially textbooks and articles in journals were used to get a picture that represents the current state of the art. The second part of the master thesis also consists of a literature review. In order to get an overview of the wind and photovoltaic markets in Austria and China, especially reports published by institutions and interest groups from recent years have been used. However, also articles published in journals were used. The third part of the thesis is of qualitative nature. Four case studies were conducted. These case studies have the purpose of comparing the business conditions for wind and photovoltaic projects in Austria and China. The case studies try to present a realistic view on wind and photovoltaic projects in Austria and China, while maintaining the comparability of the chosen scenarios. Most of the data is subject to secrecy, since no business owner wants to disclose his investments and costs. For this reason, assumptions had to be made to obtain data from which calculations could be carried out. On the one hand, this was done by means of literature in the form of specialist books and articles in journals to get an overview of the average costs. But also laws on feed-in tariffs and taxes were reviewed. On the other hand, current projects with basic data was found and used to prepare a realistic initial situation. In order to carry out a validity check of the calculations, a tool from the Austrian Energy Agency was used. The tool was programmed for private users, but a rough overview of the investments and rentability of wind and solar power plants can be shown. The results of the crosscheck are not part of the master thesis, but should be mentioned nevertheless. The calculations showed similar results as the calculations performed in the master thesis. For this reason, it can be assumed that the calculations are close to reality. A comparable tool for the Chinese market could not be found, but the calculations in all cases were performed in the same way due to comparability.

2. Part I: Technology Introduction

2.1. Photovoltaic

Photovoltaics have an impressive long-term perspective to play an important role in the electricity mix of the upcoming decades. That's why it is important to understand the technology behind photovoltaic systems.

Electricity is the most elegant, versatile and future-oriented form of the energy carriers. Electricity can be obtained from numerous processes and converted into all forms of energy, including mechanical, chemical, thermal, and others. All the energy scenarios developed over the last few years expect a steady increase in the share of electricity in the entire energy mix over the next decades. The global energy sector is faced with a fundamental change to the increased use of environmentally sustainable types of production. Photovoltaics are now regarded by many experts as the "king" in renewable electricity production. Reasons for this are, among other things, the almost inexhaustible supply of solar radiation. The solar radiation which is directed towards the earth represents a multiplicity of the world energy demand. Photovoltaics, together with solar thermal utilization, has the highest potential of all renewable energy sources worldwide (Fechner & Lugmaier, 2007).

The production of electricity by means of photovoltaics is similar to other technologies, dependent on the given site conditions. In this particular case, the energy generation is determined by the inclination and orientation of the photovoltaic system, but also, in particular, by the actual solar radiation. In contrast to wind turbines, electricity generation is less volatile here, especially as wind power forecasts can be compiled reliably up to one day in advance. For this reason, scientists attributed enormous potential to photovoltaics in connection with the provision of large amounts of energy from renewable sources (Müller, et al., 2014).

The history of photovoltaics goes back to the discovery of the photo effect by the French physicist Alexandre Edmond Becquerel in 1839. In electrolytic experiments, Becquerel discovered that the current in its arrangement changed according to lighting. One distinguishes the external photo effect observed by Becquerel, in which electrons emanate from a solid under light, and the internal photo effect, which is relevant for photovoltaics, but in which the electrons remain in the solid state, are transformed into an energy-safe state by the absorption of the energy of a light quantum. The inner photo effect was first described in 1873 by the British engineer Willoughby Smith in the form of a change in the electrical resistance of selenium observed during illumination. The first functional solar generator was introduced by the American scientist Charles Fritts in 1883 on the basis of selenium. The module had an area of about 30 cm2 and an efficiency of 1% (Wesselak & Schabbach, 2009).

For many years research and development focused especially on an increase of efficiency of crystalline cells. However, after the 1990s the industry focused on material and cost savings. This was achieved due to the development and production of thinner semiconductors. Further costs savings were made possible because of the use of silicon with a lower purity. Primarily the thin-film technology together with crystalline solar cells offer an excellent price-performance ratio and therefore it is assumed that the market share of these technologies will grow in the future (Green, et al., 2007).

2.1.1. Principle of the Photovoltaic process

The photovoltaic process is based on the photovoltaic effect in semiconductor materials. Semiconductor materials absorb a portion of the light incident on the cell. This releases electrons that allow the flow of an electrical charge through the material (Roberts & Guariento, 2009).

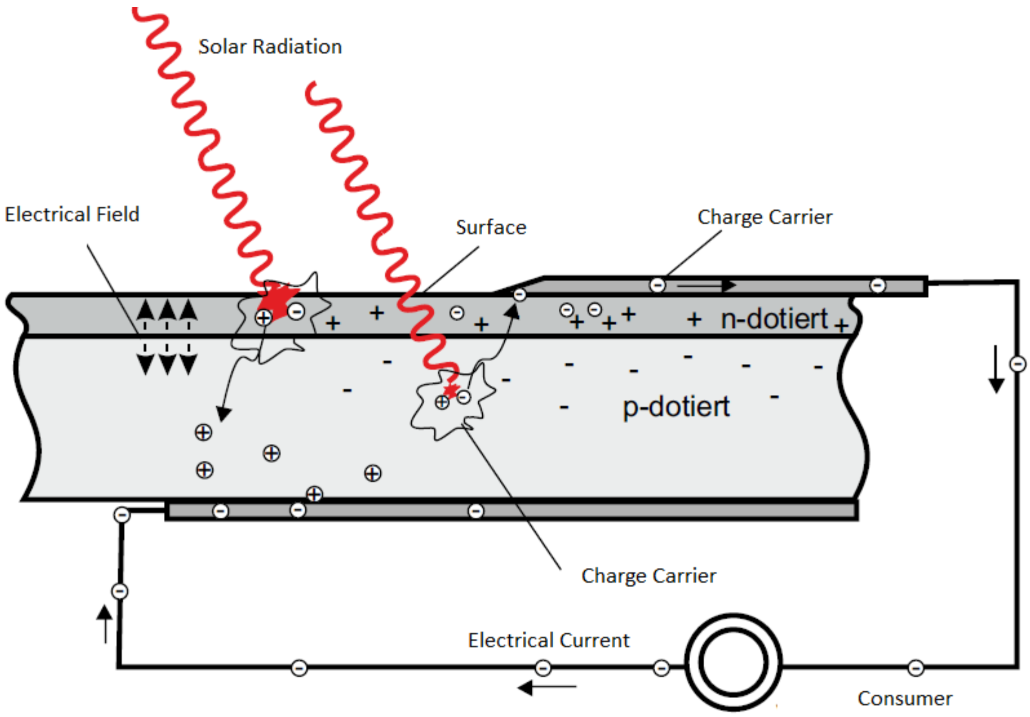

Figure 1 - Photoeffect - (Schabbach & Leibbrandt, 2014)

PV cells consist of one or more semiconductor materials and allow direct conversion of solar energy into electrical energy. The semiconductor material must be doped, to produce the photoelectric effect. Then chemical elements are introduced to produce two layers, a p-conducting layer with a positive and an n-conducting layer with a negative charge carrier excess. Because of this imbalance an electric field is formed at the boundary layer which causes a charge separation when a light incident happens. The charge carriers thus released can be dissipated via metal contacts and consumed directly by an electrical device or fed into the grid via an interposed inverter as an alternating current. For higher capacities, PV cells are often combined into modules (Bartlett, 2010), see also Figure 1.

The voltage of only one solar cell is too small for technical applications, so several solar cells are connected to form solar modules. They are usually connected in series. In a series circuit, voltages of the individual cells add up to a higher total voltage, whereas the same current flows in all the cells. In the case of a parallel connection, the voltage remains constant and the current intensities are added. The interconnected cells are mostly embedded in transparent ethylene vinyl acetate (EVA), bonded to composite film or glass, provided with a frame made of aluminium or stainless steel and covered on the front with glass (Konstantin, 2013).

We can differentiate between 3 different types of silicon photovoltaic solar cells. For an overview see Table 1 and Table 2. The technologies will be explained in more detail below in the chapters 2.1.2 to 2.1.4.

Table 1 - Different Types of Silicon Photovoltaic cells - (Behrla,n.d.)

	Monocrystalline	**Polycrystalline**	**Thin Film**
Low-light Behavior	Reduction in diffuse light	Reduction in diffuse light	Only slight losses
Heat Behavior	Loss at high temperatures	Loss at high temperatures	Only slight losses
Costs	More expensive than polycrystalline and thin film	Cheaper than monocrystalline	More economical than monocrystalline, polycrystalline
Long-term Test	Very high power, stable, long life	Very high power, stable, long life	Medium power, slightly lower life
Weight per Square Meter	Higher	Higher	lower
Interference susceptibility	very low	very low	low

After the temporary silicon shortage between 2004 and 2008, silicon prices fell dramatically, as did the cost of wafer-based silicon solar cells. In 2013, their market share was close to 90 % and they became the main technology (Jäger-Waldau, 2014). The efficiency of a solar cell is the ratio between the electrical power output and the solar radiation. The efficiency has an influence on the area requirement of a PV system. Lower efficiency results in a larger area requirement (Konstantin, 2013). Commercial module efficiencies range widely from 12 % to 21 %, with monocrystalline modules from 14 % to 21 %, and polycrystalline modules from 12 % to 18 %. The massive increases in manufacturing capacity for both technologies were followed by the capacity expansions needed for polysilicon raw materials (Jäger-Waldau, 2014).

Table 2- Cell Efficiency - (Konstantin, 2013)

Material	Cell Efficiency		Module Efficiency
	Laboratory	Production	
Monocrystalline Silicon	24,70%	21,50%	14% - 21%
Polycrystalline Silicon	20,30%	16,50%	12% - 18%
Amorphous Silicon	11% - 12%	10,50%	8% - 12%
CIS, CuInSe2	19,50%	14%	11% - 15%

2.1.2. Monocrystalline

This material is well suited because its band gap of approximately 1.1 eV is close to the optimum for the conversion of the solar radiation and its technology from microelectronics is very well researched. Silicon is available in large quantities and is non-toxic. Currently, around 30% of all solar cells are made of monocrystalline silicon. Because of the low absorption coefficient of crystalline silicon, solar cells of this material must be relatively thick (100-200 μm) in order to absorb the irradiated light completely, if no additional measures are taken. The generated charge carriers have to be induced by diffusion from the largely field-free railway regions for separation to the np junction. The emitter is kept very thin in order to keep losses due to recombination at the surface low. The base is chosen from the p-type to exploit the better diffusion properties of the electrons ($L_n >> L_p$) (Wagemann & Eschrich, 2010). Monocrystalline cells characterize a periodic arrangement of their crystals in only one direction. Monocrystalline rods are drawn from the silicon melt and then sawn into thin slices. They require high-purity semiconducting material for manufacture and require the highest energy and cost requirements compared to all other cell types. However, as mentioned above, they also achieve the highest efficiency (Konstantin, 2013).

2.1.3. Polycrystalline

Polycrystalline cells are the cell technology which is mostly used today. Silicon in its liquid form is poured into blocks during the production of the cells. In the process of solidification crystal structures are formed which are different of size and orientation. These structures are not free of defects. In a further production step the cells are sawn into thin slices. Compared with monocrystalline cells, the energy consumption of the production process and the costs of the production are significantly lower for polycrystalline cells. On the downside, as indicated in Table 1 respectively Table 2 the efficiency is lower for polycrystalline cells (Green, 2001).

2.1.4. Thin film technology

Thin-film solar cells are an alternative to wafer-based solar cells. They differ in the layer thickness of the semiconductor material used as well as in the production process. Thin-film solar cells consist of a carrier material on which a semiconductor layer of a few μm thicknesses is applied. The semiconductor material used is mainly amorphous silicon (μ-Si), copper (indium / gallium) (selenium / sulphur) compounds (CIS / CIGS) or cadmium stellurite (CdTe), metal or plastic films (Wesselak, et al., 2013).

In 2005, for the first time, the production of thin-film solar modules reached more than 100 MW per annum. Between 2005 and 2009, the compound annual growth rate of thin-film solar module production exceeded that of the overall industry, increasing the market share of thin-film products from 6 % in 2005 to 10 % in 2007 and from 16 % to 20 % in 2009. Since then, the thin-film share has declined slowly as the ramp-up of new production lines has not followed that of wafer-based silicon. The majority of thin-film manufacturers remain silicon-based and use either amorphous silicon or an amorphous/microcrystalline silicon structure. Fewer companies use Cu(In,Ga)(Se,S)2 as absorber material for their thin-film solar modules, and only a few use CdTe (cadmium telluride) or dye and other materials (Jäger-Waldau, 2014).

One differentiates between substrate and superstrate construction depending on whether the semiconductor material is applied starting with the back or the front side contacting. The advantage of thin-film solar cells lies in the significantly lower material use for the semiconductor substrate. The layer thickness is lower by a factor of 100 than in the case of crystalline solar cells, and the absence of saw losses. However, the efficiency of thin-film cells is not yet sufficient for the crystalline solar cells. In addition, in the case of amorphous semiconductors, the efficiency is reduced by up to 25 percent within the first year of operation. This aging phenomenon can also be observed to a lesser extent in crystalline solar cells and is due to the light-induced formation of impurities (Wesselak, et al., 2013).

2.1.5. Future development

At present, production in most of the cell factories is being high. At the same time, companies are exposed to enormous price pressure due to the current worldwide overcapacity. In order to cope with this price pressure, technological improvements, which have already been realized in the laboratories, have to be implemented quickly into production. Among the short-term targets are accelerated absorber growth and the further improvement of the efficiency, which should result in a doubling of the throughput in critical process steps. Efficiency improvements are directly a question of improved light coupling of all outer and inner interfaces by suitable structuring and optically adapted intermediate layers. The nanoscale mixture of a-Si: Ox: H and μc-Si: H is currently being used as an electrically and optically suitable material for internal contact layers. Faster absorber growth and therefore shortened process times require modification of the process management, in particular the establishment of excitation frequencies for the plasma position above 40 MHz. For this purpose, in particular, the large-area electrodes of industrial deposition plants must be "redesigned". In the medium term, the use of new, particularly flexible, substrates must be intensified in order to be able to serve new segments in the event of an emerging market diversification. The production of efficient coating systems by means of dynamic deposition combined with new production technologies (e.g. roll-to-roll processes, longer-term printing techniques) plays a central role. Environmental aspects and availability of materials Against the background of the ever-increasing production volume, the question of environmental compatibility and the availability of materials used in the process, including intermediate and waste products, must be examined for all photovoltaic technologies (Powalla, et al., 2010).

Another alternative could be concentrating photovoltaics (CPV) which are growing at a fast pace, although from a low starting point. In 2015, around 60 companies were active in the field of CPV development, the majority of them focusing on high-concentration concepts. Over half of them are located either in the United States (primarily in California) or Europe (mainly in Spain). Within CPV, there is a differentiation according to concentration factors and whether the system uses a dish (Dish CPV) or lenses (Lens CPV). The main parts of a CPV system are the cells, the optical elements and the tracking devices. The recent growth in CPV is based on significant improvements in all these areas, as well as in system integration. However, it should be pointed out that CPV is at the beginning of an industry learning curve, with considerable potential for both technical and cost improvements. The most challenging task is to become cost-competitive with other PV technologies quickly enough in order to grow to reach factory sizes and thus benefit from economies of scale. Despite the current small installed capacity, various consultancy companies predict that the CPV market will grow to 500 MW by 2015. The existing PV technology mix is a solid foundation for the future growth of the sector as a whole. No single technology can satisfy all the different consumer requirements, ranging from mobile and consumer applications, and the need for a few watts up to multi-MW utility-scale power plants. If material limitations or technical obstacles restrict the further growth or development of a single technology pathway, then the variety of technologies will be an insurance against any stumbling blocks in the implementation of solar PV electricity (Jäger-Waldau, 2014).

2.2. Wind Energy

Wind energy significantly influences the success story of renewable energies. For centuries, man has been able to exploit the power of the wind, but only with the help of recent experiences and technical possibilities has it been possible to reliably exploit the enormous potential. The use of wind as a source of energy therefore plays a vital role in the development of renewable energies towards economically viable and climate-tolerant energy supply at reasonable prices and a high level of prosperity. Wind energy plants use the energy of the wind caused by different air pressure conditions near the surface of the earth. Modern wind turbines use the boost principle instead of the resistance principle. They do not oppose the wind; instead, the wind generates a buoyancy on the wings of the plant, causing the blades of the plant to rotate. In order to maintain a high level of wind energy utilization, the progressive expansion of wind power at sea will also be required in addition to the further development of suitable rural locations and the replacement of older, smaller plants by means of modern and more powerful plants and offshore wind energy plants (Bundesministerium für Wirtschaft und Energie, 2017).

Humans have been using the power of the wind for about 4000 years. Early on, a windmill with a vertical axis was developed which was driven by the resistance force exerted by the flow on the rotor blades. This design, which is designated as a resistance rotor, has a low efficiency of a maximum of about a quarter of the buoys described below. Therefore, they are usually only used in the form of the widely used window-type anemometers for wind measurements. Around the 12th century windmill types such as the bock windmill or the Dutch windmill were developed, which work according to another, more effective principle. In this case, not the usually horizontal orientation of the rotor axis is the decisive step forward, but the fact that the flowing air drives the rotor blades via an aerodynamic buoyancy force. In the case of a resistance rotor, which is quasi "floating" in the flow, the relative speed at the rotor blade is always smaller than the wind speed. By contrast, buoyancy impellers can achieve higher inflow velocities by superimposing wind speed and circumferential speed. This is the only way to produce the forces required for optimum deceleration of the wind and the aerodynamic efficiency approaches the theoretical maximum of 59% found by Albert Betz and F. W. Lancaster. In addition to an increase in the aerodynamic efficiency, it is also expedient for the generation of electrical energy if the circumferential speed is a multiple of the wind speed. In the case of these so-called high-speed engines, only very slender blades are required and the generator is driven at a high rotational speed and correspondingly small torque. The use of three rotor blades has been established for structural dynamics, acoustic and aesthetic reasons. (Kühn, 2007).

2.2.1. Principles and Technology of Wind Energy

There are a variety of technical embodiments for wind power plants. Today, almost exclusively three-blade designs with a horizontal axis of rotation are used for grid-connected power generation.

Horizontal axis converters are realized almost exclusively in the propeller type. The European windmills, the American wind turbine and the modern wind power plants belong to this design. The advantages of the propeller type are that the rotor speed and the power output can be controlled by adjusting the rotor blades around their longitudinal axis. This method is called pitch angle control. In addition, the adjustment of the rotor blades is the most effective protection against overspeed and extreme wind speeds, especially for larger systems. With an optimal design of the rotor blade platform, maximum aerodynamic efficiency can be achieved by maximum use of the aerodynamic buoyancy principle. The technological development advancement of the propeller design is another decisive argument for this technology. Nearly all of the wind turbines built to date is of such a design. FIG. 1 shows the schematic structure of a horizontal-axis wind power installation. The components identified therein and their arrangements are typical of larger plants. Particularly in the case of small installations, structural simplifications are to be found which have different constructional features which differ from this standard construction. One example of this is the lack of possibility to adjust the rotor blade angle (Jungbauer, n.d.).

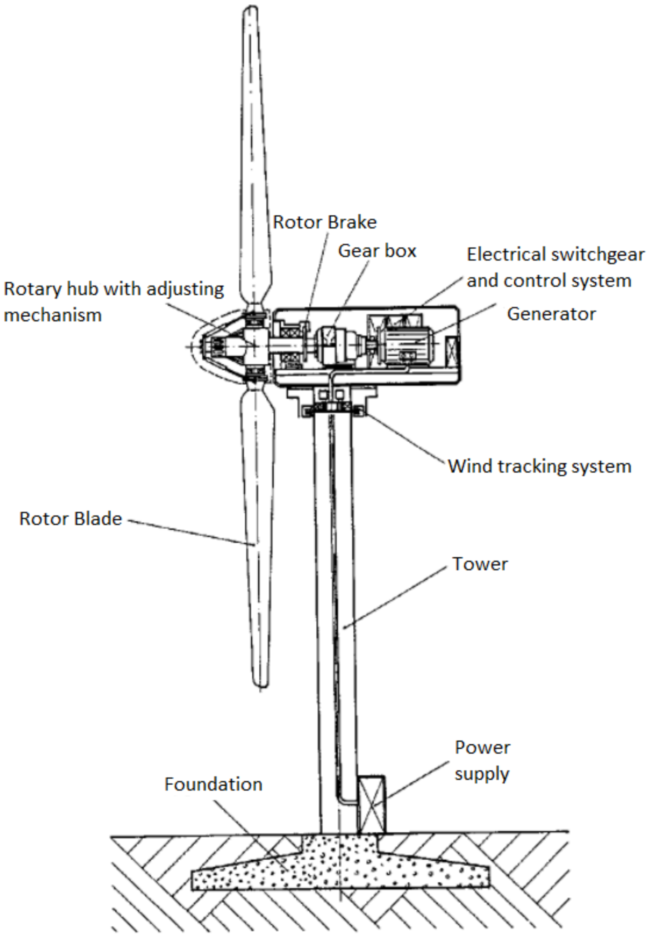

Figure 2 - Wind Turbine - (Jungbauer, n.d.)

In modern wind turbines for generating electricity with a horizontal axis, one distinguishes between rotors with one, two or three rotor blades. More than three rotor blades are usually not used. The smaller the number of rotor blades, the less material is necessary. For single-blade rotors, a counterweight must be attached to the rotor hub on the opposite side of the rotor blade. Single-blade rotors have a very uneven run and a heavy material load. At present there are only a few prototypes for wind turbines with only one rotor blade. The optimum performance coefficient of 3-blade rotors is slightly higher than that of 2-blade rotors. 3-blade rotors are visually calmer and better adapt to the landscape from a visual point of view. The mechanical loading of the wind turbine is also lower for 3-blade rotors than for single-blade or 2-blade rotors. The advantages of the 3-blade rotors weigh the disadvantage of the higher material use, so that today mainly 3-blade rotors are built. The shape of the rotor blade generally has a decisive influence on the achievable power coefficient. The rotor blade depth should then taper from the hub to the rotor blade tip (Quaschning, 2015).

The question as to the appropriate material is generally the starting point for considerations about the rotor blade design. Both the structural design and the manufacturing technology are determined to a large extent by the property of the material. On the other hand, the design principle also places certain requirements on the materials and thus sets criteria for material selection. It can thus be said that the material selection, design principle and manufacturing technology cannot be seen separately from one another in the concrete case. Nevertheless, it is useful to first analyse the construction materials which are basically suitable for their suitability for wind rotor blades. The following materials are considered to be the most suitable: aluminium, titanium, steel, fiber composite (glass, coal, and aramid fiber) and wood (Jungbauer, n.d.).

The tower is an essential component of a horizontal-axis wind turbine. This circumstance is both a disadvantage and a disadvantage. The costs which can account for up to 20% of the total costs of a wind turbine are, of course, disadvantageous. On the other hand, the specific supply of energy to the rotor increases with increasing tower height. Theoretically, the optimum tower height is obtained at the intersection of the two growth functions of construction costs and energy supply. Unfortunately, this intersection cannot be specified in a generic form. The installation site plays a decisive role. In areas with high surface roughness, i.e. in the interior, the wind speed increases with the altitude slower. Under these circumstances "higher towers" are more worthwhile than, for example, in offshore applications, where the reverse effect is present. In the interior, tower heights of 100m and beyond are decisive for the economic usability of the wind energy. Besides the height, the stiffness of the tower is the second important design parameter. Above all, the determination of the first flexural frequency is decisive for the design, the required material expenditure and thus ultimately for the construction costs. The goal of the tower design is to realize the required tower height with the necessary stiffness at the lowest possible construction costs. With increasing height, the transportability of the tower to the installation site becomes a criterion for the selection of the suitable design and construction. Today's tower heights of the large plants with more than 100m are increasingly placing this problem in the foreground. In recent years, many different tower designs have been developed for this reason. Even older concepts, which were temporarily replaced by the long-standing steel tube towers, are again becoming topical. Steel or concrete are available as materials. The range of designs ranges from lattice constructions to steel towers with and without rope bracing to massive concrete structures. The technical requirements set by the entire system can be fulfilled with almost every variant, but the economic optimum is achieved only with a sensible assignment of the chosen tower design to the requirements. Thus, it is clear that the tower of a wind turbine itself is a conventional component, but its design requires a considerable degree of overlapping system understanding (Hau, 2008).

A distinction is made between onshore and offshore installations see chapter (2.2.2.). Most of the foundations for onshore facilities are foundations made of concrete and steel. In the case of soft ground, pile foundations are also used. The tower not only carries the masses of the gondola and the rotor blades, but also has to absorb the high loads due to the changing forces of the wind. At coastal locations, at sea or other strong wind locations, smaller towers are sufficient, since wind speeds are already present at a lower hub height. In order to adjust the rotor speed of a wind turbine (approx. 6-20 revolutions per minute) to the mains frequency, the generator speed (approx. 500-1800 revolutions per minute) must be significantly higher than the rotor speed. The gearbox assumes the task of adjusting the rotor speed to the generator speed. However, some disadvantages must be accepted with the transmission. This reduces the power due to frictional losses and increases the noise load as well as the maintenance effort. A high-pole synchronous generator and a frequency converter are required for gearless wind turbines as well as for all wind turbines with variable speed, so that a good adaptation between the rotor and the grid is ensured even at low rotor rotation speeds. However, the higher number of poles causes a larger diameter and thus a high material input of the generator and consequently a higher tower head mass. Systems with permanent magnet generators can compensate for this disadvantage, but require the use of rare earth (Hartmann, et al., 2015).

Depending on the wind speed, a different output is to be taken from the wind. After reaching the rated power, i.e. above the rated wind speed, the power must be kept constant in order not to overload the electrical generator. For this purpose, a power limitation must be made for the wind power installation, for which one is different between the two processes (Quaschning, 2015):

- Stall (flow break due to structural measures on the rotor blade)
- Pitch (change of rotor blade angle).

While today's modern, network-connected wind energy systems use pitch control, the stall control is only available for smaller systems and for island networks. Because of the very fast pitch control, wind turbines can be driven in such a way that they can provide negative control and reserve energy. If the wind turbine is only driven with 95% of the current power, it can also provide positive control power with the unused 5% power (Hartmann, et al., 2015).

2.2.2. Special Case: Offshore Wind Power Plant

The requirements at sea, are different to onshore installations. Nevertheless, offshore wind turbines are not differing from those of the maritime environment, and generally the largest available tested types are currently not as effective as onshore turbines. For the development of offshore wind turbines with a rated output of 1.5 MW, two different technical approaches are applied: the marination of robust and onshore tested plants or concepts on the one hand and the integration of offshore specific concepts into completely new plant designs on the other. In the course of the marinisation process, onshore concepts are gradually modified for use at sea. This procedure is judged as advantageous by many manufacturers, since a certain type of plant with small modifications is suitable not only for offshore but also for specific markets on land. Offshore is provided with maintenance aids which allow the repairs or the exchange of components on site. Heat exchangers for the gearbox and generator cooling reduce the air throughput in the nacelle, the corrosion protection is improved. Frequently, the specific rating is the ratio of rated power to the oversized rotor area is increased and the control possibilities are expanded. An airtight closed gondola is sometimes proposed. In addition to expensive seals, this requires an expensive and additional energy-consuming cooling system for dissipating the radiant heat of the smaller units (Kühn, 2010).

Special requirements must be placed on the foundations in particular. There is a danger, for example, in the ejection. These are rinses of the sea floor at the foot of the foundations. Wind energy systems can lose their hold. Countermeasures are, for example, the very deep anchorage of the plant in the seabed, stone deposits and the stacking of sandbags around the foundation. There are different foundation types for wind parks on the sea (Bundesministerium für Wirtschaft und Energie, 2015):

- Monopile (single pile)
    - The monopile is the easiest to construct and has the least amount of material. The foundation is hollow and consists of a support. A variety of

European wind parks near the coast use the monopile. So far it was more suitable for a water depth of 20 meters. Meanwhile so-called XL monopiles are manufactured, which can be fastened up to 40 meters under water. Especially in terms of profitability, this foundation has advantages: The savings potential is 30 to 40 percent compared to jacket and tripod models (Bundesministerium für Wirtschaft und Energie, 2015).

- Tripod
    - The tripod foundation was developed by the manufacturer especially for offshore wind power plants. A three-pronged steel construction supports the main pillar under water. Tripods are suitable for sea depths of up to 50 meters and cannot be used on a rocky surface. According to the manufacturer, the foundation is suitable for water depths of up to 50 meters (Bundesministerium für Wirtschaft und Energie, 2015).
- Jacket (lattice mast structure)
    - The foundation is similar to a current mast, saving 40 to 50 percent of material. A jacket stands on four feet, which are anchored with piles in the ground, the concept has already proved itself with oil platforms and can be used up to a water depth of 70 meters. Transport and assembly are simple and cost-saving. However, since the foundation consists of welded joints, which must be serviced regularly, the operating costs are high (Bundesministerium für Wirtschaft und Energie, 2015).
- Gravity foundation
    - This type is a large concrete block, which carries the steel structure of a wind power plant. Since the foundation itself is not made of steel, the material price is lower than with other foundation types (Bundesministerium für Wirtschaft und Energie, 2015).
- Floating Foundations
    - In this design, the wind power system floats on the water and can be connected to the foundation by a steel cable, for example. The advantage: a swimming foundation is easier to install. It can be prefabricated completely on land and thus can be installed without installation vessels. Nevertheless, there are major challenges in the

connection of cables and the handling of the forces that influence the foundation as well as the drive train of the installation by wind and waves (Bundesministerium für Wirtschaft und Energie, 2015).

- Bucket foundation
    - The bucket foundation is an inexpensive and still relatively new way of anchoring a wind energy installation. This creates a vacuum between a steel flange, which resembles a twisted bucket, and the bottom of the sea. The foundation sucks on the ground and thus gives the wind power system a secure and vertical support. However, in order to achieve this suction effect, the surface must be homogeneous and not rocky. An advantage of the bucket foundation is that it does not have to be rammed and is therefore particularly environmentally friendly (Bundesministerium für Wirtschaft und Energie, 2015).

The grid connection of offshore wind parks is more complex than on land. Sea cables connect the individual wind turbines with a transformer station. This is also located on the lake within the wind park and resembles the appearance of a small drilling platform. The transformer station converts the electrical voltage of the wind power plants into high voltage in order to keep the transmission losses low. Larger distances to the shore may also require DC transmission, since the losses in AC sea cables are relatively high. A special inverter converts the alternating voltage into DC voltage. On land the back conversion is carried out in alternating current (Quaschning, 2015).

3. Part II: Market Analysis

3.1. Market Analysis Austria

3.1.1. Photovoltaic

Photovoltaic systems are an essential carrier of the global energy supply. Currently shares of around 10% of the total energy mix are already a reality in some countries or regions. Within the European Union currently about 4% of the total energy mix are photovoltaics. Current values of photovoltaic production in Germany suggest that temporarily 50% of the total energy load in Germany could be covered up, signal the necessity of adapting the electricity infrastructure and electricity market design. Various other countries follow the German development. Globally, photovoltaics in 2015 exceeded the 200 GW limit (227 GW), equivalent to 1.3% of global electricity generation output. What was foreseen for 2020 will be achieved at the end of 2015 (Fechner & Lugmaier, 2007).

After some pioneering plants in the late 1980s, the first slight market development of photovoltaics occurred in Austria after the introduction of the Green Electricity Act in 2002. With the introduction of the photovoltaic subsidies of the Climate and Energy Fund and significant changes in the Green Electricity Act, a first significant market emerged from 2009 onwards (Fechner & Lugmaier, 2007).

With the exception of a record value in 2013, which has ceased as a result of a one-time supplementary subsidy, the photovoltaic market in Austria has fluctuated between 150 and 160 MWpeak between 2012 and 2015, despite continuously reduced subsidies. In 2015 the total output of the newly installed photovoltaic installations in Austria were about 152.000 kWpeak which is a decrease from 2014 from roughly 8.000kWpeak (see Table 3). (Biermayr, et al., 2016).

Table 3 - Annual PV Power Austria - (Biermayr, et al., 2016)

Year	Annual PV power installed in kWpeak		
	Grid-connected	**Self-sufficient**	**Sum**
1992	187	338	525
1993	159	85	244
1994	107	167	274
1995	133	165	298
1996	245	133	378
1997	365	104	469
1998	452	201	653
1999	541	200	741
2000	1.030	256	1.286
2001	1.044	186	1.230
2002	4.094	127	4.221
2003	6.303	169	6.472
2004	3.755	514	4.269
2005	2.711	250	2.961
2006	1.290	274	1.564
2007	2.061	55	2.116
2008	4.553	133	4.686
2009	19.961	248	20.209
2010	42.695	207	42.902
2011	90.984	690	91.674
2012	175.493	220	175.712
2013	262.621	468	263.089
2014	158.974	299	159.273
2015	151.806	46	151.851

There is a federal tariff promotion for installations on buildings with a size of 5 kWp to 200 kWp. The tariff promotion is regulated by the Green Electricity Act, which applies throughout Austria. The Green Electricity Act has existed since 2002 and has already been amended several times. The green electricity tariff promotion applies to plants which are larger than 5 kWp. For the electricity fed into the electricity network, a transport tariff is resisted. The amount of the feed-in tariffs is regulated annually by a regulation (Ökostromverordnung). After the conclusion of the contract, the tariffs applies for 13 years. With the green electricity feed-in tariff regulation 2012, it is new that there is a one time investment subsidy in addition to the subsidy tariff. Each year, a subsidy budget of 8 million euros is available for photovoltaics. However, only for powerplants greater than 5 kWp and less than 200 kWp, module peak power. The PV feed-in tariff for applicants in 2017 is 7,91 cents / kWh. The one time investment grant is 40% of the construction costs, but a maximum of 375 euros / kWp (OeMAG Abwicklungsstelle für Ökostrom AG, 2017).

There is also a nationwide investment promotion for small plants (up to 5 kWp). Photovoltaic systems (private and commercial) are subsidized. The investment grant is available for the first 5 kWp of a system. The funding budget is € 8 million for the year 2017 (OeMAG Abwicklungsstelle für Ökostrom AG, 2017).

Moreover, most of the provinces of Austria provide their own support and promotion programs for small photovoltaic plants.

Photovoltaic is a technology whose manufacture requires high-tech processes. Austria is currently active in the value-added chain in all areas except the production of solar silicon as well as ingots and wafers made from raw silicon. In addition to the supply of single elements such as encapsulation films, wiring and inverter production, the production of modules (in the form of standard modules or as a roof tile) has been part of the Austrian value chain. The first two production plants for solar cells in Austria were launched in 2007. Individual companies are also excellently positioned on the world market (Fechner & Lugmaier, 2007).

The 2014 figure of 11.2 jobs per installed MWpeak has fallen to 8.36 jobs in 2015, due to increasing experience and specialization. On the basis of this figure and the installed capacity of 151.85 MWpeak in 2015, 1.270 jobs were created, which means a further decline of almost 29% compared to the previous year. Photovoltaic planners and installers are responsible for more than 43% of the total photovoltaic workplaces. The second largest share which amounts to 30.9% or in total 906 jobs are provided by of the Austrian manufacturers of inverters and photovoltaic add-on components. However, the number of employees in this area is much higher in practice because many producers do not produce their products exclusively for the photovoltaic sector and therefore have not been able to provide reliable figures. Finally, the 578 jobs in research and development (19.7%) follow. Despite a marked increase in the production volume, the number of jobs of the Austrian module producers in the year 2015 fell by 14.7% to 183 jobs. The total sum in 2015 can thus be estimated to 2.936 jobs. This corresponds to a decrease of 8.6% compared to 2014. This decline is primarily due to the lower installed photovotaic output in 2015 compared with the previous year, as well as the more efficient operation of photovoltaic planners and installers in the implementation process (Biermayr, et al., 2016).

3.1.2. Wind

The rapid technological development of modern wind power plants has mean that their generation costs are now below those of new fossil power plants. Wind energy on land is now the most cost-effective source of energy. Wind power is clean and safe and does not entail any social costs. In contrast to electricity generation with fossil and atomic energies, which cause immense costs due to environmental and health damage, nuclear reactor accidents, nuclear waste disposal and last but not least their negative effects on climate change (IG Windkraft Österreich, 2016).

For a long time it was assumed that the Austrian wind potential was insufficient for use by wind power plants. Only first measurements of wind turbine users at the end of the 1980s showed the good wind conditions. Many sites in Eastern Austria, especially in the province of Burgenland, can compete even with areas 15 km behind Danish and German coasts (Näher, 2010).

In 1991 the discussion about the introduction of tariffs for renewable energies began. Three years it had to be negotiated before a first subsidy scheme came into force in 1994: the usual tariff for electricity produced ("compound tariff") of about 65 “Groschen” was doubled for the first three years of operation. In addition, the Ministry of the Environment sponsored the construction of wind turbines with a 30% investment cost subsidy, which was awarded in the framework of tenders by Österreichische Kommunalkredit AG an Austrian Bank specialized in infrastructure projects. The efforts to improve the general conditions for wind power led to the founding of the “interest group Windkraft Austria” in 1993. The “IG Windkraft” has been acting as the Austrian representative for wind power operators and companies since then. As a result of the new regulation, 1994 saw the construction of Austria's first major wind turbine with a capacity of 150 kWpeak. In 1995 further windmills followed, among them Michelbach the first "Bürgerwindrad", which was financed jointly by more than a hundred people. At the end of 1996, the first funding model ran out. Apart from isolated initiatives by some of the federal states, no new subsidy tariffs were imposed until autumn 1999 (Näher, 2010).

The Green Electricity Act, which came into force at the beginning of 2003, was adopted in 2002. For the first time, green electricity was regulated nationwide, until then subsidized regulations for eco-friendly energies where only found in the electricity laws of the Austrian states. The Green Electricity Act standardized an unlimited acceptance obligation for electricity from renewable sources of energy for a duration of 13 years. The Green Electricity Act initiated a decisive expansion phase of wind power in Austria. At the end of 2002, 140 MW were connected to the grid. Between 2003 and 2006, an average of 200 MW was built annually. The amendment to the Green Electricity Act 2006 almost halted the expansion of wind power. In combination with the extremely low feed-in tariffs for wind energy demanded in 2006, 2007, 2008 and 2009 led to economic and legal uncertainty. The result was an almost four years standstill of wind power expansion. In 2008, two amendments were made to the Green Electricity Act. The second, the "big" green electricity act of July 2008, brought significant improvements for green electricity producers, but could only be put into effect after a lengthy aid notification procedure at the Commission of the European Union in October 2009. As a result of this amendment and the feed-in tariff set in February 2010 in the amount of 9,7 cent per kilowatt hour, the wind power expansion started again in 2010 (IG Windkraft, n.d.).

An expansion of 12.490 MW of new installed wind power, the total expansion within the European Union decreased by 3% compared to the previous year. Germany is once again responsible that the last year in Europe was not a complete slump in wind power expansion. With a newly installed capacity of 5.443 MW of wind power, 44% of the European wind power capacity was built in Germany. With 1.561 MW, France increased its expansion from last year by 45% and thus took second place. In no other country in Europe more than 1.000 MW have been built. The transition from feed-in tariff systems to transport systems with tenders did not work out as it was hoped. There are still electricity markets that do not work and are not fit for renewable energies. The European figures unfortunately confirm analyses that tender systems are not suitable for the ambitious expansion of wind power (Fliegenschnee-Jaksch, 2017).

For many years, Austria was one of the top ten countries in Europe to participate in wind energy anchoring. In 2016 for the first time, Austria has not been among the top ten regarding new wind power installations for a long time. If Austria were still in sixth place in 2014, it is now only 12th place within Europe. It is up to the Austrian politics to finally end this downward trend. The small eco-novelty is at the table and could eliminate the reform jam with a few changes. The reduction of the queue of the approved wind power projects would be the turnaround and could significantly increase the green electricity production in Austria (Fliegenschnee-Jaksch, 2017).

Nevertheless, wind energy has grown rapidly over the last decades. Starting from 0,3 megawatts of installed capacity in 1994, the wind power output in Austria grew to almost 2.409 MW by 2015. The slumps or stagnation in the expansion between mid-2006 and 2009 were the result of an amendment of the Green Electricity Act 2006 and the extremely low green electricity feed-in tariffs as mentioned above. This standstill could only be ended by the Green Electricity Act 2012, which was passed by the National Council in July 2011. It was only because of the resulting stable conditions that modern facilities could be planned and built again. In this respect, a record increase of around 411 MW was achieved in 2014, which in 2015 could no longer be achieved. In 2015, 108 wind turbines with a total output of 322,8 MW were installed. Due to the radical deterioration in market conditions on the electricity market (low market price, lack of CO2 pricing, market failure in the regulatory energy market) (Biermayr, et al., 2016).

At the end of 2016 1.191 wind turbines with a total output of 2.632 megawatts (See Table 4) generated clean and environmentally friendly electricity for more than 1.6 million households. With this wind power production, 3.7 million tonnes of CO2 can be avoided annually. A single of these modern 3 MW wind power plants save as much CO2 as 2.000 cars produce in total. In contradiction to the forecasts (see above) in 2017 the expansion phase of wind power will be braked, with some 60 wind turbines with more than 180 megawatts of power being added. Austrian wind farm initiators will invest around 300 million euros in just one year and provide a sustainable impetus for a clean energy future (IG Windkraft, n.d.).

Table 4 - Wind Capacity Austria - (IG Windkraft, n.d.):

Province	Installed Capacity	Number of Plants
Vienna	7,4 MW	9
Lower Austria	1.411,5 MW	654
Upper Austria	47, 3 MW	30
Carinthia	0,5 MW	1
Styria	168 MW	81
Burgenland	997,2 MW	416
TOTAL in AUT	2.632 MW	1.191

As Table 4 indicates Lower Austria and Burgendland are the two most important provinces of Austria when speaking about the production of wind energy.

Burgenland is, in terms of wind power development, Austria's flagship country. From an international point of view, it is also a showcase region, since in 2013 only the wind turbines installed there produce more electricity than the entire state consumes. By the end of the year 2014 it will be more than 130% of the electricity consumption. Burgenland has already dealt with wind energy at an early stage. Around 2000 the Burgenland had produced almost no kilowatt hours of electricity (3%). Only the first wind farm, which was built in Zurndorf in 1997, produced clean wind energy. In 2006 it was decided in the state parliament that the federal state should be self-sufficient in regards to electricity in 2013. During this time a zoning concept was also developed. All stakeholders were involved in the process. The result was impressive. In just seven years, the Burgenland has managed to generate more wind power than to consume, and the expansion of photovoltaics has just begun. By the end of 2014, around 960 MW of wind power will were installed in Burgenland. The wind turbines produce 2.1 million kWh, equivalent to the consumption of 16% of Austrian households. The wind power expansion in the Burgenland since then continued with smaller steps. Around 300 MW could still be achieved by 2020 (IG Windkraft Österreich, 2014).

Since the middle of 2014, wind energy expansion in Lower Austria has been regulated by a zoning plan for wind energy. Only 1.5% of the Lower Austrian land area has been made available to wind power. Due to the restrictive zoning, the accessibility of the self-imposed goals of the state is very questionable. By the end of 2014 about 1,026

MW of wind power were installed in Lower Austria. In the 2030 energy plan, 1,900 MW of wind power in Lower Austria were set for the year 2020. With a stable green electricity law and good conditions in Lower Austria, this goal can be achieved. However, if only one of the two parameters changes, the country of Lower Austria will miss the self-imposed targets. It should not be forgotten that according to the energy timetable, wind power is expected to deliver half of the CO_2-saving measures by 2020. This goal would also be missed. Since Lower Austria has the largest wind potential in Austria, the state also has a strong role model. Changes in this federal state have an extremely strong impact on the overall development of wind power in Austria (IG Windkraft Österreich, 2014).

In addition to the production of renewable energy, the use of wind power plants results in considerable micro- and macroeconomic effects along the supply chain through services, infrastructure and the production of components for wind power plants. The value chain, that is, the sequence of individual production and service steps, can go from inputs for the erection of wind power plants, but also from subcomponent manufacture to the dismantling and recycling of wind power plants. The erection of a wind turbine with a capacity of 3 MW in Austria brings the local companies an order volume of € 1.4 million. During the 20-year service life approx. € 3.3 million will be needed for maintenance and operation. Overall, the Austrian wind power economy benefits about € 4.7 million per wind turbine. This is about 50% of the total project costs over 20 years. In the Austrian wind industry, around 5,500 people were employed at the end of 2015. Of these, 383 are for wind turbine operators and around 3,135 for construction, dismantling and maintenance (Biermayr, et al., 2016).

By 2030, 20% of the energy consumed in the EU is to be provided with renewable energies. Former Federal Chancellor Werner Faymann has already set the direction up to the year 2030 that the goal is 100 percent renewable electricity generation by 2030. The wind power will play an important role in this. However, in order to achieve this goal, a new green electricity law and a stable, predictable framework for the expansion of renewable energies are urgently needed. At the moment, many of the wind power projects already approved are awaiting implementation by the year 2021 (IG Windkraft, n.d.).

3.2. Market Analysis China

3.2.1. Photovoltaic

The Peoples Republic of China is now the world's second largest energy consumer after the US. Regarding Photovoltaics China is already the leading country both with installed capacity and newly installed capacity per year. China is followed by Japan and the United States.

What is happening in China, especially in the field of photovoltaics, is a typical development for a country, which has already seen similar transitions in other branches of industry. China is slowly transforming itself into an industrialized country, away from a low-wage country, which generates its economic output primarily as a cheap production location for foreign companies. The result is a middle class with a certain purchasing power, as well as a business landscape which in a way is getting more similar to western standards. Demand for solar modules is emerging in these areas. In other emerging markets like India, this also offers opportunities for foreign suppliers. Although India itself has considerable overcapacity in the field of photovoltaics, it is a classic low-cost provider. Where high-quality components and key concepts are required, both are imported despite the domestic overcapacity. China uses its economic management tools to prevent a comparable development. In September, the supposedly private solar producers, working purely on the domestic market, were hindered by state regulations to continue to focus exclusively on quantity, i.e. on an expansion of production capacities. At least three percent of their sales will have to be invested in R & D in order to improve their existing capacities qualitatively (Photovoltaik.org, 2013).

China's current five-year plan provides for enormous investment in renewable energy. The intention of China to reduce its own greenhouse gas emissions is particularly evident in the ambitious photovoltaic construction projects. In the coming years, China plans to install between 15 and 20 gigawatts of photovoltaic, so that in 2020 a cumulative output of more than 100 gigawatts will be achieved. This would correspond approximately to a tripling of the installed solar power to date. In order to achieve this ambitious goal, China is also planning to invest around 330 billion euros in high-voltage networks, distribution networks and smart grid technologies. These should allow a smooth transition to renewable energies (Pothecary, 2016).

In the first half of 2016, China had reported a rapid expansion of solar energy. In 2016, China originally intended to achieve only a total of 18.100 MW newly installed capacity. Due to the extremely high addition in installed capacity in the first half of the year of 2016, the government adjusted the tariffs for solar power in the middle of the year, which also reduced demand. For 2017, the solar analysts of Mercom Capital from the USA expect a significantly smaller Chinese market volume of 17.500 MW. According to the latest official figures, China has almost doubled its photovoltaic power plant installed capacity by 2016. With an annual photovoltaic construction of approximately 34.000 MW, China ranks 1st in the world's solar market. 2015 photovoltaic plants with an output of 15.130 MW and 2016 with an output of 34.240 megawatts were newly built. The total photovoltaic output in China will increase to a total of 77.420 MW by the end of 2016. China plans to achieve an installed photovoltaic output of 105.000 MW by the year 2020 (IWR, 2017). 21% of the global total installed capacity is installed in China (Fraunhofer Institute for Solar Energy Systems, 2016).

The prices for installed capacity in China decreased sharply within the last years. In Figure 3 the development from 2001 to 2014 can be seen. In 2014 the investment costs where only one sixth of the costs in 2001. Until 2017 the costs still continued to fall however the rate slowed down (Zhang, et al., 2016).

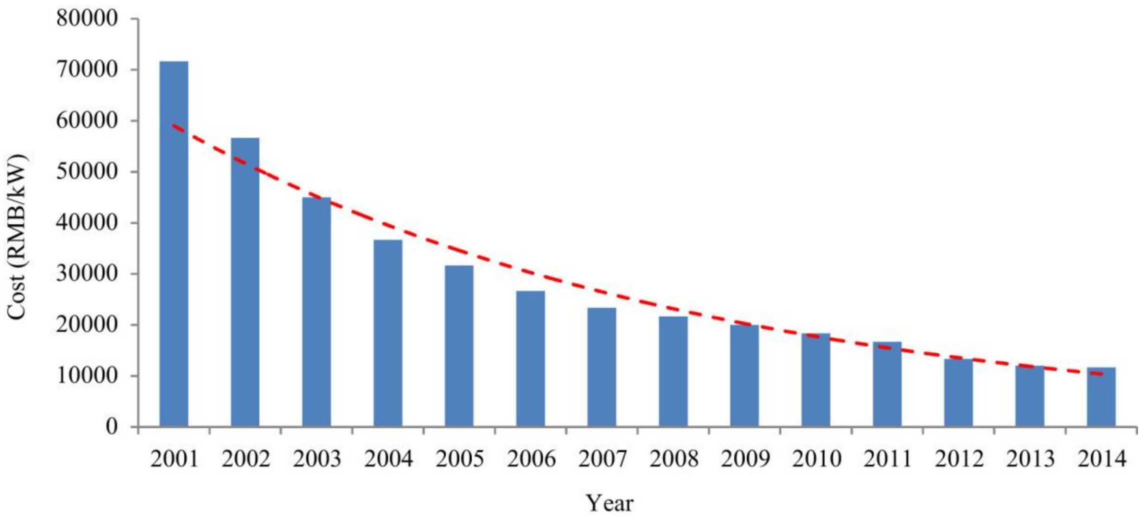

Figure 3 - China Costs PV - (Zhang, et al., 2016)

Despite the fact that the country is the global market leader, the industry is still heavily fragmented. Strong support, especially at the regional level, has generated numerous solar cell and module manufacturers in provinces such as Jiangsu or Zhejiang. Some had already left the market, many were in red numbers. The quality of the produced solar cells is often inferior to the suffering of the government, the price war is ruinous. The European Union has introduced anti-dumping duties on Chinese solar cells since

December 2013 and extended an additional 18 months early 2017. The counter-charges of 26 companies (in China and Europe) were rejected by the European Court of Justice on 27.2.17. As a result, penalties of almost 48% remain in force for the prices of Chinese solar cells (Abele, 2017).

Nevertheless, Chinese dominance in the global photovoltaic segment has become very strong. This can be clearly shown by a list of the top 10 worldwide production companies for wafers, polysilicon, solar cells and solar modules. There are only seven non-Chinese companies (including a Taiwanese company) among them. This will not change in 2017. China sees the sector of renewable energies as a strategically important growth area with considerable export potential and drives the quality level of the domestic photovoltaic value chain upwards. In the future, the industry will be able to set international standards on its own (Abele, 2017).

In 2013 the National Development Reform Commission started to support photovoltaic installations with feed-in tariffs, the feed-in tariff is valid for the first 20 years of operation. The tariff is weighted differently according to three resource regions which have different solar radiation values. Over time the feed-in tariffs have substantially lowered. In 2017 the feed-in tariff was lowered to RMB 0,65, 0,75 and 0,85 per kwh, respectively. In Resource area I the following regions can be found: Ningxia, Haixi, Jiayuguan, Wuwei, Zhangye, Jiuquan, Dunhuang, Jinchang, Hami, Tacheng. In Resource area II the following regions can be found: Beijing, Tianjin, Heilongjiang, Jilin, Liaoning, Sichuan, Yunnan, Shanxi. Resource area III includes all other areas except above mentioned areas (International Energy Agency, 2017).

3.2.2. Wind

China began in 2005 with the construction of wind parks. The capacity was 1.3 GW. This was followed by an enormous expansion of the wind parks, which were installed along the long coast. This has meant that China is now also the world market leader in wind energy. At the end of 2010, the capacity of wind parks was already about 45 GW. Within two and a half years, China has almost doubled its capacity. In June 2013 the capacity was almost 81 GW.

In 2009 the National Development and Reform Commission (NDRC) of China introduced a feed-in tariff to support the deployment of onshore and offshore wind farms. Since 2009 the tariff was amended several times. In the beginning of 2017 it was change the last time. The tariff is split into 4 categories. Starting from 1 Jan 2017, the feed-in tariff levels for onshore wind are reduced to RMB 0.4, 0.45,0.49 and 0.57 per kwh for zones 1 to 4. The Feed-in tariff for offshore wind and intertidal zone are set to RMB 0.85 and RMB 0.75 per kwh respectively (International Energy Agency, 2017). The following provinces are listed in category 1: Inner Mongolia (West) (except Chifeng, Tongliao, Xinganmeng, Hulunbeier), Xinjiang Urumqi, Yilihasake, Changji Huizu, Kelamayi, Shihezi. In category 2 the following provinces are listed: Zhangjiakou and Chengde of Hebei province; Chifeng, Tongliao, Xinganmeng, Hulunbeier of Inner Mongolia (East); Zhangye, Jiayuguan and Jiuquan of Gansu. In category 3 the following provinces are listed: Baicheng, Songyuan of Jilin province; Jixi, Shuangyashan, Qitaihe, Suihua, Qichun, Daxinganling of Heilongjiang; Gansu province (except Zhangye, Jiayuguan and Jiuquan); Xinjiang Uyghur Autonomous Region (except Urumqi, Yilihasake, Changji Huizu, Kelamayi, Shihezi) and Ningxia. In category 4 all remaining provinces can be found (Yeung, et al., 2016).

Through the reduction of the feed-in tariff, there has been a record increase in wind power plants in China over the last two years in order to be able to take advantage of the better feed-in tariffs. More than 30.000 MW of wind power were added in 2015. Overall, China had an installed capacity of over 145.000 MW at the end of 2015 (GWEC, 2016).

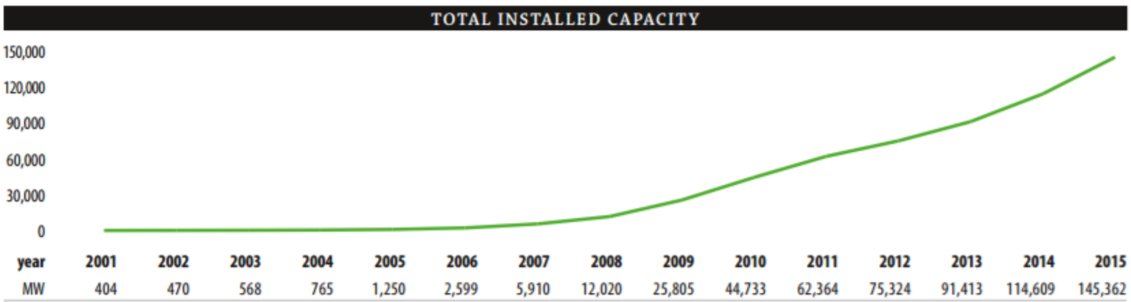

Figure 4 - China Wind Capacity - (GWEC, 2016)

In China, some provinces are developing into true wind kings. In 2015, 4 provinces had more than 10.000MW of installed power, see Table 5 (GWEC, 2016).

Table 5 - China Province Wind Capacity - (GWEC, 2016)

Province	Total Installed Capacity (2015)
Inner Mongolia	25,667.51 MW
Xin Jiang	16,250.76 MW
Gansu	12,628.85 MW
Hebei	11,030.30 MW
Shandong	9,559.90 MW
Ninxia	8,374.50 MW
Shanxi	7,549.75 MW
Yunnan	6,014.75 MW
Jiangsu	4,888.15 MW
Guizhou	3,259.90 MW
Others	65,805.03 MW
Total	145,361.89 MW

As can be seen in Figure 5, China has by far the largest share of installed capacity worldwide at 35%. Behind China there is the USA with 17% of the world's installed wind energy. Germany still produces 10% of global wind energy.

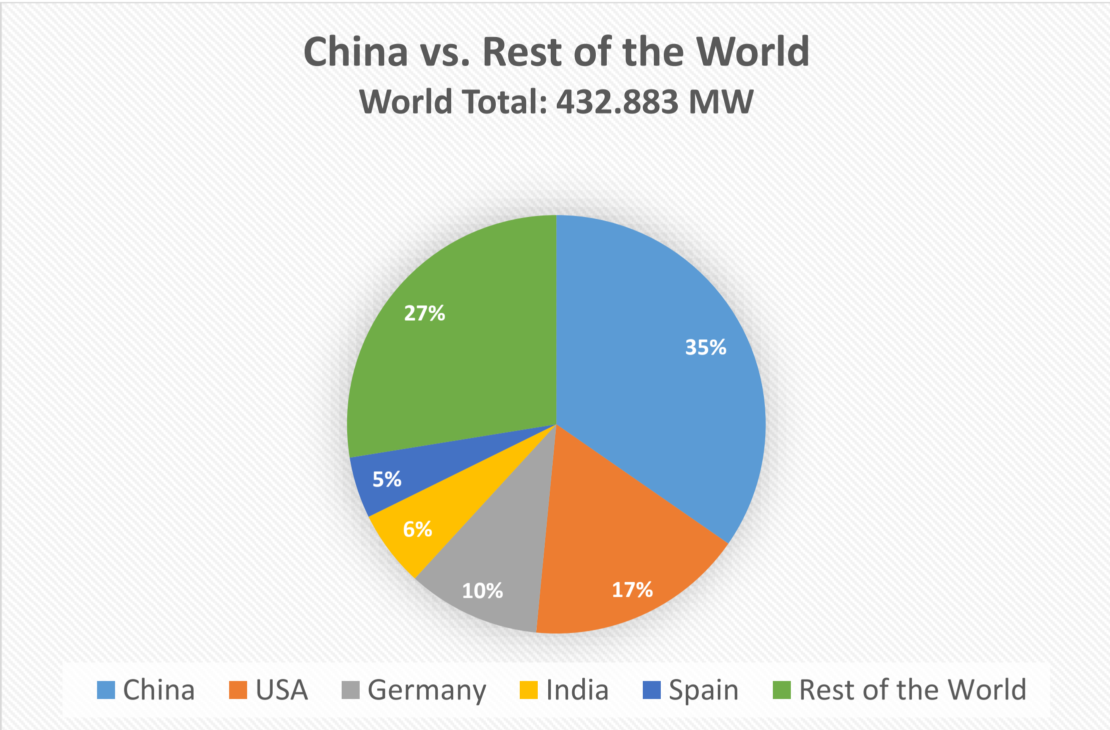

Figure 5- China vs World - (GWEC, 2016)

Government measures have a very high influence on the competitors in the Chinese market. China can take direct action to control development on the domestic wind energy market. It was found that the "state measures" have several positive as well as negative characteristics for foreign companies. On the one hand, tariff and non-tariff barriers can make it difficult for foreign companies to enter the market, so that the domestic industry is protected. On the other hand, high feed-in tariffs and favourable credit allocations can increase the attractiveness of the market. Another factor that benefits the wind industry is population development and economic growth. As China's population continues to grow and become economically an industrialized country, energy supplies are steadily growing. Moreover, China has great problems with its environment. China is the world's largest carbon emitter, with the result that the People's Republic has been exposed to major environmental disasters in the past and will continue to exist in the future. Natural catastrophes also have an impact on the economy as well as the grid infrastructure, and also require new technical requirements for renewable energy sources to build these catastrophe proof (Reinick, et al., 2011).

In addition to the enormous opportunities on the home market of China, the country also has an extreme influence on the global wind market. In 2015, China exported over 2000 MW on-shore wind turbines and other 1000 MW off-shore wind turbines. The top 3 export countries for China were the USA and Pakistan followed by France (GWEC, 2016).

4. Part III: Case Study

In the following chapter four case studies are presented and compared. The case studies are comparing the business conditions for wind and photovoltaic projects in Austria and China. In the case of Austria the two cases are projects which have been built already respectively will be built in the future. The dimensions in China regarding renewable energy projects are in general on a much larger scale. However, to compare the business conditions in the two countries it was assumed that the projects in Austria and China will have the same capacity. For the Austrian wind energy case the state of Burgenland was chosen, which is one of the strongest and most promising wind energy states of Austria (see chapter 3.1.2). For the Austrian photovoltaic case the largest Austrian photovoltaic plant was chosen this is due to the fact that in China smaller projects are very unlikely to be realized. For the Chinese cases the province of Shandong was chosen for both, the wind and the photovoltaic case. The amortization time of the different cases will be compared and interpreted.

Please note:

- *an exchange rate of 1 Chinese yuan = 0.129298932 Euros was chosen for all calculations for the Chinese market*
- *the operating costs are on a nominal basis, there is no increase factor calculated*

4.1. Wind Austria

The first case which is presented is a wind power plant in Austria which was already approved to be built. The Windpark Bruckneudorf / Seibersdorf will have when build a total capacity of 39 MW. The wind turbine used for the project is an Enercon E-115 – 3,0 MW. As the total capacity is stated with 39 MW, in total 13 Enercon E-115 will be needed for the project. The total investment sum according to the project data sheet is 74.000.000€. Moreover, it is stated that a loan from the European Investment bank was granted which amounts to 40.000.000€. As there is no more data about the project available there must be some assumptions made. For the purpose of the case study all other costs will be assumed according to the literature available.

According to Hau (Hau, 2008) Project costs are about 1% - 2% of the total investment costs. Infrastructure amounts to about 13-14% of the total investment and the wind turbine is about 85% of the total costs of the project.

Considering that the initial investment is 74.000.000€ the costs are distributed in the following way:

Table 6 - Austria Wind Costs

Planning Costs	1,5%	€ 1.110.000,00
Infrastructure	13,5%	€ 9.990.000,00
Wind Turbine	85,0%	€ 62.900.000,00
Total costs of Project	100%	€ 74.000.000,00

The yearly costs will be calculated from the initial price of the wind turbines, which is 62.900.000€. We must take several factors into account when calculating yearly costs. In the following subchapters, these cost factors are explained in more detail.

Maintenance

Regarding the costs of maintenance and repair, there is sufficient experience of thousands of commercially operated wind power plants available. The costs of maintenance are between 0,7% and 0,9% per year in relation to the ex-works price (Hau, 2008).

Table 7- Austria Wind Maintenance Costs

	Median value	Costs	Literature
Maintenance	0,80%	€ 503.200,00	0,7% - 0,9%

Maintenance repairs

Since maintenance repairs cannot be completely avoided, annual repair costs for a wind turbine are also incurred. For repair costs, wind turbine operators expect an annual cost of approx. 0,5% - 1,0% of the ex-works price of the wind turbine (Hau, 2008).

Table 8 - Austria Wind Maintenance Repair Costs

	Median value	Costs	Literature
Maintenance repairs	0,75%	€ 471.750,00	0,5% - 1%

Insurance

As a rule, a wind turbine operator will endeavour to cover the financial risks associated with the operation of the installation as far as possible through insurance. Private operators have the financial endeavour to secure the repair risk in particular. There is a differentiation between liability insurance, machinery insurance and business interruption insurance which accounts together to about 0,5% to 0,6% of the ex-works price of the wind turbine (Hau, 2008).

Table 9 - Austria Wind Insurance Costs

	Median value	Costs	Literature
Insurance	0,55%	€ 345.950,00	0,5% - 0,6%

Land for each Turbine

In Austria, it is common to lease the land on which the wind farms are built. Prices for a plant range from 0,8% to 1% of the ex-works price of the wind turbine (Hau, 2008).

Table 10 - Austria Wind Land Lease Costs

	Median value	Costs	Literature
Cost of land	0,90%	€ 566.100,00	0,8% - 1%

Administration and control

The operation of a wind farm with an investment value of several million is not possible without a certain administrative burden. The preparation of profit and loss accounts, balance sheets, the determination of profit distributions, external services, etc., create costs. Commercially organized wind farms calculate about 1% of the investment sum per year for administration and control (Hau, 2008).

Table 11 - Austria Wind Administration and Control Costs

	Median value	Costs	Literature
Administration and control	1%	€ 629.000,00	1%

Other costs

In addition to the costs mentioned, there are still some smaller costs which need to be also calculated. The wind power system and the auxiliary devices have a certain current requirement which is obtained from the mains. In addition, the peripheral devices of the wind park also require a certain maintenance and repair effort.

Table 12- Austria Wind Other Costs

	Median value	Costs	Literature
Other costs	0,90%	€ 566.100,00	0,8% - 1%

Loan

As mentioned above the initiators of the project will take out a loan worth 40.000.000€ which needs to be paid back. For the purpose of the case study a running time of 13 years is assumed. Moreover, the interest rate is set to 2%. It must be mentioned that normally debt financing according to the literature accounts to 70% to 80% of the total investment sum. In the case of the "Windpark Bruckneudof" the debt capital is only at 54%. The annuity account gives an annual repayment of 3.524.734,11€, see Table 13.

Table 13 - Austria Wind Annuity Table

Period	**Start**	**Interest Rate**	**Repayment**	**Total Repayment**	**End**
1	40.000.000,00 €	800.000,00 €	2.724.734,11 €	-3.524.734,11€	37.275.265,89 €
2	37.275.265,89 €	745.505,32 €	2.779.228,79 €	-3.524.734,11€	34.496.037,10 €
3	34.496.037,10 €	689.920,74 €	2.834.813,36 €	-3.524.734,11€	31.661.223,74 €
4	31.661.223,74 €	633.224,47 €	2.891.509,63 €	-3.524.734,11€	28.769.714,11 €
5	28.769.714,11 €	575.394,28 €	2.949.339,82 €	-3.524.734,11€	25.820.374,28 €
6	25.820.374,28 €	516.407,49 €	3.008.326,62 €	-3.524.734,11€	22.812.047,66 €
7	22.812.047,66 €	456.240,95 €	3.068.493,15 €	-3.524.734,11€	19.743.554,51 €
8	19.743.554,51 €	394.871,09 €	3.129.863,02 €	-3.524.734,11€	16.613.691,49 €
9	16.613.691,49 €	332.273,83 €	3.192.460,28 €	-3.524.734,11€	13.421.231,21 €
10	13.421.231,21 €	268.424,62 €	3.256.309,48 €	-3.524.734,11€	10.164.921,73€
11	10.164.921,73 €	203.298,43 €	3.321.435,67 €	-3.524.734,11€	6.843.486,06 €
12	6.843.486,06 €	136.869,72 €	3.387.864,39 €	-3.524.734,11€	3.455.621,67 €
13	3.455.621,67 €	69.112,43 €	3.455.621,67 €	-3.524.734,11€	0,00 €

Revenues

The revenues depend on the amount of electricity generated (in kWh), which is based on the rated output of the plants and the annual full load hours and their remuneration. In Austria, a feed-in tariff is guaranteed for the duration of 13 years and in the amount of 8,95 Cent/kWh per kWh (2017). After these 13 years, the operator will only receive the current market price per kWh from the network operator (Republik Österreich, 2016).

The market price from the 14th year onwards will be calculated from the current price of energy (3,008 Cent/kWh) and an inflation rate of 2% / year (E-Control, 2017).

Table 14 - Austria Energy Marekt Price

Year	Market price
14	€ 0,0407
15	€ 0,0416
16	€ 0,0424
17	€ 0,0432
18	€ 0,0441
19	€ 0,0450
20	€ 0,0459
21	€ 0,0468
22	€ 0,0477
23	€ 0,0487
24	€ 0,0497
25	€ 0,0507
26	€ 0,0517
27	€ 0,0527
28	€ 0,0538
29	€ 0,0548

To determine the revenues of the wind park the generated power in kWh needs to be calculated:

generated power in kWh = nominal capacity * full-load hours * 1000

The yearly average windspeed in Bruckneudorf is 5,5 m/s to 6,5 m/s 50 meters above ground (Energiewerkstatt, 2017). The Encron E-115 produces an average of 2600 full-load hours at a wind speed of 6,0 m/s – 6,2 m/s (Prowindkraft-Niedernhausen, n.d.).

Income Tax

The income tax in Austria is 25% and there are no tax incentives for wind plants in Austria.

Amortization Time

Considering all costs and revenues as well as taxes the amortization time of the wind plant can be calculated. In the years 1 to 13 the project will make the largest profits. The profits drop considerably in the 13th year of operation. This is due to the fact that the feed-in tariff drops to the market price of electricity. After 29 years the "Windpark Bruckneudorf" has amortized as can be seen in Figure 6.

Year	Feed-in Tariff	Full load hours	Revenue	Yearly Costs	EBT	25% Income Tax	EAT	Cashflow
								-44.000.000
1	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 42.148.650,58
2	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 40.297.301,16
3	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 38.445.951,74
4	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 36.594.602,32
5	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 34.743.252,90
6	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 32.891.903,48
7	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 31.040.554,06
8	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 29.189.204,64
9	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 27.337.855,22
10	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 25.486.505,80
11	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 23.635.156,38
12	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 21.783.806,96
13	€ 0,0895	2600	€ 9.075.300,00	€ 6.606.834,11	€ 2.468.465,89	0,75	€ 1.851.349,42	-€ 19.932.457,54
14	€ 0,0407	2600	€ 4.131.594,13	€ 3.082.100,00	€ 1.049.494,13	0,75	€ 787.120,59	-€ 19.145.336,95
15	€ 0,0416	2600	€ 4.214.226,01	€ 3.082.100,00	€ 1.132.126,01	0,75	€ 849.094,51	-€ 18.296.242,44
16	€ 0,0424	2600	€ 4.298.510,53	€ 3.082.100,00	€ 1.216.410,53	0,75	€ 912.307,90	-€ 17.383.934,54
17	€ 0,0432	2600	€ 4.384.480,74	€ 3.082.100,00	€ 1.302.380,74	0,75	€ 976.785,55	-€ 16.407.148,99
18	€ 0,0441	2600	€ 4.472.170,35	€ 3.082.100,00	€ 1.390.070,35	0,75	€ 1.042.552,77	-€ 15.364.596,22
19	€ 0,0450	2600	€ 4.561.613,76	€ 3.082.100,00	€ 1.479.513,76	0,75	€ 1.109.635,32	-€ 14.254.960,90
20	€ 0,0459	2600	€ 4.652.846,04	€ 3.082.100,00	€ 1.570.746,04	0,75	€ 1.178.059,53	-€ 13.076.901,38
21	€ 0,0468	2600	€ 4.745.902,96	€ 3.082.100,00	€ 1.663.802,96	0,75	€ 1.247.852,22	-€ 11.829.049,16
22	€ 0,0477	2600	€ 4.840.821,02	€ 3.082.100,00	€ 1.758.721,02	0,75	€ 1.319.040,76	-€ 10.510.008,39
23	€ 0,0487	2600	€ 4.937.637,44	€ 3.082.100,00	€ 1.855.537,44	0,75	€ 1.391.653,08	-€ 9.118.355,32
24	€ 0,0497	2600	€ 5.036.390,19	€ 3.082.100,00	€ 1.954.290,19	0,75	€ 1.465.717,64	-€ 7.652.637,68
25	€ 0,0507	2600	€ 5.137.117,99	€ 3.082.100,00	€ 2.055.017,99	0,75	€ 1.541.263,49	-€ 6.111.374,19
26	€ 0,0517	2600	€ 5.239.860,35	€ 3.082.100,00	€ 2.157.760,35	0,75	€ 1.618.320,26	-€ 4.493.053,92
27	€ 0,0527	2600	€ 5.344.657,56	€ 3.082.100,00	€ 2.262.557,56	0,75	€ 1.696.918,17	-€ 2.796.135,76
28	€ 0,0538	2600	€ 5.451.550,71	€ 3.082.100,00	€ 2.369.450,71	0,75	€ 1.777.088,03	-€ 1.019.047,73
29	€ 0,0548	2600	€ 5.560.581,72	€ 3.082.100,00	€ 2.478.481,72	0,75	€ 1.858.861,29	€ 839.813,56

Figure 6 - Austria Wind Cashflow

4.2. Wind China

In the case of China a hypothetical project was chosen. The project will be assumed to be built in the province of Shandong. The turbine used for the project will be assumed to be from “Goldwind” which is the market leader of wind turbines in China. To make the the Austrian and the Chinese case more comparable the turbine 3MW GW3S which is also a 3MW turbine will be calculated with (Goldwind, 2017). The capacity of the plant will be the same as in the Austrian case, which is 39MW. According to the literature average cost per kWp amount to 1897,44€ in China. This means that a 39MW wind plant will cost around 51.090.000€ (IRENA, 2015). What needs to be added to this sum is the cost of land which needs to be purchased. The initial costs have therefore a slightly different composition, the factor that is responsible for these changes is the fact that in China the land for wind power plants is normally not leased but bought. The costs for the land will amount to 2.518.475,00€ (Liu, et al., 2015).

Maintenance and repairs

The maintenance and repair costs for wind power plants in China is normally set to be 1,5% - 2%. However, according to the literature a percentage of about 4% should be calculated because of the bad quality of the used equipment (Liu, et al., 2015). These costs are much higher than in the case of the Austrian wind plant.

Table 15 - China Wind Maintenance and Repairs Costs

	Median value	Costs	Literature
Maintenance	4%	€ 1.737.060,00	4%

Insurance

The insurance of a wind power farm in China is about 0,25% of the initial investment (Liu, et al., 2015).

Table 16 - China Wind Insurance Costs

	Median value	Costs	Literature
Insurance	0,25%	€ 108.566,25	0,25%

Administration and control

For administration and control it is assumed that for every 10 MW of installed capacity the plant needs one additional employee. An average salary of a Chinese worker at a wind power plant is 8000 RMB which is about 10.366€. For a plant with 39 MW at total of 4 workers will be needed (Liu, et al., 2015).

Table 17- China Wind Administration and Control Costs

	Workers	Costs	Literature
Administration and control	4	€ 41.466,80	1 worker / 10MW

Other costs
In addition to the costs mentioned, there are still some smaller costs which need to be also included.

Table 18 - China Wind Other Costs

	Median value	Costs	Literature
Other costs	0,90%	€ 390.838,50	0,8% - 1%

Loan
A normal capital to debt ratio for wind projects in China is 20:80. The complete cost of the project are assumed to be € 53.608.475,00. Therefore the loan which has to be taken out is € 42.886.780,00. The payback time is 13 years which is the same as for the Austrian case to make the two cases more comparable. The interest rate is set to 6% and therefore significantly higher than in Austria (Liu, et al., 2015). The total annual repayment is € 4.844.495,19 (Table 19).

Table 19 - China Wind Annuity

Period	**Start**	**Interest Rate**	**Repayment**	**Total Repayment**	**End**
1	42.886.780,00 €	2.573.206,80 €	2.271.288,39 €	-4.844.495,19€	40.615.491,61 €
2	40.615.491,61 €	2.436.929,50 €	2.407.565,69 €	-4.844.495,19€	38.207.925,92 €
3	38.207.925,92 €	2.292.475,56 €	2.552.019,63 €	-4.844.495,19€	35.655.906,29 €
4	35.655.906,29 €	2.139.354,38 €	2.705.140,81 €	-4.844.495,19€	32.950.765,48 €
5	32.950.765,48 €	1.977.045,93 €	2.867.449,26 €	-4.844.495,19€	30.083.316,23 €
6	30.083.316,23 €	1.804.998,97 €	3.039.496,21 €	-4.844.495,19€	27.043.820,01 €
7	27.043.820,01 €	1.622.629,20 €	3.221.865,99 €	-4.844.495,19€	23.821.954,03 €
8	23.821.954,03 €	1.429.317,24 €	3.415.177,94 €	-4.844.495,19€	20.406.776,08 €
9	20.406.776,08 €	1.224.406,56 €	3.620.088,62 €	-4.844.495,19€	16.786.687,46 €
10	16.786.687,46 €	1.007.201,25 €	3.837.293,94 €	-4.844.495,19€	12.949.393,52 €
11	12.949.393,52 €	776.963,61 €	4.067.531,58 €	-4.844.495,19€	8.881.861,95 €
12	8.881.861,95 €	532.911,72 €	4.311.583,47 €	-4.844.495,19€	4.570.278,48 €
13	4.570.278,48 €	274.216,71 €	4.570.278,48 €	-4.844.495,19€	0,00 €

Revenues
The revenues depend on the amount of electricity generated (in kWh), which is based on the rated output of the plants and the annual full load hours and their remuneration. In China, a feed-in tariff is guaranteed for the duration of 20 years and in the amount of 7,56 Cent/kWh per kWh (2017) for regions in group IV like Shandong (International Energy Agency, 2017).

The average windspeeds in Shandong are between 6,5 m/s to 7 m/s therefore an average full load hour of 2300 is assumed (Shi, et al., 2015).

Tax
The income tax in China is 15% for companies. For wind projects, there is a full income tax exemption in the first three operation years. In the second 3 years of operation half of the income tax will be exempted (Liu, et al., 2015).

Moreover, there is a property tax to pay that amounts to 1,2% with 30% exemption on land and building assets this is about 10% of the total investment (Liu, et al., 2015).

Amortization time
In the first 13 years the wind park in Shandong creates losses. After the loan is paid back which will be after 13 years the profits will rise sharply and the project will be amortized already in year 18 which is more than 10 years faster than in the Austrian case. Given the fact that the project does not make any profits in the first 13 years, the loan payback time will be set to at least 15 years if a project like this would be implemented. In this case, the project will create profits of around 65.000€ from the first year, the amortization time would not change significantly, however a positive cashflow would be guaranteed for the whole time of operation.

									Cashflow
Year	Feed-in Tariff	Full load hours	Revenue	Yearly Costs	EBT	Property Tax	Income Tax	EAT	-€ 10.721.695,00
1	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 11.086.204,15
2	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 11.450.713,29
3	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 11.815.222,44
4	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 12.179.731,58
5	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 12.544.240,73
6	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 12.908.749,88
7	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 13.273.259,02
8	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 13.637.768,17
9	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 14.002.277,31
10	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 14.366.786,46
11	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 14.731.295,61
12	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 15.095.804,75
13	€ 0,0756	2300	€ 6.777.217,10	€ 7.122.426,74	-€ 345.209,64	€ 19.299,05	1	-€ 364.509,15	-€ 15.460.313,90
14	€ 0,0756	2300	€ 6.777.217,10	€ 2.277.931,55	€ 4.499.285,55	€ 19.299,05	0,85	€ 3.807.988,14	-€ 11.652.325,76
15	€ 0,0756	2300	€ 6.777.217,10	€ 2.277.931,55	€ 4.499.285,55	€ 19.299,05	0,85	€ 3.807.988,14	-€ 7.844.337,62
16	€ 0,0756	2300	€ 6.777.217,10	€ 2.277.931,55	€ 4.499.285,55	€ 19.299,05	0,85	€ 3.807.988,14	-€ 4.036.349,48
17	€ 0,0756	2300	€ 6.777.217,10	€ 2.277.931,55	€ 4.499.285,55	€ 19.299,05	0,85	€ 3.807.988,14	-€ 228.361,35
18	€ 0,0756	2300	€ 6.777.217,10	€ 2.277.931,55	€ 4.499.285,55	€ 19.299,05	0,85	€ 3.807.988,14	€ 3.579.626,79

Figure 7 - China Wind Cashflow

4.3.Photovoltaic Austria

For the Austrian photovoltaic case a project that was built in Flachau in the province of Salzburg was chosen. It is the biggest photovoltaic power plant of Austria. At 1.200 meters above sea level, the 3,5 hectare plant was built in an ideal south-facing slope. Two families invested around 3,4 million euros. The capacity of the power plant is 3,15 megawatts, about 1,000 households can be supplied which are nearly all households of Flachau (Salzburg 24, 2016).

Knowing the costs of over 3 million Euros it was assumed that the initial costs for 1 kWp are 1100€, which makes a total initial investment sum of 3.465.000€.

Operation and Maintenance

Even if photovoltaic plants primarily generate electricity, which can be fed into the public grid, the plants also cause operating costs. Photovoltaic systems are usually low-maintenance. Only the inverters contain a wearing part - the capacitors. Depending on utilization and dimensioning, their life expectancy is different. They may last 20 years. However, a one-time exchange within this period should be considered as a basis for calculation. It is important to note that the modules must also be cleaned. Operating costs can be set at approximately 1% of the initial costs (Konrad, 2007).

Table 20 - Austria PV Operation and Maintenance Costs

	Median value	Costs	Literature
Maintenance	1,00%	€ 69.300,00	1,00%

Insurance

A good insurance is just as important for operators of solar power systems as high-quality modules and reliable inverters. However, in order to decide what is needed and what is not, it has to be known which risks are to be secured at all. The costs for photovoltaic insurances are to be applied at around 0,3% - 0,8% of the purchase price (Finke, 2017).

Table 21 - Austria PV Insurance Costs

	Median value	Costs	Literature
Maintenance	0,55%	€ 19.057,50	0,30% - 0,80%

Land Costs
The prices for land lease range from 0,8% to 1% of the ex-works price (Hau, 2008).

Table 22 - Austria PV Land Lease Costs

	Median value	Costs	Literature
Maintenance	0,90%	€ 31.185,00	0,80% - 1,00%

Loan
For the case study a debt capital ratio of 80% to 20% is assumed. The interest rate is set to 2% with a payback time of 13 years.

Table 23 - Austria PV Annuity

Period	**Start**	**Interest Rate**	**Repayment**	**Total Repayment**	**End**
1	2.772.000,00 €	55.440,00 €	188.824,07 €	-244.264,07€	2.583.175,93 €
2	2.583.175,93 €	51.663,52 €	192.600,56 €	-244.264,07€	2.390.575,37 €
3	2.390.575,37 €	47.811,51 €	196.452,57 €	-244.264,07€	2.194.122,81 €
4	2.194.122,81 €	43.882,46 €	200.381,62 €	-244.264,07€	1.993.741,19 €
5	1.993.741,19 €	39.874,82 €	204.389,25 €	-244.264,07€	1.789.351,94 €
6	1.789.351,94 €	35.787,04 €	208.477,03 €	-244.264,07€	1.580.874,90 €
7	1.580.874,90 €	31.617,50 €	212.646,58 €	-244.264,07€	1.368.228,33 €
8	1.368.228,33 €	27.364,57 €	216.899,51 €	-244.264,07€	1.151.328,82 €
9	1.151.328,82 €	23.026,58 €	221.237,50 €	-244.264,07€	930.091,32 €
10	930.091,32 €	18.601,83 €	225.662,25 €	-244.264,07€	704.429,08 €
11	704.429,08 €	14.088,58 €	230.175,49 €	-244.264,07€	474.253,58 €
12	474.253,58 €	9.485,07 €	234.779,00 €	-244.264,07€	239.474,58 €
13	239.474,58 €	4.789,49 €	239.474,58 €	-244.264,07€	0,00 €

Revenues
The annual profit on electricity will be around 3,7 million kWh. This corresponds roughly to the electricity demand of 1000 households and thus quite exactly the need of Flachau (Salzburg 24, 2016). The feed-in tariff for Austria as well as the market price after the first 13 years of operations are the same as in chapter 4.1.

Degradation Factor
Typically, a decrease of the output of photovoltaic systems is assumed to be 0.5% per year. This would represent a drop of 5% of the power after 10 years.

Tax
There are no special tax incentives for photovoltaic system for this particular case in Austria. Therefore, the normal income tax of 25% applies.

Amortization Time

The photovoltaic project will create small profits in the first two years of operation followed by minor losses until the 13th year of operation. After the loan is paid back the profits will rise sharply due to the decrease of running-costs. After 28 years the solar power plant in Flachau will be amortized, see figure 8. The time of amortization is similar to the Austrian wind project.

									Cashflow
Year	Feed-in Tariff	Full load hours	degradation factor = 0,5%	Revenue	Yearly Costs	EBT	25% Income Tax	EAT	-€ 693.000,00
1	€ 0,0895	3700000	99,5000%	€ 331.150,00	€ 329.156,57	€ 1.993,43	0,75	€ 1.495,07	-€ 691.504,93
2	€ 0,0895	3681500	99,5000%	€ 329.494,25	€ 329.156,57	€ 337,68	0,75	€ 253,26	-€ 691.251,67
3	€ 0,0895	3663092,5	99,5000%	€ 327.846,78	€ 329.156,57	-€ 1.309,79	1	-€ 1.309,79	-€ 692.561,47
4	€ 0,0895	3644777,038	99,5000%	€ 326.207,54	€ 329.156,57	-€ 2.949,03	1	-€ 2.949,03	-€ 695.510,50
5	€ 0,0895	3626553,152	99,5000%	€ 324.576,51	€ 329.156,57	-€ 4.580,07	1	-€ 4.580,07	-€ 700.090,56
6	€ 0,0895	3608420,387	99,5000%	€ 322.953,62	€ 329.156,57	-€ 6.202,95	1	-€ 6.202,95	-€ 706.293,51
7	€ 0,0895	3590378,285	99,5000%	€ 321.338,86	€ 329.156,57	-€ 7.817,72	1	-€ 7.817,72	-€ 714.111,23
8	€ 0,0895	3572426,393	99,5000%	€ 319.732,16	€ 329.156,57	-€ 9.424,41	1	-€ 9.424,41	-€ 723.535,64
9	€ 0,0895	3554564,261	99,5000%	€ 318.133,50	€ 329.156,57	-€ 11.023,07	1	-€ 11.023,07	-€ 734.558,71
10	€ 0,0895	3536791,44	99,5000%	€ 316.542,83	€ 329.156,57	-€ 12.613,74	1	-€ 12.613,74	-€ 747.172,45
11	€ 0,0895	3519107,483	99,5000%	€ 314.960,12	€ 329.156,57	-€ 14.196,45	1	-€ 14.196,45	-€ 761.368,91
12	€ 0,0895	3501511,945	99,5000%	€ 313.385,32	€ 329.156,57	-€ 15.771,25	1	-€ 15.771,25	-€ 777.140,16
13	€ 0,0895	3484004,386	99,5000%	€ 311.818,39	€ 329.156,57	-€ 17.338,18	1	-€ 17.338,18	-€ 794.478,34
14	€ 0,0407	3466584,364	99,5000%	€ 141.247,73	€ 84.892,50	€ 56.355,23	0,75	€ 42.266,42	-€ 752.211,92
15	€ 0,0416	3449251,442	99,5000%	€ 143.352,32	€ 84.892,50	€ 58.459,82	0,75	€ 43.844,86	-€ 708.367,06
16	€ 0,0424	3432005,185	99,5000%	€ 145.488,27	€ 84.892,50	€ 60.595,77	0,75	€ 45.446,83	-€ 662.920,23
17	€ 0,0432	3414845,159	99,5000%	€ 147.656,04	€ 84.892,50	€ 62.763,54	0,75	€ 47.072,66	-€ 615.847,57
18	€ 0,0441	3397770,933	99,5000%	€ 149.856,12	€ 84.892,50	€ 64.963,62	0,75	€ 48.722,71	-€ 567.124,86
19	€ 0,0450	3380782,078	99,5000%	€ 152.088,97	€ 84.892,50	€ 67.196,47	0,75	€ 50.397,36	-€ 516.727,50
20	€ 0,0459	3363878,168	99,5000%	€ 154.355,10	€ 84.892,50	€ 69.462,60	0,75	€ 52.096,95	-€ 464.630,55
21	€ 0,0468	3347058,777	99,5000%	€ 156.654,99	€ 84.892,50	€ 71.762,49	0,75	€ 53.821,87	-€ 410.808,68
22	€ 0,0477	3330323,483	99,5000%	€ 158.989,15	€ 84.892,50	€ 74.096,65	0,75	€ 55.572,49	-€ 355.236,20
23	€ 0,0487	3313671,866	99,5000%	€ 161.358,09	€ 84.892,50	€ 76.465,59	0,75	€ 57.349,19	-€ 297.887,00
24	€ 0,0497	3297103,506	99,5000%	€ 163.762,32	€ 84.892,50	€ 78.869,82	0,75	€ 59.152,37	-€ 238.734,63
25	€ 0,0507	3280617,989	99,5000%	€ 166.202,38	€ 84.892,50	€ 81.309,88	0,75	€ 60.982,41	-€ 177.752,22
26	€ 0,0517	3264214,899	99,5000%	€ 168.678,80	€ 84.892,50	€ 83.786,30	0,75	€ 62.839,72	-€ 114.912,50
27	€ 0,0527	3247893,824	99,5000%	€ 171.192,11	€ 84.892,50	€ 86.299,61	0,75	€ 64.724,71	-€ 50.187,79
28	€ 0,0538	3231654,355	99,5000%	€ 173.742,88	€ 84.892,50	€ 88.850,38	0,75	€ 66.637,78	€ 16.449,99

Figure 8- Austria PV Cashflow

4.4. Photovoltaic China

In the Chinese photovoltaic case a hypothetical project in the Province of Shandong was assumed. The installed capacity will be like the Austrian case and therefore set to 3,15 megawatts. According to the literature, 1 Watt of installed capacity costs around 7 RMB which is 0.90701 Euros (Rigter & Vidican, 2010). Knowing the total amount of installed capacity, the initial cost for the Chinese plant are at 2.857.321,93€. One hectare of land costs 144.000 RMB which is about 18.660€ (Liu, et al., 2015). From the Austrian case, it is known that a power plant with a capacity of around 3,15MW occupies about 3,5 hectares of land. The total investment is therefore 2.922.631,93€.

Operation and Maintenance

According to the literature the operation and maintenance costs for a Chinese photovoltaic plant is around 0,1 RMB / Watt (0,0132 € / Watt) (Rigter & Vidican, 2010).

Table 24 - China PV Operation and Maintenance Costs

	Median value	Costs	Literature
Maintenance	0,0132€ / Watt	€ 41.753,67	0,0132€ / Watt

Insurance

The insurance costs can be set to 0,5% of the initial investment (Rigter & Vidican, 2010).

Table 25 - China PV Insurance Costs

	Median value	Costs	Literature
Insurance	0,50%	€ 14.286,61	0,5%

Loan

A normal capital to debt ratio for photovoltaic projects in China is 20:80. The complete costs of the project are assumed to be 2.922.631,93€. The loan which will be taken out is therefore 2.338.105,54€. The payback time will be the same as for the Austrian case to make the two cases more comparable. The interest rate is set to 6% and therefore significantly higher than in Austria (Liu, et al., 2015).

Table 26 - China PV Annuity

Period	Start	Interest Rate	Repayment	Total Repayment	End
1	2.338.105,54 €	140.286,33 €	123.826,32 €	-264.112,65€	2.214.279,23 €
2	2.214.279,23 €	132.856,75 €	131.255,89 €	-264.112,65€	2.083.023,33 €
3	2.083.023,33 €	124.981,40 €	139.131,25 €	-264.112,65€	1.943.892,08 €
4	1.943.892,08 €	116.633,52 €	147.479,12 €	-264.112,65€	1.796.412,96 €
5	1.796.412,96 €	107.784,78 €	156.327,87 €	-264.112,65€	1.640.085,09 €
6	1.640.085,09 €	98.405,11 €	165.707,54 €	-264.112,65€	1.474.377,55 €
7	1.474.377,55 €	88.462,65 €	175.650,00 €	-264.112,65€	1.298.727,55 €
8	1.298.727,55 €	77.923,65 €	186.189,00 €	-264.112,65€	1.112.538,55 €
9	1.112.538,55 €	66.752,31 €	197.360,33 €	-264.112,65€	915.178,22 €
10	915.178,22 €	54.910,69 €	209.201,96 €	-264.112,65€	705.976,26 €
11	705.976,26 €	42.358,58 €	221.754,07 €	-264.112,65€	484.222,19 €
12	484.222,19 €	29.053,33 €	235.059,32 €	-264.112,65€	249.162,88 €
13	249.162,88 €	14.949,77 €	249.162,88 €	-264.112,65€	0,00 €

Revenues

The revenues depend on the amount of electricity generated (in kWh), which is based on the rated output of the plant. For Shandong the calculator of the National Renewable Energy Laboratory estimated 3.509.652 kWh per Year. The NREL is financed by the US Department of Energy. It is considered the most important US laboratory for research and development in the fields of renewable energy and energy efficiency (National Renewable Energy Laboratory, 2017).

For the next 20 years, the guaranteed photovoltaic feed-in tariff of 2017 is 0,85 RMB (0,110€) (International Energy Agency, 2017).

Degradation Factor

The degradation factor is 0,5% / year and therefore the same as in Chapter 4.3.

Tax

The Tax regulations are the same as in Chapter 4.2.

Amortization Time

Due to the high feed-in tariff for photovoltaics and the tax reductions the photovoltaic project in Shandong has an amortization time of only 11 years.

										Cashflow
Year	Feed-in Tariff	Full load hours	degradation factor = 0,5%	Revenue	Yearly Costs	EBT	Property Tax	Income Tax	EAT	-€ 584.526,39
1	€ 0,1101	3509652	99,5000%	€ 386.574,82	€ 320.152,93	€ 66.421,89	€ 1.052,15	1	€ 65.369,75	-€ 519.156,64
2	€ 0,1101	3492103,74	99,5000%	€ 384.641,95	€ 320.152,93	€ 64.489,02	€ 1.052,15	1	€ 63.436,87	-€ 455.719,77
3	€ 0,1101	3474643,22	99,5000%	€ 382.718,74	€ 320.152,93	€ 62.565,81	€ 1.052,15	1	€ 61.513,66	-€ 394.206,11
4	€ 0,1101	3457270,01	99,5000%	€ 380.805,14	€ 320.152,93	€ 60.652,22	€ 1.052,15	0,925	€ 55.130,06	-€ 339.076,04
5	€ 0,1101	3439983,66	99,5000%	€ 378.901,12	€ 320.152,93	€ 58.748,19	€ 1.052,15	0,925	€ 53.368,84	-€ 285.707,21
6	€ 0,1101	3422783,74	99,5000%	€ 377.006,61	€ 320.152,93	€ 56.853,68	€ 1.052,15	0,925	€ 51.616,42	-€ 234.090,78
7	€ 0,1101	3405669,82	99,5000%	€ 375.121,58	€ 320.152,93	€ 54.968,65	€ 1.052,15	0,85	€ 45.829,03	-€ 188.261,76
8	€ 0,1101	3388641,47	99,5000%	€ 373.245,97	€ 320.152,93	€ 53.093,04	€ 1.052,15	0,85	€ 44.234,76	-€ 144.027,00
9	€ 0,1127	3371698,26	99,5000%	€ 379.884,62	€ 320.152,93	€ 59.731,70	€ 1.052,15	0,85	€ 49.877,62	-€ 94.149,38
10	€ 0,1127	3354839,77	99,5000%	€ 377.985,20	€ 320.152,93	€ 57.832,27	€ 1.052,15	0,85	€ 48.263,11	-€ 45.886,27
11	€ 0,1127	3338065,57	99,5000%	€ 376.095,27	€ 320.152,93	€ 55.942,35	€ 1.052,15	0,85	€ 46.656,67	€ 770,40

Figure 9 - China PV Cashflow

4.5. Interpretation of the Results

The amortization time of the wind power plant in Austria and China have very different results. In the Austrian case the amortization time is 29 years compared to the 18 years of the Chinese case, see Figure 10.

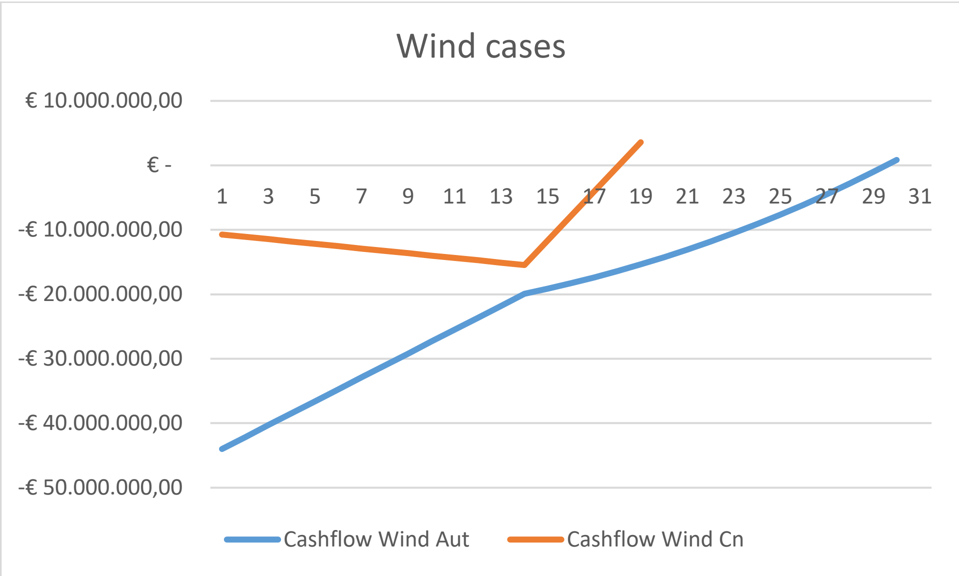

Figure 10 - Wind Amortization

It has several reasons why the results differ so strongly from each other. First, the initial costs of the Chinese wind farm are significantly lower than those of the Austrian wind park. This is mainly due to the fact that wind turbines are much more expensive in Austria. But the costs for the construction of the wind park are cheaper in China because of the cheaper workforce. Current costs are even slightly higher in China than in Austria. However, this is mainly due to the fact that the amount of the loan taken out as well as the interest rates are higher in China than in Austria. After the repayment of the loan, the running costs are considerably reduced. The fixed costs without credit in Austria are almost € 1,000,000 higher. Furthermore, the factor of the feed-in tariff plays an important role. The initial rate is higher in Austria, but this is only the case for the first 13 years of operation, in the case of China the favourable feed-in tariff is granted for the first 20 years of operation. Finally, the tax advantages must be mentioned. In Austria, operators of a wind farm have no possibility to avail themselves of tax advantages. In contrast to China, operators of wind parks are exempt from income tax for 3 years and a further 3 years they have to pay only half of the tax. Also, the normal tax rate is only 15% which is 10% lower than in Austria.

The results of the comparison between photovoltaic plants are even more serious, see Figure 11. In the Chinese case, the plant only needs 11 years to amortize, the Austrian plant needs 28 years to amortize. First and foremost, this depends on the higher investment costs. These initial costs are about 500,000 € more in Austria than in China. Unlike with the wind turbine, the running costs are very similar, especially until the credit is abated after 13 years of operation. Only then can a greater difference in costs can be recognized. This in turn is linked to the higher interest rate in China, which has already been mentioned above. As in the case of the wind turbines, the long-term feed-in tariff as well as the tax advantages are good for the Chinese project.

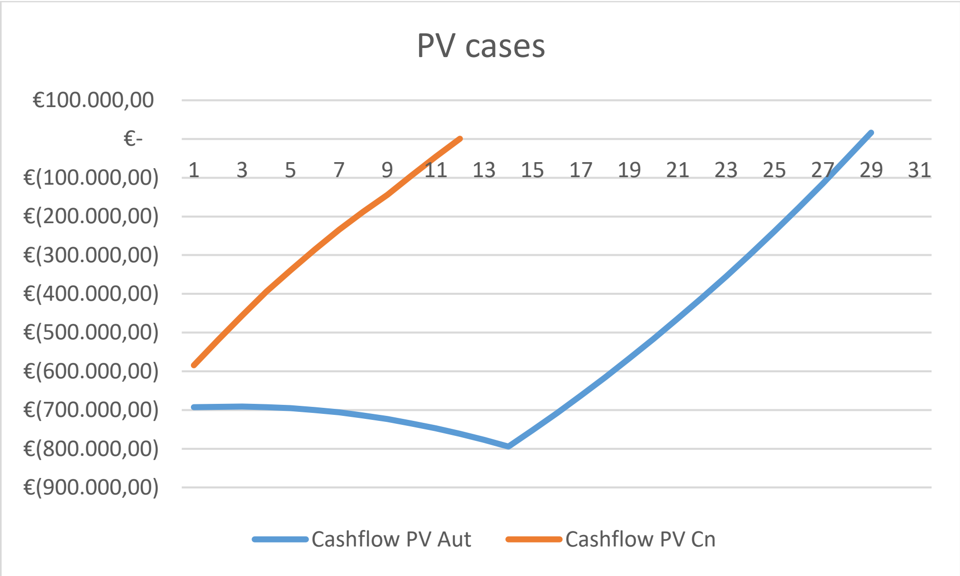

Figure 11 - PV Amortization

Interestingly the two Austrian cases, have both an amortization period of around 30 years. In my opinion, this is mainly due to the reduction of the feed-in tariff after 13 years of operation. In addition, the annual costs (with loan) are just under 10% of the initial investment. If both projects had a consistent feed-in tariff in the first 20 years, like it is in China both Austrian projects would pay for themselves around 10 years earlier. In this case, at least the amortization times at the Chinese wind farm and the Austrian wind farm would be almost the same. This has the main reason that the full-load hours in the Austrian case are somewhat higher than in the Chinese case. If the full load hours were the same, the Chinese wind park would still pay off more quickly than the Austrian wind farm. If the kWh of the Austrian photovoltaic plant could be increased together with a consistent feed-in tariff one would approach also here closer to the Chinese case.

4.6. Limitations of the case study

Of course, the case study is not free of limitations. A limitation of this study is that only one project per country was analysed. The fact that only one province in China was chosen makes the findings less generalizable for the whole Chinese market because of the different conditions and incentives in other provinces of China. Another province, would have most likely brought another outcome. In the case of Austria the fact that only one province for every case was chosen does not influence the outcome in the same way because incentives are the same in the whole country. Only in smaller projects that are designed to enable operators to be self-sufficient energy users, different incentives apply in different provinces. Moreover, the study is limited by the lack of information on the costs of the projects. This is due to, the fact that the necessary costs for the calculations are in most cases confidential. An additional uncontrolled factor is that there is the possibility of a variation in full load hours and solar radiation. In the study average data was used. Moreover, the scope of this study was limited in terms of the calculation of amortization time. Other business key figures could have been interesting to analyse too. Further research suggestions will be mentioned in chapter 5.1.

5. Conclusion

The master thesis has laid out and underlined the importance of wind- and solar energy for the future energy mix. The study has shown that these technologies play a significant role in the Chinese as well as in Austrian energy market. Of course the potential of the markets are very different in both countries. This is due to the size of the markets, the different costs involved in the technologies but also the geography and topography of the countries. Moreover, the policies which support wind respectively solar energy significantly differ from each other. The results of this investigation shows that China wants to promote renewable energy as much as the current circumstances allow it. This study has found that generally the peak of incentives has been reached already in both countries. The next years will show if the countries will continue to promote renewables in the same extent as it was done until now. However, especially in the case of China the evidence from this study suggests that the promotion of wind and solar energy by the government worked out like nowhere else. China made it to the global leader in wind- and solar energy in only a few years. Not only in regard to the total wind and solar energy output but also in the export of solar modules and wind turbines, China is now the leading country. The investigation of the Austrian market has shown that especially regarding solar power, Austria would have more potential than it currently uses. Of course, given the circumstances wind power is more favourable in Austria due to topographic conditions. The results of the market analysis support the findings of the case study. This is due to the fact that China invested a lot of money in recent years in research and development of renewable energies, gradually reducing the initial investment costs of wind and solar energy projects. Moreover, the favourable policies supporting renewable energies made wind power and solar power a real alternative to coal fired power plants. If the Austrian policy makers would like to push the underlaying technologies further a tax reduction like the one in place in China could be an option. The most obvious finding to emerge from this study is that, the special feed-in tariff period is the most important factor when speaking about the rentability and amortization time of wind and solar power projects. The relevance of a favourable tax and feed-in tariff policy is clearly supported by the findings of the case study.

The differences between the costs and revenues in the Austria and China are highlighted in Figure 12 and Figure 13. The figures show the costs and revenues of the wind cases and the photovoltaic cases compared to each other in a time sequence.

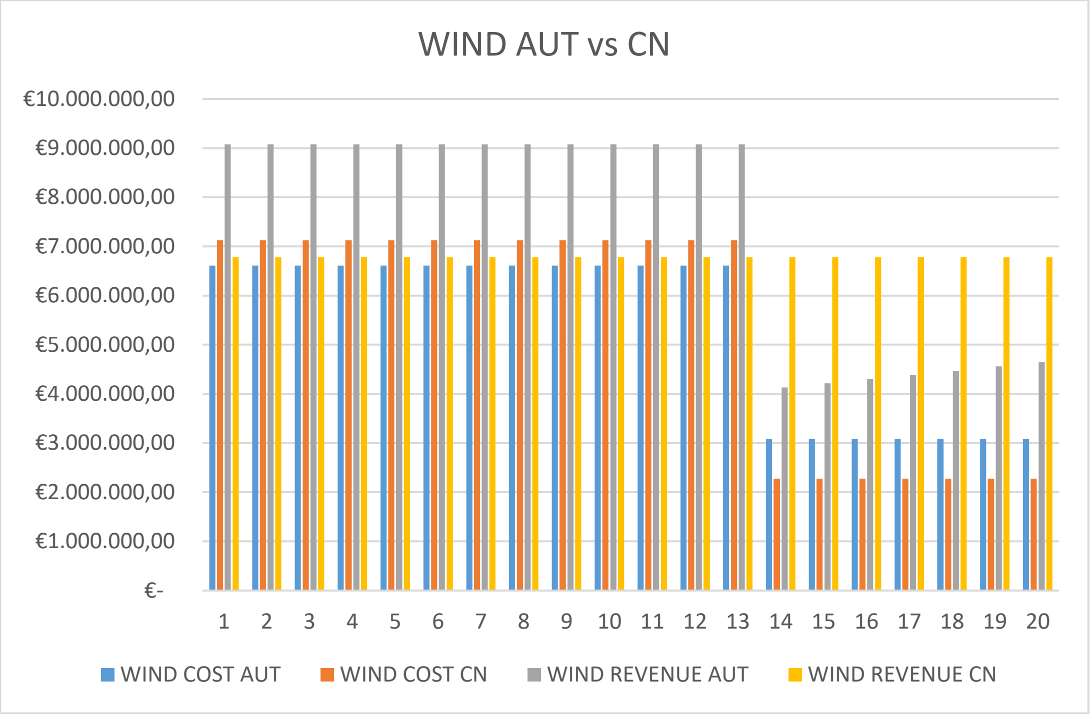

Figure 12 - Wind cases AUT vs CN - Costs and Revenues

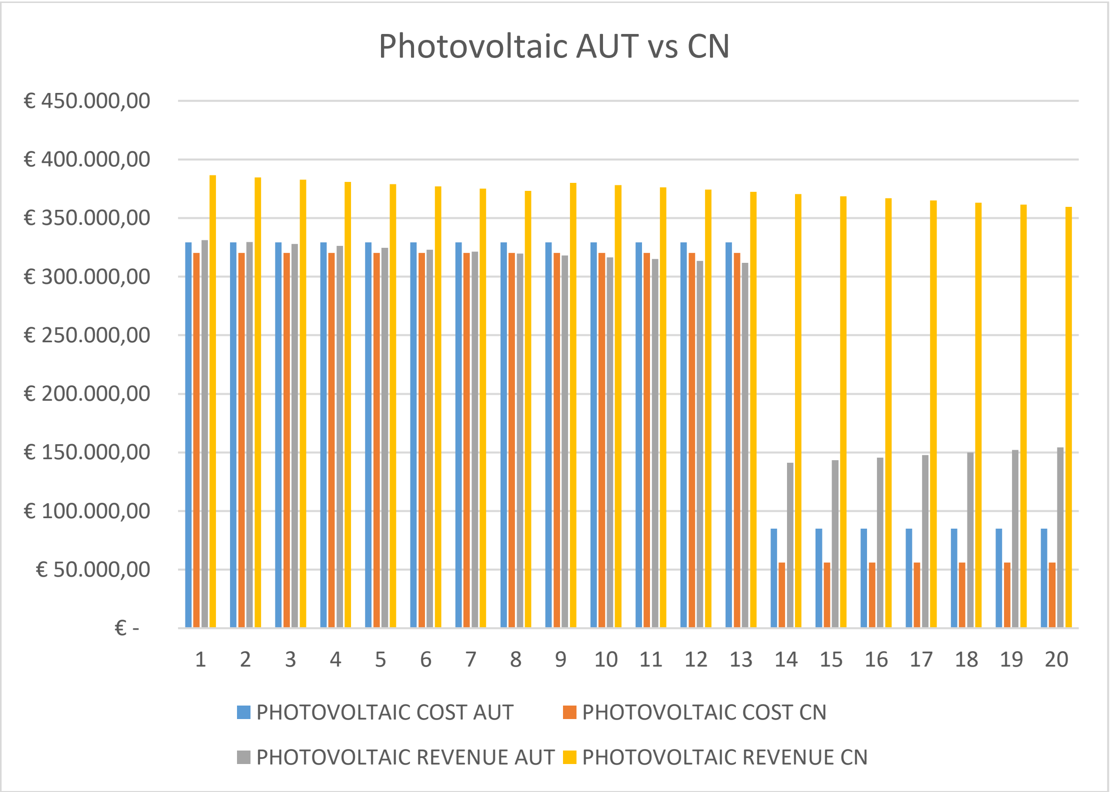

Figure 13 - Photovoltaic cases AUT vs CN - Costs and Revenues

Finally, it can be said the given the differences of the markets and the conditions in the two analysed countries it is hard to find a common denominator. However, both countries can still learn from each other. China can take an example of Austria and increase its quality in the infrastructure and the used technology. This would further decrease the costs of maintenance and extend the lifespan of wind- and solar power plants. Especially, the maintenance costs of wind turbines could be significantly decreased if the quality of the used materials would increase. Austrian plants have maintenance costs which are only a fourth compared to Chinese plants. Moreover, China needs to work on the stability of their grids so the power generated can actually be fed into the system. Austria on the other hand could, as mentioned above, work on their subsidies for large wind- and solar power plants. The amendment to the Green Electricity Act is an important starting point. The law has been under discussion for four years. If the breakthrough is not successful, hundreds of green power plants remain in the waiting list, and in many cases bankruptcy would be the outcome.

Although the current study is based on a small sample, the findings suggest that the business opportunities in China are greater than in Austria. The market conditions are more favourable, investment costs are cheaper and the policies in place promote wind- and solar power projects more than in Austria.

5.1.Future Research and Recommendations

The technological review as well as the market analysis are coherent. Given the scope of this thesis also the case study fulfils its purpose. However, this research has thrown up many questions in need of further investigation. What is now needed is a cross-provincial study in China to get an understanding how the conditions within the country differ. Another interesting viewpoint would be to compare the economic conditions within the European Union. In a further research the Chinese market could then be compared with the market of the European Union. These markets would be from size, economic power and opportunities more comparable than the Chinese market and the Austrian market. Further studies need to be carried out in order to validate the results of the underlying thesis. It would be interesting to compare the results with the results of a more quantitative approach. However, this approach, has obstacles in the form of data collection. As mentioned before there is not much public data on costs of commercial projects available. Finally, further investigation could assess the effects of the grid stability in China. Reportedly, the stability of the grid is one of the bottle necks when feeding in renewable energy especially wind energy. A lot of the produced wind energy in China is lost due to the uneven balancing of the deployment of wind energy and power from other sources like coal. It is suggested that the association of these factors is investigated in future studies.

References

Abele, C., 2017. *China treibt Qualität seiner Photovoltaik- branche voran,* Berlin: Germany Trade and Invest - Gesellschaft für Außenwirtschaft und Standortmarketing mbH.

Bartlett, J., 2010. *Solar Photovoltaic Technologies & Trends,* Littleton, Colorado: Arise Energy Solutions.wind

Behrla, O., n.d. *Monokristallin oder Polykristallin - Solarzellen im Vergleich.* [Online]
Available at: https://www.solaranlagen-portal.com/solarmodule/systeme/vergleich
[Accessed 27 03 2017].

Biermayr, P., Eberl, M. & Enigl, M., 2016. *Innovative Energietechnologien in Österreich Marktentwicklung 2015,* Wien: bmvit.

Bundesministerium für Wirtschaft und Energie, 2015. *Offshore-Windenergie, Ein Überblick über die Aktivitäten in Deutschland,* Berlin: Bundesministerium für Wirtschaft und Energie (BMWi), Öffentlichkeitsarbeit.

Bundesministerium für Wirtschaft und Energie, 2017. *Windenergie an Land.* [Online]
Available at: http://www.erneuerbare-energien.de/EE/Redaktion/DE/Dossier/windenergie-an-land.html?cms_docId=61944
[Accessed 22 04 2017].

E-Control, 2017. *Aktueller Marktpreis gemäß § 41 Ökostromgesetz 2012.* [Online]
Available at: https://www.e-control.at/de/marktteilnehmer/oeko-energie/marktpreis
[Accessed 02 05 2017].

Energiewerkstatt, 2017. *Windatlas.* [Online]
Available at: http://www.windatlas.at/
[Accessed 01 05 2017].

Fechner et al., H., 2007. *Technologie-Roadmap für Photovoltaik in Österreich,* s.l.: Bundesministerium für Verkehr, Innovation und Technologie .

Fechner, H. & Lugmaier, A., 2007. *Technologie-Roadmap für Photovoltaik in Österreich,* Wien: Bundesministerium für Verkehr, Innovation und Technologie.

Finke, S., 2017. *Photovoltaik-Kosten.* [Online]
Available at: http://www.photovoltaiksolarstrom.de/photovoltaik-kosten
[Accessed 10 05 2017].

Fliegenschnee-Jaksch, M., 2017. *Windkraft in Europa am Abgrund.* [Online]
Available at: https://www.igwindkraft.at/?mdoc_id=1034430
[Accessed 15 06 2017].

Fraunhofer Institute for Solar Energy Systems, 2016. *Photovoltaics Report,* Freiburg im Breisgau: Fraunhofer Institute for Solar Energy Systems.

Fried, L., 2017. *Global Wind Statistics 2016,* Brussels: Global Wind Energy Council.

Goldwind, 2017. *3 MW PMDD: The GW3S.* [Online]
Available at: http://www.goldwindamericas.com/30-mw-pmdd
[Accessed 03 05 2017].

Green, M., 2001. *CRYSTALLINE SILICON SOLAR CELLS,* Sydney: s.n.

Green, M., Emery, K., Hisikawa, Y. & Warta, W., 2007. Solar cell effciency tables (version 30). *Progress in Photovoltaics,* 15(30), pp. 425-430.

GWEC, 2016. *Global Wind 2015 Report,* Brussels: GWEC.

Hartmann, N. et al., 2015. Stromerzeugung aus Windenergie. In: S. U. P. M. F. S. F. G. Martin Wietschel, ed. *Energietechnologien der Zukunft.* Wiesbaden: Springer Fachmedien, pp. 103-122.

Hau, E., 2008. *Windkraftanlagen, Grundlagen, Technik, Einsatz, Wirtschaftlichkeit.* 4 ed. München: Springer.

IG Windkraft Österreich, 2014. *Windenergie in Österreich 2020 und 2030,* St. Pölten: IG Windkraft.

IG Windkraft Österreich, 2016. *Windkraft in der Steiermark,* St. Pölten: IG Windkraft Österreich.

IG Windkraft, n.d. *Historie des Ökostromgesetzes im Kurzüberblick.* [Online]
Available at: https://www.igwindkraft.at/?mdoc_id=1014570
[Accessed 02 05 2017].

IG Windkraft, n.d. *Windenergie in Österreich.* [Online]
Available at: https://www.igwindkraft.at/fakten/?xmlval_ID_KEY[0]=1234
[Accessed 02 05 2017].

International Energy Agency, 2017. *Feed-in tariff for onshore and offshore wind.* [Online]
Available at: https://www.iea.org/policiesandmeasures/pams/china/name-24855-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVv
[Accessed 02 05 2017].

International Energy Agency, 2017. *Feed-in tariff support for solar PV.* [Online]
Available at: http://www.iea.org/policiesandmeasures/pams/china/name-46873-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SW50ZXJuYXRpb25hbCBFbmVyZ3kgQWdlbmN5Jnp3bmo7PC9hPjxzcGFuPiAmZ3Q7IDwvc3Bhbj48YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzd
[Accessed 15 05 2017].

International Energy Agency, I., 2017. *Feed-in tariff support for solar PV.* [Online]
Available at: http://www.iea.org/policiesandmeasures/pams/china/name-46873-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI

-PGEgaHJlZj0iLyI-SW50ZXJuYXRpb25hbCBFbmVyZ3kgQWdlbmN5Jnp3bmo7PC9hPjxzcGFuPiAmZ3Q7IDwvc3Bhbj48YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzd
[Accessed 03 05 2017].

IRENA, 2015. *Renewable Power Generation Costs in 2014,* Bonn: IRENA.

IWR, 2017. *China verdoppelt Photovoltaik-Zubau auf über 30.000 Megawatt.* [Online]
Available at: http://www.iwr.de/news.php?id=32907
[Accessed 10 05 2017].

Jäger-Waldau, A., 2014. *PV Status Report 2014,* Ispra, Italy: European Commission, DG Joint Research Centre.

Jungbauer, n.d. *Stand der Technik.* [Online]
Available at: http://www.elite.tugraz.at/Jungbauer/3.htm
[Accessed 20 4 2017].

Konrad, F., 2007. *Planung von Photvoltaik-Anlagen.* 2 ed. Wiesbaden: GWV Fachverlage GmbH.

Konstantin, P., 2013. *Praxisbuch Energiewirtschaft.* Burgstetten: Springer-Verlag.

Kratena, K., Sommer, M., Eysin, U. & Rose, K., 2014. *Energieszenarien 2050, Herausforderungen an die österreichische Energiewirtschaft* , s.l.: Österreichisches Institut für Wirtschaftsforschung .

Kühn, M., 2007. Rückenwind für zukunftsfähige Technik. *Physik in unserer Zeit,* 3, pp. 116-122.

Kühn, M., 2010. Offshore-Windparks . In: R. GASCH & J. TWELE, eds. *Windkraftanlagen: Grundlagen, Entwurf, Planung und Betrieb.* Berlin: Springer, pp. 539-561.

Liu, Z., Zhang, W., Zhao, C. & Yuan, J., 2015. The Economics of Wind Power in China and Policy Implications. *Energies,* pp. 1529-1546.

Mechler, R., Rezai, A. & Mehdi, B., 2014. *Volume 3 Chapter 6: Transformation paths,* s.l.: Austrian Academy of Sciences Press.

Müller, K., Schmeiser, H. & Siegel, C., 2014. *Energiestrategie 2050 – Evaluierung der schweizerischen Risikolandschaft,* St. Gallen: Institut für Versicherungswirtschaft, I.VW-HSG, St. Gallen.

Näher, U., 2010. *Geschichte der WIndkraft in Österreich,* St. Pölten: IG Windkraft.

National Renewable Energy Laboratory, 2017. *PV Watts Calculator.* [Online]
Available at: http://pvwatts.nrel.gov/pvwatts.php
[Accessed 10 05 2017].

OeMAG Abwicklungsstelle für Ökostrom AG, 2017. *Österreichweite Förderungen für Photovoltaik.* [Online]
Available at: http://www.pvaustria.at/forderungen/
[Accessed 28 04 2017].

Photovoltaik.org, 2013. *China: Weltgrößter Photovoltaik-Markt.* [Online]
Available at: http://www.photovoltaik.org/news/international/china-weltgroesster-photovoltaik-markt-13110093
[Accessed 02 05 2017].

Pothecary, S., 2016. *China will 143 Gigawatt installierte Photovoltaik-Kapazität bis 2020.* [Online]
Available at: https://www.pv-magazine.de/2016/03/22/china-will-143-gigawatt-installierte-photovoltaik-kapazitt-bis-2020/
[Accessed 05 05 2017].

Powalla, M., Schock, H.-W. & Rau, U., 2010. *Dünnschichtsolarzellen – Technologie der Zukunft?,* Berlin: ForschungsVerbund Erneuerbare Energien.

Prowindkraft-Niedernhausen, n.d. *Wirtschaftlichkeit.* [Online]
Available at: https://www.prowindkraft-niedernhausen.de/niedernhausen/wirtschaftlichkeit/
[Accessed 02 05 2017].

Quaschning, V., 2015. Windkraft. In: V. Quaschning, ed. *Regenerative Energiesysteme, Technologie – Berechnung – Simulation.* München: Carl Hanser Verlag GmbH & Co. KG, pp. 255-309.

Reinick, C., Zabel, J., Specht, M. & Schissler, J., 2011. *Trendanalyse im Bereich Windenergie am Beispiel,* Wismar: Wismar Discussion Papers, Hochschule Wismar, Wismar Business School.

Republik Österreich, 2016. *Ökostromförderbeitragsverordnung 2017.* Wien: BUNDESGESETZBLATT FÜR DIE REPUBLIK ÖSTERREICH.

Rigter, J. & Vidican, G., 2010. Cost and optimal feed-in tariff for small scale photovoltaic systems in China. *Energy Policy,* pp. 6989-7000.

Roberts, S. & Guariento, N., 2009. *Gebäudeintegrierte Photovoltaik/Ein Handbuch.* Basel: Birkhäuser.

Salzburg 24, 2016. *Größtes Sonnenkraftwerk Österreichs auf Flachauer Alm.* [Online]
Available at: http://www.salzburg24.at/groesstes-sonnenkraftwerk-oesterreichs-auf-flachauer-alm/4690988
[Accessed 23 04 2017].

Schabbach, T. & Leibbrandt, P., 2014. *Technik im Fokus.* Berlin Heidelberg: Springer Vieweg.

Schönberger, P., 2016. *Kommunale Politik zum Ausbau erneuerbarer Energien: Handlungsmöglichkeiten, Praxisbeispiele und Erfolgsbedingungen,* München: Oekom-Verl..

Shi, P.-J., Zhang, G.-F., Kong, F. & Ye, Q., 2015. Wind speed change regionalization in China (1961–2012). *Advances in Climate Change Research,* p. 151–158.

Wagemann, H.-G. & Eschrich, H., 2010. *Photovoltaik.* 2 ed. Wiesbaden: Vieweg+Teubner.

Wesselak, V. & Schabbach, T., 2009. *Regenerative Energietechnik.* 1 ed. Nordhausen: Springer.

Wesselak, V., Schabbach, T., Link, T. & Fischer, J., 2013. *Regenerative Energietechnik.* 2 ed. Nordhausen: Springer-Verlag.

Yeung, P., Dai, A. & Wu, T., 2016. *Renewable Energy in China,* Hong Kong: DBS.

Zhang, M., Zhou, D., Zhou, P. & Liu, G., 2016. Optimal feed-in tariff for solar photovoltaic power generation in China: A real options analysis. *Energy Policy*, p. 181–192.

List of Tables

List of Figures