Topic n.5

The economics of small decentralized PV systems - without battery storage

David Hampl, Mohammadsadigh Eisazadeh

Supervisor

Prof. R. Haas

haas@eeg.tuwien.ac.at

Co-operating Universities

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Content

1. Abstract

An increasing investment seen in today's society is the switch to alternative energy. There are a few different energy conversion methods, but one of the largest is solar. This switch is seen because of harmful emissions produced by existing machinery used. Installing solar panels would be an example of a financial investment. Financial investments can look vastly different depending on the industry they are in. They can range from a large corporation looking to buy out a smaller company, to a small family ranch looking to purchase new equipment. Either way, they are not taken lightly and can impact the company or person drastically. In the case of a family ranch, many financials decisions are made daily, some of more importance than others. An example of an important financial decision is where to invest or what to invest in. Each decision needs to be thought through fully and analysed completely, which can be done through a cost-benefit analysis. An example of a cost-benefit analysis is capital budgeting, or investment analysis.

This process consists of four stages:

1) project definition and estimation of cash flows;
2) project analysis and selection;
3) project implementation;
4) project review.

The purpose of a cost-benefit analysis is to examine both the costs and benefits in order to determine which outweighs the other. If the costs outweigh the benefits, the project will not be cost-beneficial, but if the benefits outweigh the costs, it would seem to be a profitable project.

The key performance indicator is the return on investment (ROI) of the total savings' NPV in relation to the initial investment costs. We choose a depreciation period of 30 years for our Project in both countries (see below).

2. The economics of small decentralized PV systems

2.1. Introduction to the topic, motivation

The aim of this work is to design and implement a photovoltaic system (PV system) without the use of accumulation of electric energy into accumulators. In this work we will design a PV system for installation on a specific area such as the roof of a family house or on the roof of a public building. We will propose this solution in any place in the Czech Republic and further in Austria. We will compare the proposed systems both on a legislative basis, ie on support and subsidies, as well as technically and economically. So our objective will be to compare the technical and economic realization of the photovoltaic system in the Czech Republic and Austria.

We have divided our work according to the countries from which we come, or from the countries in which we currently live and therefore study college. Based on this, student David Hampl firstly focuses on the issue of photovoltaic systems (PVS) in his home country in the Czech Republic and on the other hand the student Mohammadsadigh Eisazadeh deals similarly with the area of Austria where he is currently studying.

For a proper comparison of these systems across countries, we will try to design technically similar systems. That is why we have decided to install a small photovoltaic power plant without accumulation of electrical energy into batteries with a target location on the roof of any family house or some private building with a maximum power output in a range of 10-15 kWp.

2.2. Problematics of PV systems

Photovoltaic (PV) markets have significantly progressed in the worldwide. While the market stabilized globally, the PV industry was put under heavy cost pressure. The price decrease of PV modules and system is opening new opportunities, in both grid-connected and off-grid applications. This report aims at providing a comparison analysis of the PV project, together with the policy support for PV applications. The PV industry, its impact on the economy in general and the electricity sector in particular. Smaller size countries have performed quite significantly and raised their total installed capacity above the GW mark: Belgium installed 600 MW and has now reached 3,228 GW. Some countries that grew dramatically over recent years have now stalled or experienced very small additions: Spain now totals 4,92 GW of PV systems followed by the Czech Republic at 2,1 GW and Austria 935.3 MW.

2.2.1. Basic information

2.2.1.1. PV panels

- **Grid-connected PV Systems**

In grid-connected PV-systems, an inverter is used to convert electricity from direct current (DC) as produced by the PV array to alternating current (AC) that is then supplied to the electricity network. The typical weighted conversion efficiency – often stated as 'European' or 'CEC' efficiency of inverters is in the range of 95% to 97%, with peak efficiencies reaching 98%. Inverters connected directly to the PV array incorporate a Maximum Power Point Tracker (MPPT), which continuously adjusts the load impedance to provide the maximum power from the PV array. One inverter can be used for the whole array or separate inverters may be used for each 'string' of modules. PV modules with integrated inverters, usually referred to as 'AC modules', can be directly connected to the electricity network (where approved by network operators) and play an increasing role in certain markets.

- **Off-grid PV Systems**

For off-grid systems a storage battery is required to provide energy during low-light periods. Nearly all batteries used for PV systems are of the deep discharge lead-acid type. Other types of batteries (e. g. NiCad, NiMH, LiO) are also suitable and have the advantage that they cannot be over-charged or deep discharged, but are considerably more expensive. The lifetime of a battery varies depending on the operating regime and conditions but is typically between 5 and 10 years. A charge controller (or regulator) is used to maintain the battery at the highest possible state of charge (SOC) and provide the user with the required quantity of electricity while protecting the battery from deep discharge or overcharging. Some charge controllers also have integrated MPP trackers to maximize the PV electricity generated. If there is the requirement for AC electricity, a 'stand-alone inverter' can supply conventional AC appliances.

2.2.1.1. Other factors

Cells, Modules and Arrays

The key components of a photovoltaic power system are various types of photovoltaic cells (sometimes also called solar cells) interconnected and encapsulated to form a photovoltaic module (the commercial product), the mounting structure for the module or array, the inverter (essential for grid-connected systems and required for most off-grid systems), the storage battery and charge controller (for off-grid systems but also increasingly for grid connected ones).

Photovoltaic cells represent the smallest unit in a photovoltaic power producing device, typically available in 12,5 cm, 15 cm and up to 20 cm square sizes. In general, cells can be classified as either wafer-based crystalline (single crystal and multicrystalline silicon, compound semi-conductor) thin film or organic. Currently, crystalline silicon technologies account for about 80% of the overall cell production in the IEA PVPS countries. Single crystal silicon (sc-Si) PV cells are formed with the wafers manufactured using a single crystal growth method and have commercial efficiencies between 16% and 24%. Multicrystalline silicon (mc-Si) cells, usually formed with multicrystalline wafers manufactured from a cast solidification process, are becoming increasingly popular as they are less expensive to produce but are marginally less efficient, with average conversion efficiency around 14- 17%. Quasi-monocrystalline silicon PV cells, manufactured using similar processes as multicrystalline silicon PV cells, have been gaining recent attention. III-V compound semiconductor PV cells are formed using materials such as GaAs on the Ge substrates and have high conversion efficiencies of 40% and more. Due to their high cost, they are typically used in concentrator PV systems with tracking systems or space applications. Thin film cells are formed by depositing extremely thin layers of photovoltaic semi-conductor materials onto a backing material such as glass, stainless steel or plastic. Module conversion efficiencies reported for thin film PV currently range from 7% (a-Si) to 13% (CIGS) but they are potentially less expensive to manufacture than crystalline cells. The disadvantage of low conversion efficiencies is that larger areas of photovoltaic arrays are required to produce the same amount of electricity. Thin film materials commercially used are amorphous and micromorph silicon (a-Si), cadmium telluride (CdTe), and copper-indium-gallium-diselenide (CIGS). Organic thin film PV cells, using dye or organic semiconductors, have created interest and research, development and demonstration activities are underway. Further research and development is being carried out to improve the efficiency of all the basic types of cells with laboratory efficiency levels of 25% for single crystal cells, and 20% for thin film technologies being achieved. Photovoltaic modules are typically rated between 50 W and 300 W with specialized products for building integrated PV systems at even larger sizes. Crystalline silicon modules consist of individual PV cells connected together and encapsulated between a transparent front, usually glass, and a backing material, usually plastic or glass. Thin film modules encapsulate PV cells formed into a single substrate, in a flexible or fixed module, with transparent plastic or glass as the front material. Quality PV modules are typically guaranteed for up to 25 years by manufacturers and are type approved to IEC 61215 Ed. 2, IEC 61646 Ed. 2.0 and IEC 61730 International Standards. A PV array consists of a number of modules connected in series (strings), then coupled in parallel to produce the required output power. A wide range of mounting structures has been developed especially for building integrated PV systems (BIPV), including PV facades, sloped and flat roof mountings, integrated (opaque or semi-transparent) glass modules and 'PV roof tiles'. Single or two-axis tracking systems have recently become more and more attractive, particularly for PV utilization in countries with a high share of direct irradiation. By using such systems, the energy yield can typically be increased by 25-35% for single axis trackers and 35-45% for double axis trackers compared with fixed systems.

Estimating System Output

PV systems produce power in proportion to the intensity of sunlight striking the solar array surface. The intensity of light on a surface varies throughout a day, as well as day to day, so the actual output of a solar power system can vary substantial. There are other factors that affect the output of a solar power system. These factors need to be understood so that the customer has realistic expectations of overall system output and economic benefits under variable weather conditions over time.

Factors Affecting Output

Standard Test Conditions Solar modules produce dc electricity. The dc output of solar modules is rated by manufacturers under Standard Test Conditions (STC). These conditions are easily recreated in a factory, and allow for consistent comparisons of products, but need to be modified to estimate output under common outdoor operating conditions. STC conditions are: solar cell temperature = 25 oC; solar irradiance (intensity) = 1000 W/m2 (often referred to as peak sunlight intensity, comparable to clear summer noon time intensity); and solar spectrum as filtered by passing through 1.5 thickness of atmosphere (ASTM Standard Spectrum). A manufacturer may rate a particular solar module output at 100 Watts of power under STC, and call the product a "100-watt solar module." This module will often have a production tolerance of +/-5% of the rating, which means that the module can produce 95 Watts and still be called a "100-watt module." To be conservative, it is best to use the low end of the power output spectrum as a starting point (95 Watts for a 100-watt module).

Temperature

Module output power reduces as module temperature increases. When operating on a roof, a solar module will heat up substantially, reaching inner temperatures of 50-75 oC. For crystalline modules, a typical temperature reduction factor recommended by the CEC is 89% or 0.89. So the “100-watt” module will typically operate at about 85 Watts (95 Watts x 0.89 = 85 Watts) in the middle of a spring or fall day, under full sunlight conditions.

Dirt and dust

Dirt and dust can accumulate on the solar module surface, blocking some of the sunlight and reducing output. Much of California has a rainy season and a dry season. Although typical dirt and dust is cleaned off during every rainy season, it is more realistic to estimate system output taking into account the reduction due to dust buildup in the dry season. A typical annual dust reduction factor to use is 93% or 0.93. So the “100- watt module,” operating with some accumulated dust may operate on average at about 79 Watts (85 Watts x 0.93 = 79 Watts).

Mismatch and wiring losses The maximum power output of the total PV array is always less than the sum of the maximum output of the individual modules. This difference is a result of slight inconsistencies in performance from one module to the next and is called module mismatch and amounts to at least a 2% loss in system power. Power is also lost to resistance in the system wiring. These losses should be kept to a minimum but it is difficult to keep these losses below 3% for the system. A reasonable reduction factor for these losses is 95% or 0.95.

DC to AC conversion losses

The DC power generated by the solar module must be converted into common household ac power using an inverter. Some power is lost in the conversion process, and there are additional losses in the wires from the rooftop array down to the inverter and out to the house panel. Modern inverters commonly used in residential PV power systems have peak efficiencies of 92-94% indicated by their manufacturers, but these again are measured under well-controlled factory conditions. Actual field conditions usually result in overall dc-to-ac conversion efficiencies of about 88-92%, with 90% or 0.90 a reasonable compromise.

Typical System Designs and Options

PV Electrical System Types:

There are two general types of electrical designs for PV power systems for homes:

- systems that interact with the utility power grid and have no battery backup capability
- systems that interact and include battery backup as well.

2.2.1.2. System without battery storage (accumulation)

This type of system only operates when the utility is available. Since utility outages are rare, this system will normally provide the greatest amount of bill savings to the customer per dollar of investment. However, in the event of an outage, the system is designed to shut down until utility power is restored.

Typical System Components:

PV Array: A PV Array is made up of PV modules, which are environmentally-sealed collections of PV Cells— the devices that convert sunlight to electricity. The most common PV module that is 5-to-25 square feet in size and weighs about 3-4 lbs./ft2. Often sets of four or more smaller modules are framed or attached together by struts in what is called a panel. This panel is typically around 20-35 square feet in area for ease of handling on a roof. This allows some assembly and wiring functions to be done on the ground if called for by the installation instructions.

Balance of system equipment (BOS): BOS includes mounting systems and wiring systems used to integrate the solar modules into the structural and electrical systems of the home. The wiring systems include disconnects for the dc and ac sides of the inverter, ground-fault protection, and overcurrent protection for the solar modules. Most systems include a combiner board of some kind since most modules require fusing for each module source circuit. Some inverters include this fusing and combining function within the inverter enclosure.

DC-C Inverter: This is the device that takes the DC power from the PV array and converts it into standard AC power used by the house appliances. metering: This includes meters to provide indication of system performance. Some meters can indicate home energy usage.

other components: utility switch (depending on local utility)

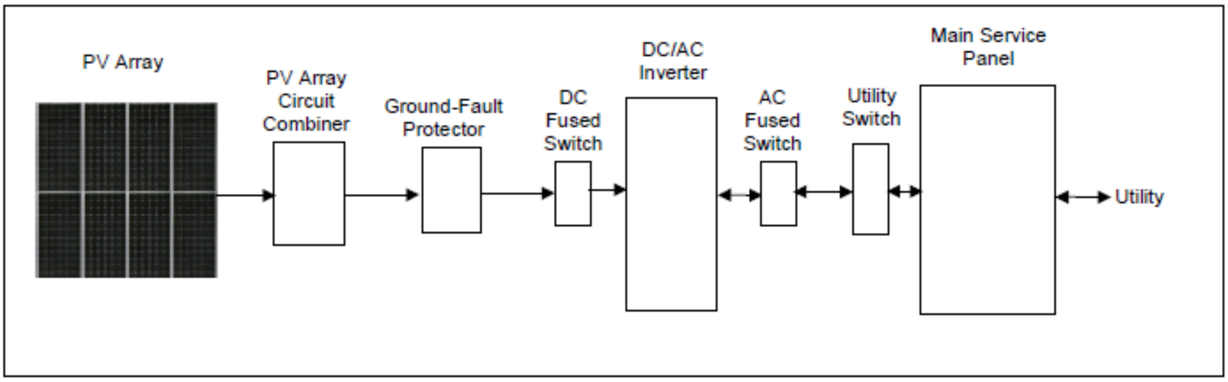

Figure 1 – PV system without battery accumulation.[1]

[1] Source of the image: Fig.1. – **Google images** [online], Available from: http://google.com

2.2.1.3. System with battery storage (accumulation)

This type of system incorporates energy storage in the form of a battery to keep “critical load” circuits in the house operating during a utility outage. When an outage occurs the unit disconnects from the utility and powers specific circuits in the home. These critical load circuits are wired from a subpanel that is separate from the rest of the electrical circuits. If the outage occurs during daylight hours, the PV array is able to assist the battery in supplying the house loads. If the outage occurs at night, the battery supplies the load. The amount of time critical loads can operate depends on the amount of power they consume and the energy stored in the battery system. A typical backup battery system may provide about 8 kWh of energy storage at an 8-hour discharge rate, which means that the battery will operate a 1-kW load for 8 hours. A 1-kW load is the average usage for a home when not running an air conditioner.

Typical System Components:

In addition to components listed in 2.2.1.2., a battery backup system may include some or all of the following:

1. batteries and battery enclosures
2. Battery charge controller
3. separate subpanel(s) for critical load circuits

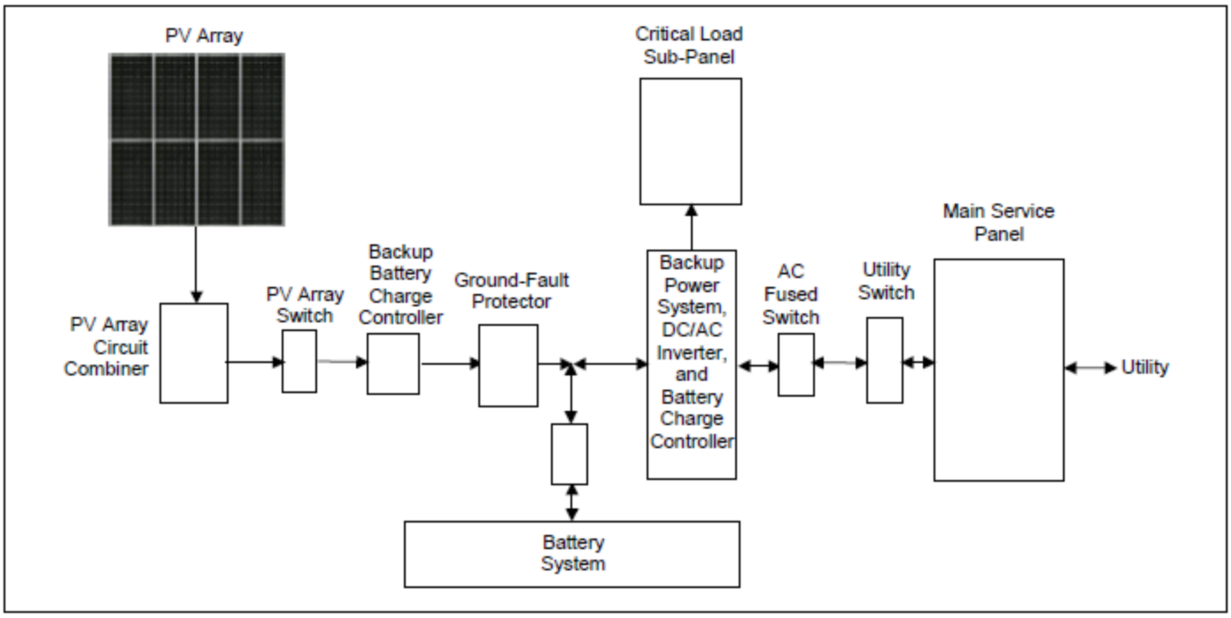

Figure 2 – PV system with battery accumulation.[2]

2.2.2. Legislation/donation

In this part we are dedicated to the legislation and the possibility of drawing subsidies separately for the territory of the Czech Republic and Austria.

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2 Source of the image: Fig.2. – **Google images** [online], Available from: http://google.com

2.2.2.1. Focused for The Czech Republic

In the first part, student David Hampl focuses on the issue of the PV systems in his native territory, the capital city of the Czech Republic, Prague:

I have decided to install a small photovoltaic power plant on the roof of a residential building where I have lived for 6 years. For this type of comparison, we have decided to install similar systems in both countries. This PV system will be with a capacity of up to maximum of 10 kWp power output with basic installation on any type of the roof without battery accumulation.

At this stage it's therefore necessary to deal with the legislation that applies to common dwelling units to the specified performance.

The apartment house is situated at the address Dolnomlýnská 6, in the city district of Prague 4. This apartment house consists of 10 apartments in total, two storeys including a basement and large garages. Residential units fall into an administrative organization called housing cooperative.

This building is located on the premises of the regional distribution company PREdistribuce, a.s., to which the grant program called "New Green Savings"

Figure 3 – "New Green Savings".[3]

<u>**In order to benefit from this subsidy, the following parameters must be respected:**</u>

• **Max. of the installed power of the PV source must not be higher than 30 kWp**

(Yes, fulfilled - expected installation of maximal power output around 10 to 15 kWp).

• **Only projects connected to the distribution network**

(Yes, our plan is to connect the PV system to an existing distribution network in Prague, which is managed by the distribution company PREdistribuce, a.s.)

• **Support applies only to systems that were connected to the network after 1.1.2016**

(Yes, the envisaged implementation and connection of the proposed PV system is in the period from 1.1.2018)

• **The system must be located on a building registered in the real estate register of the Czech Republic**

(Yes, it's a successfully completed building in the capital of Prague)

• **The converted inverter device system must have an equivalent efficiency**

(Yes, I'm going to design a PV system from technological equipment – the converter with efficiency up to 90%)

• **The realized PV panels must have adequate efficiency ... min. 10 to 15% by type**

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[3] Source of the image: Fig.3. – **Google images** [online], Available from: http://google.com

(Yes, I'm going to realize the system from high quality elements. Specifically, I plan to use BENQ photovoltaic panels with a high efficiency of 15.4%).

• The utilization rate of the el. energy within the implemented system must be at least 70%

(Yes, I also count on it. The proposed system will generate a maximum of 10% over power consumption over actual consumption)

• The selected control system must cover the maximum possible consumption of the object

(Yes, I have done an energy audit in the past, so I have an idea of total consumption and, accordingly, I am able to design and implement a suitable system.).

Based on this overview, it is possible to say that I meet all the legislative conditions for the successful implementation of the photovoltaic system on the roof of an apartment house building. The installation of this particular photovoltaic system is based on the possibility of using a type “C” subsidy, ie:

Sub-area C.3 - Installation of solar thermal and photovoltaic (PV) systems

It is only in this case that this particular support can not be used as this photovoltaic system does not use any kind of lectural energy accumulation (see the assignment). **That is why I do not count on this in my economic model.**

2.2.2.2. Focused for Austria

Austria’s support for PV relies on a mix of capped feed-in tariff and investment grants. Due to a cap for the tariffs, the development of PV in Austria remained quite low, with a market below 100 MW until 2012. In 2012 alone, the market progressed faster, with 175 MW connected to the grid. Even if the yearly budget to support PV deployment has grown, the market is still capped and not allowed to grow freely as in several other countries. This explains why, despite the country’s attractiveness (good irradiation conditions existing in the country, coupled with reasonable cost of capital), the development of PV was much slower than in Germany or Italy. 70% Renewables The share of renewable electricity sources in the country is high with close to 70% of the electricity demand covered. The share of hydro in particular is exceptionally high, which also allows the electricity system to benefit from a reserve of flexibility that will ease the PV development in the coming years. The major challenge lies in the ability to upgrade the electricity market functioning where the prices went down quite quickly in recent years.

1. ***Feed-in tariff*.**

In Austria, electricity from renewable sources is supported mainly through a feed-in tariff, which is set out in the Ökostromgesetz (ÖSG) 2012 and the regulations related thereto. The operators of renewable energy plants are entitled against the government purchasing agency, the so-called Ökostromabwicklungsstelle (hereinafter called "Clearing and Settlement Agency"), to the conclusion of a contract on the purchase of the electricity they produce ("obligation to enter into a contract") unless the promotional volume for the FiT is exhausted.

Eligible under the following condition:

The installation's capacity shall exceed 5 kWp (§ 12 par. 2 no. 3 ÖSG 2012 in conjunction with § 1 par. 1 ÖSET-VO 2016).

PV installations on roof-tops and façades with capacities over 5 kWp, up to 200 kWp, if application submitted and contract concluded until the end of 2016: €ct 7.91 per kWh (§ 5 par. 1 ÖSET-VO 2016). In addition to the feed-in tariff, an investment subsidy of 40 % of the investment costs up to 375 € per kWp is granted for PV installations on buildings (§ 5 par. 2 ÖSET-VO 2016).

Degression

The tariff for new plants may be gradually reduced to reflect the development of costs for a certain technology. The amount of annual reduction is determined by order of the Minister of Science, Research and Economy (§ 19 par. 2 ÖSG 2012). Furthermore, the overall budget for renewable electricity of € 50 million is reduced by € 1 million annually (whereby the first reduction took place in 2013) (§23 (2) ÖSG 2012).

Cap

In 2012, the overall annual support budget for renewable electricity has been set at € 50 million which is annually reduced by € 1 million in the first 10 years (§23 (2) ÖSG 2012). Plants and installations are only accepted unless funds are not exhausted. From this budget, € 8 million are granted for solar energy, € 10 million for solid and liquid biomass and biogas, at least € 11.5 million for wind energy and € 1.5 million for small hydro-power. In particular, the remaining budget of € 19 million (in 2012) is reduced annually and is available for wind and hydro power and for solar power (only grid parity tariff in this case) (§23 (3) ÖSG 2012). As of 2017, the annual budget amounts up to € 45 million in total.

2. ***Subsidy II. Investment subsidy for PV on buildings***

In addition to the feed-in tariff, a subsidy is granted for PV installations on rooftops and building-integrated installations with a capacity 5-200 kW.

An investment subsidy of 40% of the investment costs up to 375 € per kWp is granted for PV installations on buildings. The feed-in tariff amounts up to 7.91 €ct/kWh if the contract is concluded in 2016 (§ 5 par. 1 ÖSET-VO 2016).

Eligible technologies

Solar energy Eligible under the following condition:

- The installation's capacity shall be between 5 kWp and 200 kWp (§ 12 par. 2 no. 3 ÖSG 2012 in conjunction with §§ 1 par. 1 and 5 par. 1 ÖSET-VO 2016).

Amount

Solar energy for PV installations on buildings, the investment subsidy amounts to 40 % of the investment costs but no more than 375€ per kW. The feed-in tariff amounts up tp 7.91 €ct/kWh if the contract is concluded in 2016 (§ 5 par. 1 ÖSET-VO 2016).

Addressees

Entitled party. The persons entitled to the tariff are the operators of photovoltaic installations on buildings. In order to be entitled to the investment subsidy, the installation must be licensed as a "green electricity plant" by the governor (§ 7 par. 1 ÖSG 2012).

Procedure

Competent authority Ministry of Science, Research and Economy (BMWfW)

3. Subsidy III. Investment subsidy for off-grid installations

In addition to the feed-in tariff, an investment subsidy is granted for off-grid installations that generate electricity from renewable energies. Companies, other entrepreneurial organisations, confessional facilities and associations can profit from investment subsidies granted for the installation of off-grid power plants for the purpose of self-supply. Furthermore, the subsidies may be granted to electrical energy storage devices.

Eligible technologies

Investment subsidy is granted for the installation of off-grid power plants (Off-grid subsidy guidelines).
Hydro-power Eligible for small hydro-power plants.
Wind energy Eligible.
Biogas Eligible for CHP.
Solar energy Eligible.

Amount

- Standard subsidy: 30 % of the costs of installation eligible for funding
- Additional subsidy:
- 5 % for installations in areas higher than 1200 meters or in ecologically sensitive **areas.**
- 5 % in case of the implementation of different measures
- 5 % or a maximum of € 10,000 for EMAS and eco-label (Offgrid subsidy guidelines)

Addressees

Entitled party: Subsidies can only be claimed by companies or other entrepreneurial organisations, confessional facilities and associations (Offgrid subsidy guidelines).

4. Subsidy IV. Investment subsidy for small PV

PV installations under 5kWp in private households and commercial buildings are eligible to investment subsidies from the Austrian Climate and Energy Fund. The subsidies support max. 5 kWp of a PV system, whereas double funding is not possible. The promotion budget is only granted for new projects (annually announced in spring) and can be claimed by private individuals, companies, associations and confessional facilities. Since 2015, private individuals can build a PV system conjointly by accessing the funds for max. 5 kWp per capita and 30 kWp in total. Furthermore, it is also possible to apply for the funding more than once if the applicant aims to build another unit at a different site (PV Subsidy Guidelines 2016). Eligible technologies - Subsidies are granted for PV installations with a maximum capacity of 5kWp (p. 2 PV Subsidy Guidelines 2016). Solar energy - Subsidies are granted for PV installations with a maximum capacity of 5kWp (p. 2 PV Subsidy Guidelines 2016). Alternatively, also joint PV installations ('Gemeinschaftsanlagen') are eligible for subsidies, whereas the funds can be accessed for max. 5 kWp per capita and 30 kWp in total (p. 3 PV Subsidy Guidelines).

Amount

- €275 per kWp for roof-top or ground-mounted installations with a maximum capacity of 5 kWp.
- €375 per kWp for building integrated installations with a maximum capacity of 5 kWp (p. 2 PV **Subsidy Guidelines 2016).**
- The overall budget amounts up to € 8.5 million for 2016 (p.5 PV Subsidy Guidelines 2016)

Addressees

Entitled party: Subsidies can be claimed by natural or legal persons; e.g. private individuals, farmers, companies, confessional facilities and associations (p.2 PV Subsidy Guidelines 2016).

(Renewable energy policy database and support LEGAL SOURCES ON RENEWABLE ENERGY
http://www.res-legal.eu/search-by-country/austria/summary/c/austria/s/res-e/sum/91/lpid/94/

2.2.2.3. Comparison for both countries

2.2.3. Technical real. of PV sys., setting common parameters

In this section we will deal with the technical design and the actual implementation of the PV system at a specific place or location.

For a proper comparison of the possibilities of realization of photovoltaic systems in individual countries we decided to set the same conditions for the given system:

Common parameters:

- Maximum power output: **10 kWp**
- **High-efficiency equipment of the Austrian company Fronius**
- Effort to use grant programs (subsidy)
- To design optional PV system without possibility of accumulation (for example to the batteries)

- An effort to design such a system in order to prevent the overflow of electricity back into the power supply network

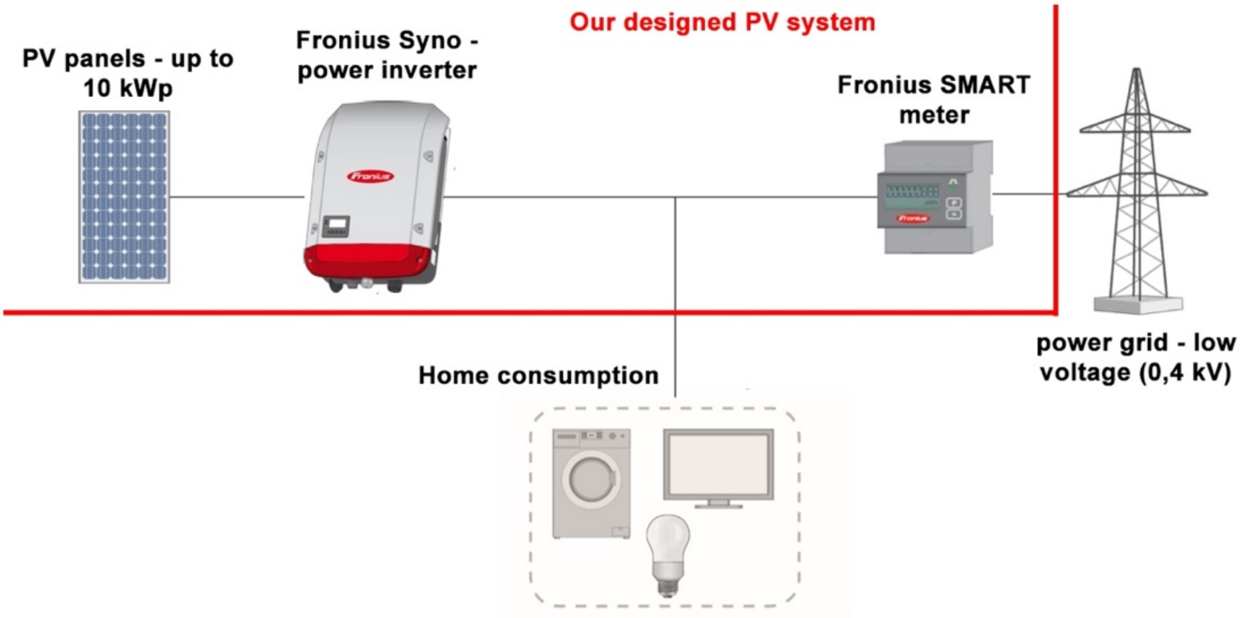

Figure 4 - Graphic design of a simple PV system without the possibility of electricity storage.[4]

An overview of the technology used

This system uses simple el. energy without accumulation (accumulator batteries), with the use of max. instantaneous generated electricity and any surpluses being "sold" back to the distribution network - in this case, the company PRE, a.s.

Design of used technology - No accumulation

- Power inverter - Type: Fronius Symo 10.0-3-M - Operating power up to 10 kW
- Smart meter - Type: Fronius SmartMeter
- PV panels BENQ

Common part of technical implementation of PV system, system connection

1. PART OF THE FV PANELS Installation - Photovoltaic panels will be placed on the roof of the building in a regular "grid", because of the possible shielding of the panels, the individual panels will be placed with a sufficient gap of 0.5 to 1 m. The panels will be firmly seated on the steel profiles Due to the requirement of an optimal 35% slope on the North-South axis of the world.

[4] Source of the image: Fig.2. – **Images of FRONIUS technology equipment** [online], Available from: http://www.fronius.com/cps/rde/xchg/SID-FD3D5147-D8621CC9/fronius_ceska_republika/hs.xsl/30.htm#.WCIixndOCNU

2. PART OF CABLE WIRING, WIRING - Individual panels will be interconnected using copper cables (cross-section 4-6 mm2). All cabling will be swept from the roof through ventilation to the technical room located in the basement of the building.

3. PART OF THE INSTALLATION OF THE POWER TRANSMITTERS - All the necessary technology will be placed in the technical room located in the basement of the building. The power transducer (Fronius Symo 1) and the "smart" Fronius Smart Meter.

4. PART OF THE INSTALLATION - commissioning - The last part of the system connection, including the connection of the "smart" meter to the main switchboard of the object (connection before the 10 th electricity meter for the common distribution). Subsequently, the system will be fully operational.

2.2.3.1. The PV system in the Czech Republic

As I wrote in the introductory part of my thesis, for my PV system I am counting on the realization of a small photovoltaic power plant on the roof of a residential building. In my own and for the sixth year I live in one of ten flats. This private building has a total of 10 apartments, two floors including an underground floor and a basement with large communal garage with a total of 20 parking spaces for cars. Although it is a new building that was built in 2010 using high-quality low-energy materials, despite the considerable passivity of the building there is a relatively large common consumption of electricity.

In 2015, I was interested in the energy audit of the common area of this building so I analyzed the total consumption of common spaces:

	Summer months (7 months)	Winter months (5 months)
Total electricity consumption per day - sum [kWh]=	79,9	94,3
Total cost per day [EUR/day]=	9,2	10,9
Total per year [kWh]=	17 025,3	14 338,3
Total cost per year [EUR/year]=	**1 965,0**	**1 654,8**
Total for SUMMER + WINTER time [EUR/year]=	**3 619,8**	EUR

Tab. 2.2.3.1. - An overview of the power consumption of an object at Dolnomlýnská 6.

Mapping the location options of the FVE system

The proposed photovoltaic system (FVE) will be located on the roof of the object under consideration. It is a straight concrete roof that is covered with 4-5 cm stones. The roof is due to its construction without any load restriction. The total roof area is approximately 250 m2 (25.5 x 9.5 m) + 2 niches of 15 m2, the total area is 280 m2.

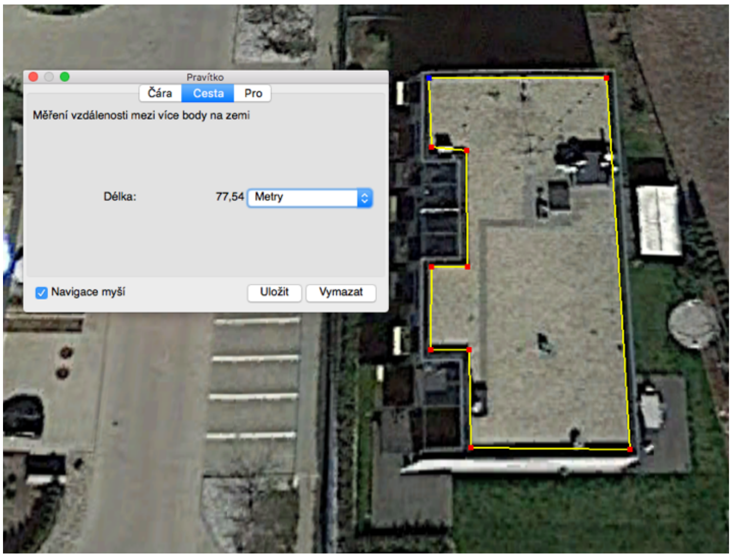

Figure 5 - View from the perspective of the object under consideration.[5]

The roof of the building is shot directly on the North-South axis, making it an ideal location to get up to 100% of sunshine during the day. It is also possible to use the "East-West" position, which does not use the maximum sunrise, but it can be used for a longer period of total sunlight.

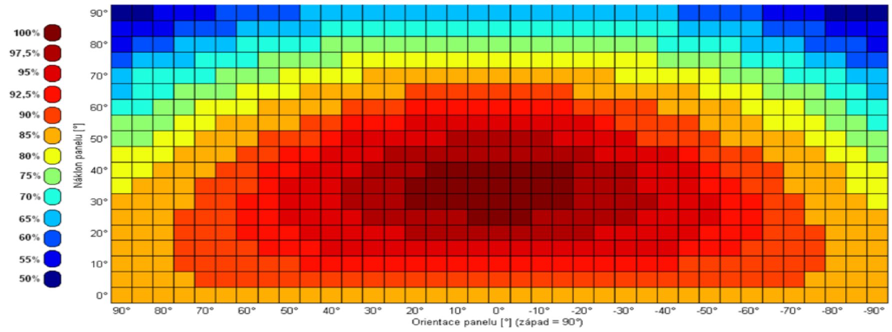

Figure 6 - Visualization of the power spectrum to determine the efficiency of the PV system.[6]

Design of layout of photovoltaic panels

As mentioned above, the object under consideration - the roof of a block of flats at Dolnomlýnská 6 is shot directly to the North-South axis, creating ideal conditions for the realization of the photovoltaic power plant. energy. I decided to use high efficiency BenQ's photovoltaic panels (PV), which have excellent price and performance parameters, and are well-run in both countries (the Czech Republic and Austria). These panels are made of the current "multi-crystalline" technology, which is on of the most perspective present technology.

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[5] Source of the image: Fig. 5. – **Satellite view of an apartment building - Dolnomlýnská 6** [online], Available from: https://www.google.cz/maps?source=tldso

[6] Source of the image: Fig.6. – **Google images** [online], Available from: http://google.com

Proposal of distribution of PV panels on the roof of building at Dolnomlýnská 6

Figure 7 - Visualization of the layout of PV panels on the assessed object - Dolnomlýnská 6.[7]

The layout of the individual panels (in the picture - black rectangles in the figure) was done depending on the North-South direction, as well as adherence to the desired spacing in order to minimize possible shielding. Individual panels would be seated on steel support profiles to create the desired 35 ° slope to achieve maximum efficiency. Individual panels will be interconnected using the appropriate cable system (red lines in the picture), including the creation of two "handover" locations (purple squares in the picture) to serve for revision purposes (eg disconnecting part of the panel sector). The final cable connection (the blue line in the figure) will be guided from the last set of panels through the existing air conditioning cabling to the target technical room located in the basement. In this room will be equipped with the necessary technology (control, converters, accumulators).

2.2.3.1.1. Parameters of used PV panels, technology

Parameters of the panels used:

1 PV panel, type: BENQ	250	Wp
Efficiency:	15,4	%
Number of panels:	40	pieces
Pnale dimensions:	1,64	height [m]
	0,992	width [m]
	0,04	depth [m]
Area of 1 panel:	1,62688	ca 2 m2
Roof area:	250	m2
Net roof area:	65,0752	m2
Required roof area:	140	m2

Table n.2.2.3.1.1. Parameters of PV panels – Czech republic.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

Source of the image: [7] Fig. 7. – **Satellite view of an apartment building - Dolnomlýnská 6** [online], Available from: https://www.google.cz/maps?source=tldso

Using the PV Gis web application (www.pvgis.com). I have verified the performance of photovoltaic panels with a selected installed capacity of 10 kWp in the area of interest - the address of the examined object Dolnomlýnská 6.

Note: Generally, it can be stated that in the areas of the Czech republic area (and central Europe) can be based on the simplification that the installed 1 kWp PV panel will produce about 1 MWh per calendar year.

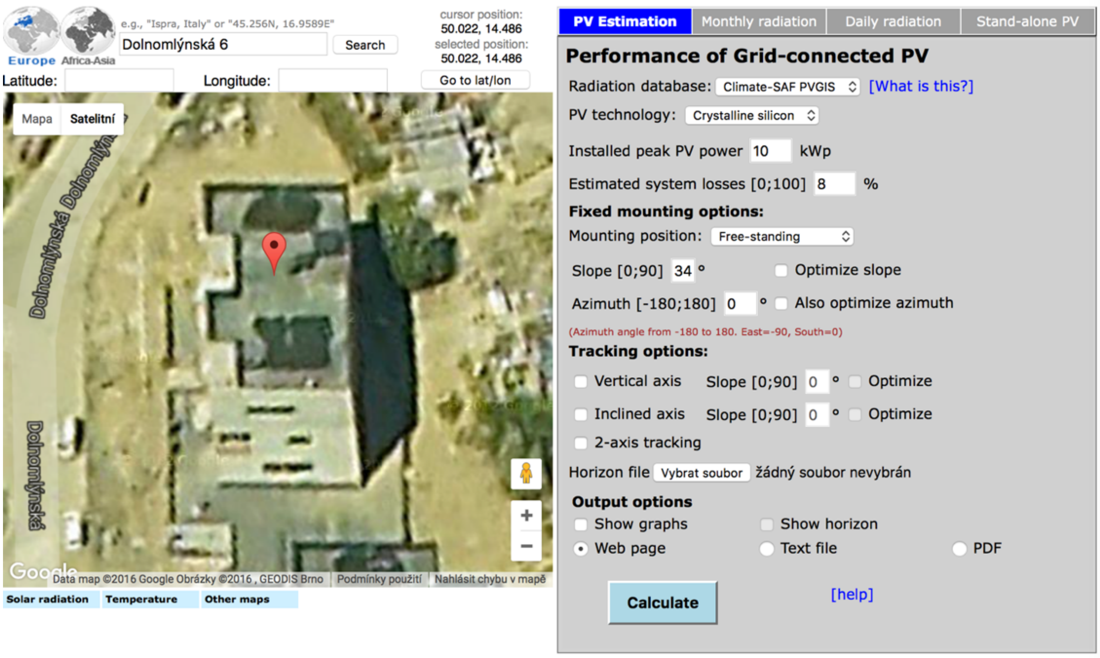

Figure 8 - Example of work with the PV Gis web software to determine the performance of the PV system.[8]

Orientation of the PV North-South Fixed system: inclination=35°, orientation=0°				
Month	**Ed**	**Em**	**Hd**	**Hm**
Jan	15 220,00	**292,00**	42 491,00	32.5
Feb	42 660,00	**480,00**	34 335,00	54.2
Mar	29.90	**926,00**	17 593,00	108,00
Apr	40.80	**1 220,00**	35 156,00	149,00
May	41.30	**1 280,00**	42 125,00	160,00
Jun	42.40	**1 270,00**	13 636,00	161,00
Jul	40.90	**1 270,00**	45 047,00	162,00
Aug	38.90	**1 210,00**	34 060,00	153,00
Sep	**31.50**	**946,00**	31 837,00	116,00
Oct	22.20	**687,00**	22 678,00	81.2
Nov	18 568,00	**345,00**	11 689,00	39.6
Dec	22 494,00	**267,00**	0.96	42 642,00
Annual average production [kWh] =	42 640,00	**849,00**	15 036,00	104,00
Total per year [kWh/year] =	**10 200,00**		1 250,00	

Table n.2.2.3.1.1. – Overview of input data –PVGis.

[8] Source of the image: Fig.8. – **PV GIS - Web SW for geographic prediction of predicted FVE system performance** [online], Available from: http://re.jrc.ec.europa.eu/pvgis/

From these values, it can be seen that the photovoltaic system (FVE) with a 10 kWp power plant at Dolnomlýnská 6 can, under ideal conditions, produce annually up to "ideally" 10, 200 MWh. Of which, on average, up to 8, 49 MWh (we expect the ideal 35° rotation of the panels and the north-south direction.)

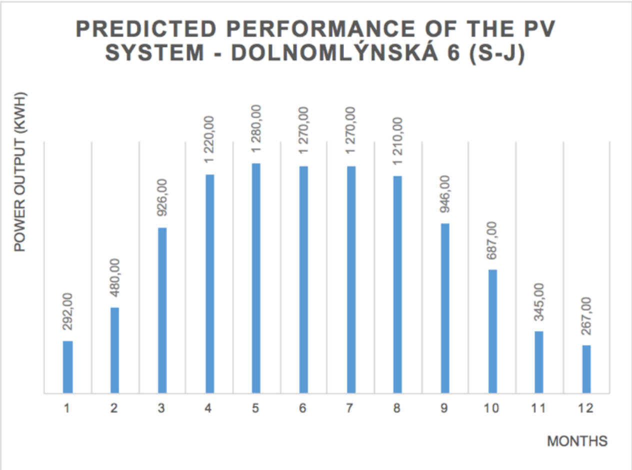

Table n.2.2.3.1.1. – Predicted performance of solar energy.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

2.2.3.1.2. Technical realisation, results

Technical connection to the power grid

In the next part of the technical realization of the photovoltaic power plant. Firstly we needed to select the appropriate technology for measurement, network connection to the electricity grid and so on. Based on the recommendations of the projection center of czech company PREměření, a.s., which deals with the design of the PV system, we decided on the technological solutions of the Austrian company called Fronius systems.

Note: This producer is very popular on the territory of the Czech Republic and, due to its competence in the territory of Austria, will be a suitable supplier of technology as well as technological solution for the student Mohammad.

We will use power converter (inverter), smart meter (production / consumption) developed by Fronius technological company:

PV system - without acumulation				
Device/project part	**Type (note):**	**Price [EUR]**	**pieces [-]**	**Final price [EUR + TAX]**
Photovoltaic panel	BENQ PM060PWO	182,33	40,00	**-7 293,23**
Inverter single	Fronius Symo 10.0.-3-M	1 268,80	1,00	**-1 268,80**
Smart meter	Fronius SmartMeter	350,34	1,00	**-350,34**
Suporting construction 1 panel (35°)	/	26,32	40,00	**-1 052,63**
Price of cables and switchboard 1 panel	/	18,80	40,00	**-751,88**
Package - FVE installation up to 12 kW	(2 technicians, 3 days = ca	16,92	48,00	**-812,03**
Project on PVP	(1 project planner, 1 days)	18,80	10,00	**-187,97**
Engineering (OTE, permit, PREdi)	(1 engineering, 2 days)	13,16	16,00	**-210,53**
+ Contract / copy	the contract	56,39	2,00	**-112,78**
First Revision Report - Commissioning	/	150,38	1,00	**-150,38**
			Total [Eur]=	-12 190,56

Table n.2.2.3.2.2. – Overview of input data – Czech PV system.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

Note: In both variants, the necessary technological items are allocated, including other necessary services. Such as the provision of human resources for the implementation of the FVE system, the implementation of the revision tests, the project itself + the engineering work, etc.

Total amount of investments: -12 190, 56 EUR for complete realisation of PV system up to 10 kWp.

2.2.3.2. The PV system in Austria

As I wrote in the introductory part of my thesis, for my PV system I am counting on the realization of a small photovoltaic power plant on the roof of a residential building. For this purpose, we found a similar building in Austria

Mapping the location options of the FVE system

The proposed photovoltaic system (FVE) will be located on the roof of the object under consideration. This is a sheet metal roof, where a photovoltaic system with a maximum output of 10 kWp will be installed.

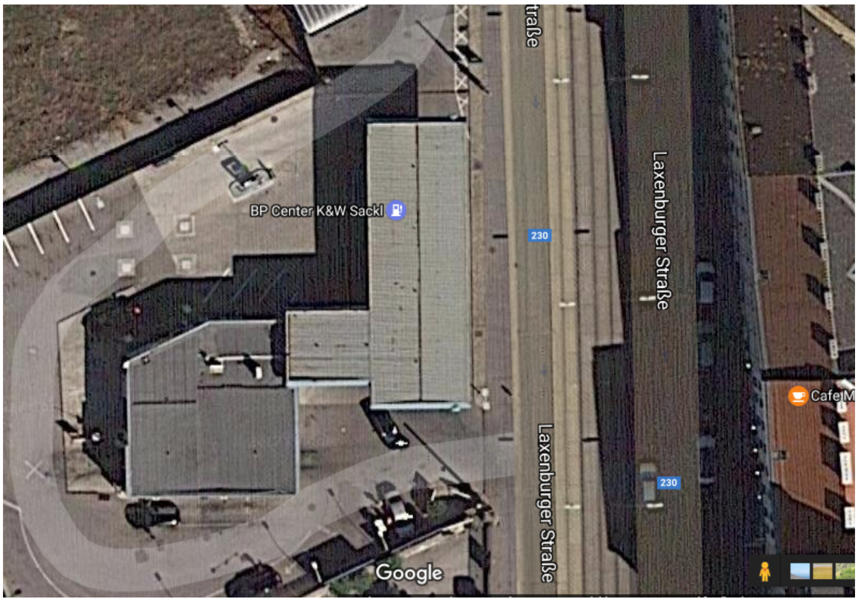

Figure 9 - View from the perspective of the object under consideration.[9]

Design of layout of photovoltaic panels

As mentioned above, the object under consideration - the roof of a block of flats at Laxenburger Str. 2A, is shot directly to the Northwest-Southeast axis, creating ideal conditions for the realization of the

[9] Source of the image: Fig. 9. – **Satellite view of an apartment building** [online], Available from: https://www.google.cz/maps?source=tldso

photovoltaic power plant. energy. We decided to use Axitec photovoltaic panels, which have excellent price / performance parameters. These panels are made of the current "multi-crystalline" technology, which is on of the most perspective present technology.

Proposal of distribution of PV panels on the roof of building at Laxenburger Str. 2A,

Figure 10 - Visualization of the layout of PV panels on the assessed object - Laxenburger Str. 2A.[10]

The layout of the individual panels (black rectangles in the figure) have been stacked in a regular structure to save space and achieve high efficiency. As in the Czech Republic.

2.2.3.2.1. Parameters

1 panel, type: Axitec	270	Wp
Efficiency:	18	%
Number of panels:	37	pieces
Pnale dimensions:	1.64	height [m]
	0.992	width [m]
	0.035	depth [m]
Area of 1 panel:	1.62688	ca 2 m2
Roof area:	245.28	m2
Net roof area:	60.19456	m2
Required roof area:	129.5	m2

Tab. 2.2.3.1.1. Parameters of PV panels – Austria

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

Using the PV Gis web application (www.pvgis.com). I have verified the performance of photovoltaic panels with a selected installed capacity of 10 kWp in the area of interest.

Note: Generally, it can be stated that in the areas of the Czech Republic (and central Europe – like Austria) can be based on the simplification that the installed 1 kWp PV panel will produce about 1 MWh per calendar year (in Austria slightly 1,1 MWh per year).

[10] Source of the image: Fig. 9. – **Satellite view of an apartment building** [online], Available from: https://www.google.cz/maps?source=tldso

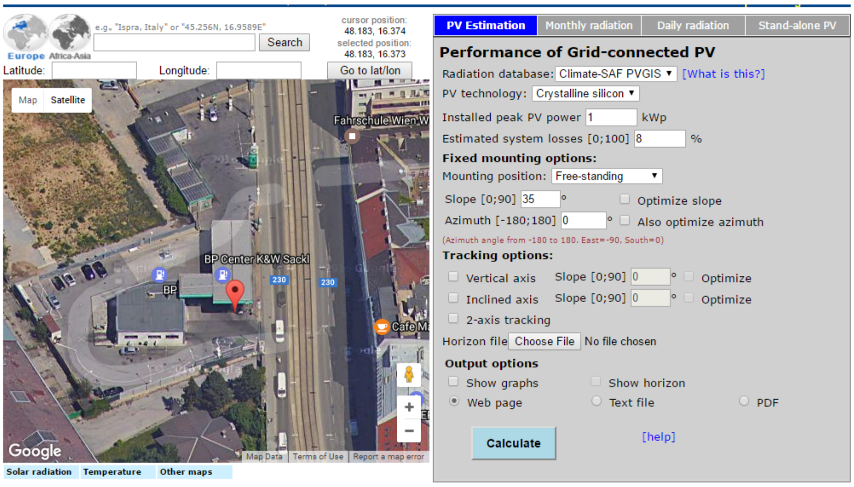

Figure 11 - Example of work with the PV Gis web software to determine the performance of the PV system.

Orientation of PV - North-South				
Fixed system: inclination=35°, orientation=0°				
Month	Ed	Em	Hd	Hm
Jan	1.26	39.20	1.41	43.60
Feb	2.29	64.20	2.58	72.10
Mar	3.47	108.00	4.08	126.00
Apr	4.52	136.00	5.52	166.00
May	4.50	140.00	5.60	174.00
Jun	4.42	133.00	5.61	168.00
Jul	4.44	138.00	5.72	177.00
Aug	4.26	132.00	5.42	168.00
Sep	3.54	106.00	4.37	131.00
Oct	2.59	80.40	3.07	95.10
Nov	1.40	42.00	1.61	48.40
Dec	1.07	33.10	1.19	37.00
Annual average production [kWh] =	3.15	95.90	3.85	117.00
Total per year [kWh/year] =	1,150.00		1,410.00	

Table n.2.2.3.3.1. – Overview of input data –PVGis.[11]

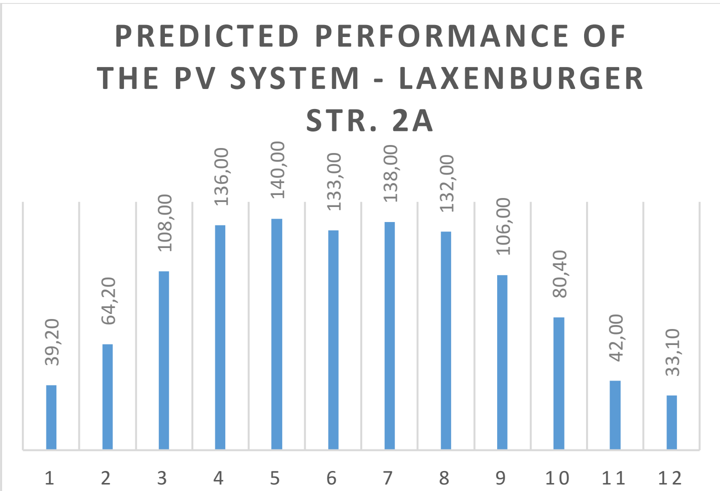

Chart n.2.2.3.3.1. – Predicted performance of solar energy.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

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11 Source of the image: Source of the image: Fig.11. – **PV GIS - Web SW for geographic prediction of predicted FVE system performance** [online], Available from: http://re.jrc.ec.europa.eu/pvgis/

2.2.3.2.2. Realization, results

We will use power converter (inverter), smart meter (production / consumption) developed by Fronius technological company:

PV system - without acumulation

Device/project part	Type (note):	Price [EUR]	pieces [-]	Final price [EUR + TAX]
Photovoltaic panel	Axitec AXIpower AC-270P p	231,42	37,00	**-8 562,41**
Inverter single	Fronius Symo 3.0-3-S	1 188,00	1,00	**-1 188,00**
Smart meter	Fronius Smart Meter 63A mi	280,00	1,00	**-280,00**
Suporting construction 1 panel (35°)		42,43	37,00	**-1 569,91**
Price of cables and switchboard 1 panel		23,90	37,00	**-884,30**
Package - FVE installation up to 12 kW	(2 technicians, 2 days)	22,00	48,00	**-1 056,00**
Project on PVP	(1 project planner, 1 days)	25,00	10,00	**-250,00**
Engineering (OTE, permit, PREdi)	(1 engineering, 2 days)	18,00	16,00	**-288,00**
+ Contract / copy		65,00	1,00	**-65,00**
First Revision Report - Commissioning		180,00	1,00	**-180,00**
			Total [Eur]=	-14 323,62

Table n.2.2.3.2.2. – Overview of input data – Austrian PV system.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx
Note: In both variants, the necessary technological items are allocated, including other necessary services. Such as the provision of human resources for the implementation of the FVE system, the implementation of the revision tests, the project itself + the engineering work, etc.

Total amount of investments: -14 323.62 EUR for complete realisation of PV system up to 10 kWp.

2.2.4. Economical evaluation

For an appropriate economic evaluation of both variants we have chosen the economic criterion of net present value (mostly known as NPV). This criterion can be used because we are able to determine a discount rate (r), such as the time which represents value of the money, the chance to "invest somewhere else". And then we have set the same comparison time for both variants (T_c). In addition, we calculated IRR internal rate of return (%) and discounted payback time (years).

2.2.4.1. Economic option and usage, common parameters

Common parameters

specified (nominal) discount rate: r = 3% (can be changed in the MS Excel file)
project lifetime T_C = 30 years (comparison time - contains the expected life of the device) – expected period of PV system usage (average time)
specified repair rate for PV system = 0,25 % per year (calculated from investment)
specified repair rate for devices = 1,5 % per year (calculated from investment)

Special parameters for CZECH PV system

Price for single revision of PV system, revision = 150 Eur

- it’s predicted for regular revision for whole PV system – around 1 time per every 4 years

Possibility of subsidy – unfulfilled conditions, no kind of electrical energy accumulation

Special parameters for AUSTRIA PV system

Price for single revision of PV system, revision = 180 Eur, Possibility of subsidy – up to 375 EUR/kWp

Economic option and usage

The first assessment economic criterion is so-called net present value or NPV (net present value). This value is determined as the sum of the discounted cash flows over the lifetime Tz:

Relation to determine net present value:

$$NPV = \sum_{t=0}^{T_c} \frac{CF_t}{(1+r)^t} \text{ [EUR]} \qquad \text{cover. condition: } NPV \geq \max \qquad [1]$$

where:

NPV ... Net Present Value [EUR]

CF_t ... cash flow for t year [EUR]

r ... nominal discount rate [%]

T_c...comparison time [years]

Another investment criterion is the so-called internal rate of return (mostly known as IRR). This criterion indicates the continuous annual return on investment relative to the set discount rate. In general, this is an interest rate at which the net present value of the NPV is equal to zero:

Relation to determine internal rate of return:

$$\sum_{t=0}^{T_c} \frac{CF_t}{(1+IRR)^t} = 0 \text{ [\%]} \qquad \text{cover. condition: } IRR \geq r \qquad [2]$$

where:

CF_t ... cash flow for t year [EUR]

IRR ... Internal Rate Of Return [%]

r ... nominal discount rate [%]

T_c... comparison time [years]

Another criterion is so-called Return on Investment (ROI) method. This is a ratio criterion that considers the profit effect as the investment effect, where the changes in profit generated by the investment characterize the benefit of the investment. This measure is calculated as the net present value of the project (NPV) divided by the total amount of the investment:

$$ROI = \frac{NPV}{INV} \cdot 100 \quad [\%] \qquad [3]$$

where:

ROI ... rate of return on investment [%]

NPV ... net present value of the investment [EUR]

INV ... total amount of investment (investments) [EUR]

The last criterion used is so-called discounted payback time (shortly DPP). This indicator is based on the calculation of a simple payback period, with only discounted cumulative cash flow expected:

Relation to determinate discounted payback period:

$$\sum_{t=0}^{T_c} DCF_t = 0 \ [years] \qquad cover.condition: \ T = min! \qquad [4]$$

where:

DCF_t ... Discounted cash flows [EUR]

r ... nominal discount [%]

T_c... comparison time [years]

2.2.4.2. Sample data from economic model for calculation of used criterions

Sample data of economic model for Czech PV system – only for the first 4 years of annual cash flow

YEAR	0	1	2	3	4
_INVESTMENTS	Realisation				
Photovoltaic panel	-7 293,23				
Inverter single	-1 268,80				
Smart meter	-350,34				
Suporting construction 1 panel (35°)	-1 052,63				
Price of cables and switchboard 1 panel	-751,88				
Package - FVE installation up to 12 kW	-812,03				
Project on PVP	-187,97				
Engineering (OTE, permit, PREdi)	-210,53				
+ Contract / copy	-112,78				
First Revision Report - Commissioning	-150,38				
+ SUBSIDY(46,99 EUR/kWp)	0,00				
_TECHNICAL RENEWAL					
Revision 4th year [EUR]	0,00				-150,38
Repairs - maintenance of PV.Sys [EUR]	0,00	-18,23	-18,28	-18,32	-18,37
Repair-maintenance DEVICES [EUR]	0,00	-24,29	-24,65	-25,02	-25,40
Total annual costs [EUR]=	-12 190,56	-42,52	-42,93	-43,35	-194,14
REVENUE - energy taken (0% overflow) [EUR]=	0,00	1 403,49	1 392,29	1 381,10	1 369,91
CF [EUR]=	-12 190,56	1 360,97	1 349,36	1 337,75	1 175,76
DCF [EUR]=	-12 190,56	1 321,33	1 271,90	1 224,23	1 044,65
kDCF [EUR]=	-10 869,24	-9 547,91	-8 276,01	-7 051,77	-6 007,12

NPV [EUR] =	10 996,38
IRR [%] =	9%
Discounted PP [years]=	10
ROI [%]=	90,20%

Table n.2.2.4.2. – Sample data – Czech PV system

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

Sample data of economic model for Austrian PV system – only for the first 4 years of annual cash flow

YEAR	0	1	2	3	4
_INVESTMENTS	Realisation				
Photovoltaic panel	-8 562,41				
Inverter single	-1 188,00				
Smart meter	-280,00				
Suporting construction 1 panel (35°)	-1 569,91				
Price of cables and switchboard 1 panel	-884,30				
Package - FVE installation up to 12 kW	-1 056,00				
Project on PVP	-250,00				
Engineering (OTE, permit, PREdi)	-288,00				
+ Contract / copy	-65,00				
First Revision Report - Commissioning	-180,00				
+ SUBSIDY(46,99 EUR/kWp)	3 746,25				
_TECHNICAL RENEWAL					
Revision 4th year [EUR]					-180,00
Repairs - maintenance of PV.Sys [EUR]		-21,41	-21,46	-21,51	-21,57
Repair-maintenance DEVICES [EUR]		-22,02	-22,35	-22,69	-23,03
Total annual costs [EUR]=	-10 577,37	-43,43	-43,81	-44,20	-224,59
REVENUE - energy taken (0% overflow) [EUR]=	0,00	2 405,37	2 388,58	2 369,37	2 350,17
CF [EUR]=	-10 577,37	2 361,95	2 344,77	2 325,17	2 125,58
DCF [EUR]=	-10 577,37	2 293,15	2 210,17	2 127,86	1 888,55
kDCF [EUR]=	-8 284,22	-5 991,07	-3 780,90	-1 653,04	235,51
NPV [EUR] =	30 214,81				
IRR [%] =	21%				
Discounted PP [years]=	4				
ROI [%]=	210,94%				

Table n.2.2.4.2. – Sample data – Austrian PV system

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

2.2.4.3. Comp. of the Czech rep. and Austria usage of PV sys.

As we can see in the last section, we tried to implement solar cells in two different building in different countries. One kind of PV system is situated in Vienna and another in Prague. Both of them as we can see for the both houses we calculated to produce 10 KWp. Because of different solar cells and different efficiencies and also different location of two projects we achieved different investment costs. But the positive point, in both projects we have a positive NPV, for Vienna around 30 214 Euro and for Prague around 10 996 Euro.

Comparison	Subsidy [EUR/kWp]	Total costs [EUR]	Total revenues [EUR]	NPV [EUR]	IRR [%]	ROI [%]	DPP [years]
PVS in CZE	not used	-14 722,19	37 233,86	10 996,38	9%	90,20%	10
PVS in AU	375	-13 329,98	63 874,88	30 214,81	21%	210,94%	4

Table n.2.2.4.3. – Overview of resulting data.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

From these results it can be seen that the realization of the photovoltaic system on the territory of the Czech Republic is less demanding than investment in the same system but on the territory of Austria. On the other hand, the final NPV is practically 3 times higher than in the Czech Republic after 30 years in the variant in Austria. At the same time, the proposed system in Austria, according to the economic indicators of IRR and ROI, is more profitable.

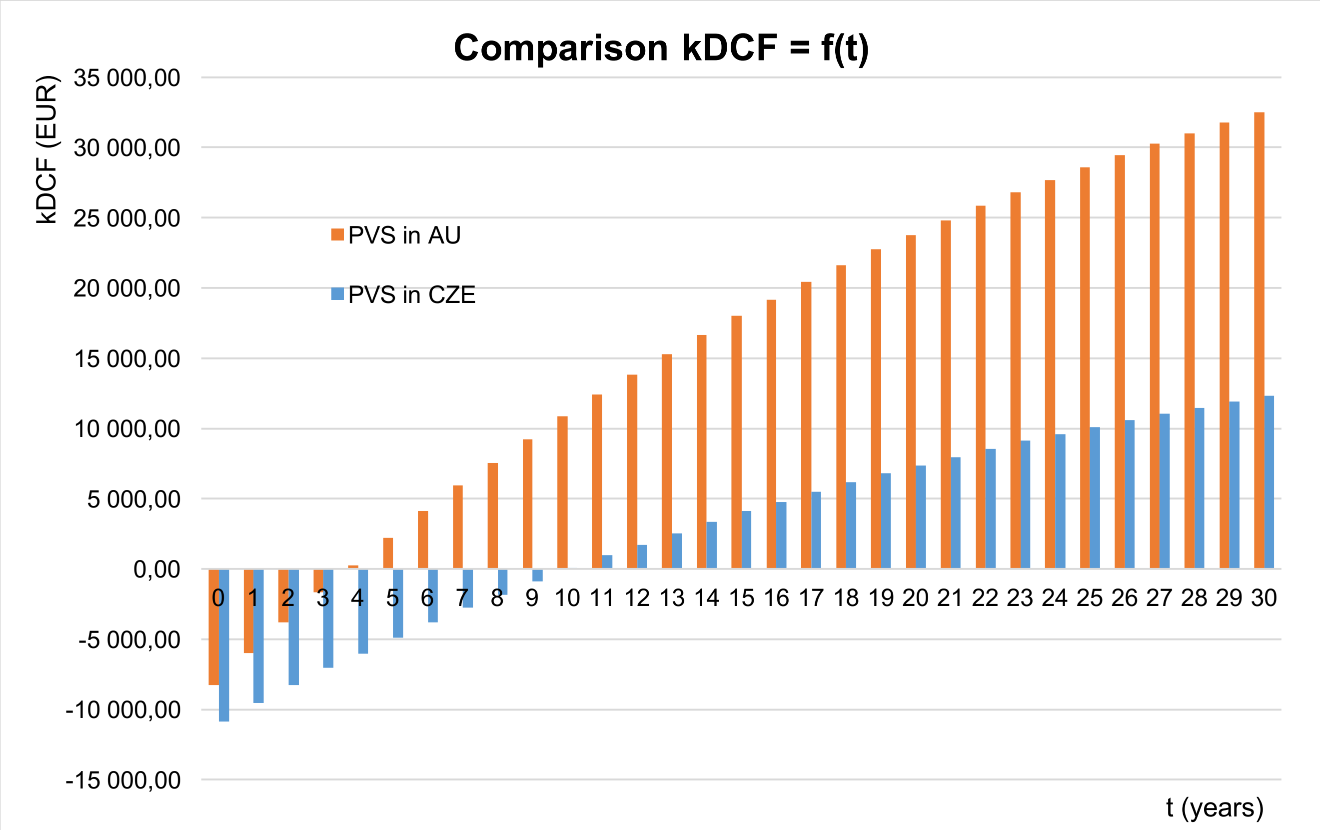

Chart n.2.2.4.3. – Comparison kDCF.

Note: Only sample data, complete data is in the enclosed file HAM.EISA_5.BW_2017.xlsx

In the chart above, you can see when the cumulative discounted cash flows are settled. The first option, which envisages the realization of the photovoltaic system in the Czech Republic, is a discounted return period of around 10 years. On the contrary, there is a half-shorter period in Austria, which is about 4 years.

2.2.5. Final part

2.2.5.1. Approach

How did you go about solving or making progress on the problem?

In order to solve this problem, ie to compare the possible realization of photovoltaic systems in the Czech Republic and Austria, we derived from college studies and practice. In addition, for the economic evaluation, I have calculated the well-known economic indicators with which we have further analyzed in MS Excel.

2.2.5.2. What's the answer?

What's the answer?

We deal with this issue in 2.2.4.3. Comp. of the Czech rep. and Austria usage of PV sys.

2.2.5.1. Conclusion

Solar energy is a resource that is not only sustainable for energy consumption, it is indefinitely renewable (at least until the sun runs out in billions of years).

Solar panels also require little maintenance. After installation and optimization they are very reliable due to the fact that they actively create electricity in just a few millimeters and do not require any type of mechanical parts that can fail. With the encouragement of European Union and the new approach in generating more renewable energies in Austria and Czech Republic we have more generous tax credits for individuals that invest in solar energy systems. As we tried to show in this paper there is a bright future in investing for solar power cells both in Austria and Czech Republic.

Based on our calculations, ie the economic model that we have in the enclosed file, we have to make a clear decision on the realization of the photovoltaic system on the territory of Austria (the resulting data and results are contained in chapter no.). This is because, in the Czech Republic, it has been profitable to implement similar systems in the past because they have been subsidized and not legally limited. This has changed dramatically in recent years, and since then these systems have not only been virtually unsupported, but it is difficult to implement them at all. On the contrary, in Austria, the social goal is now to develop renewable energy sources, so-called green electricity. As a result, the situation for the realization of photovoltaic panels is much easier than in the neighbouring country of the Czech Republic.

3. References

3.1. List of used sources

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3.1. Attachements

This work is accompanied by one MS Excel file named: **HAM.EISA_5.BW_2017.xlsx**