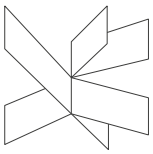

Solar Panel (PV) Cleaning System

University of Applied Sciences Augsburg

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Exchange Project

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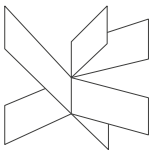

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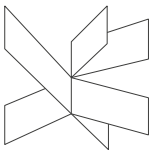


List of figures and tables

1 Background description

Regenerative energies are becoming more and more attractive. Not only for bigger investors, but also for private households. In recent years, the installed capacities of photovoltaic energy generation had their greatest growth. In the following statistic illustration (Figure 1) there is a comparison of all energy production systems in Germany and their development from 2007 to 2017.

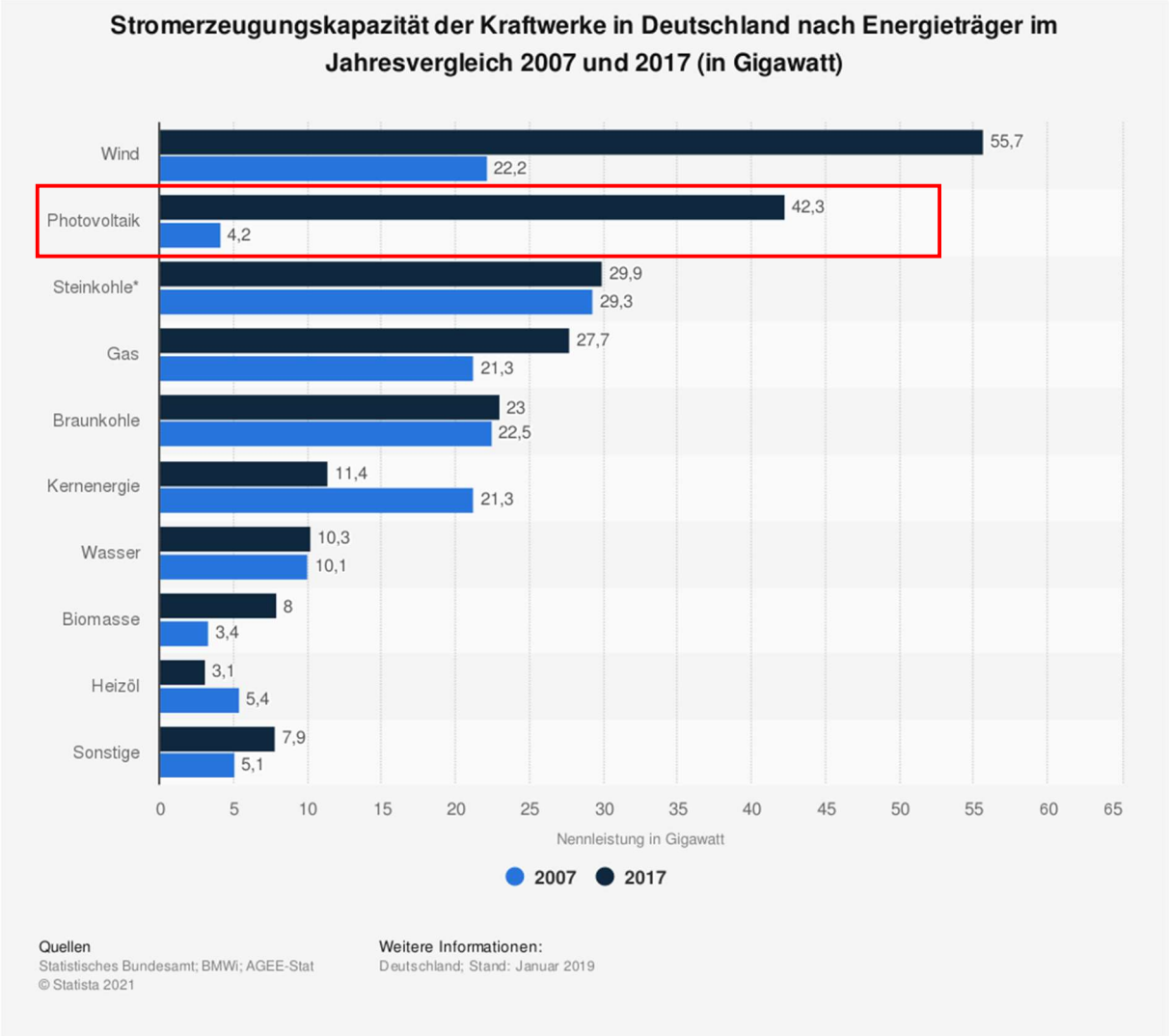


Figure 1: Energy generation development [1]

Photovoltaic has grown tenfold in just ten years and is now a large market and attractive for investments [1]. The solar power system converts solar energy into electricity. Usually solar panels are installed in big solar fields or on roofs.

Due to the fact that solar panels can only achieve an efficiency of 10% -as comparison a hydroelectric power plant can gain up to 90%- [2, p.750], it is important to get the highest possible yield. Analyses have shown that photovoltaic systems can lose up to 20% of its total power due to layers of dust, sand and other pollution on the panel [3]. That is why it is important to clean the solar panels in regularly to avoid losses in power generation (Figure 2). This problem occurs in commercial solar parks as well as in the private sector.

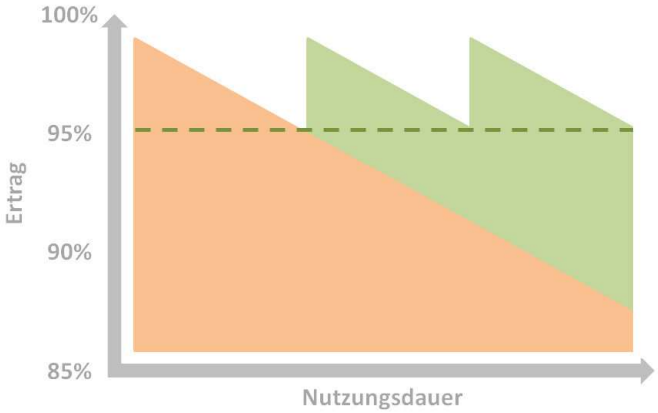


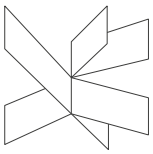
Figure 2: Efficiency with and without cleaning [1]

There are already many solutions for solar panel cleaning on the market. In Figure 3,4 and 5 you can see three different approaches. They are all leading to the same result but with different efficiency, usability and costs. Especially for private use there are no products available which are effective and low-priced. That is why private owners usually have to choose between cleaning the system by hand, which can lead to dangerous situations or contacting a cleaning company and paying up to 3€/mm² with a travel flat rate of 80€ [3].

Figure 3: Cleaning brush [4]

Figure 4: Cleaning traverse [3]

Figure 5: Cleaning roboter [5]



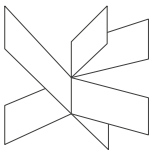
2 Definition of purpose

The overall motivation for developing a cleaning system for PV-Panels is to avoid losses in admission of solar energy in order to enable private users to reach a higher efficiency in generating electric power out of the sunlight. Therefore, the system´s costs itself and also the costs of use must be low combined with a high ease of use.

3 Problem Statement

The main task of this project is the development of an automatic, cheap PV-cell cleaning device for private users.

- Technical specifications
  - Function
    - Which solutions exist already?
    - How often shall the system be used annually?
    - Will it need electricity?
    - Will the device be permanently installed on the roof?
    - How to attach the device to the PV-cells?
    - Which cleaning means could be used?
    - Which liquid cleans the best?
  - Production
    - Which tools/machines are required to assemble the bought parts?
    - Which parts will be bought?
    - Which parts will be standard parts/customized?
    - How will the product be delivered?
    - How will the product be stored?
  - Product
    - How long is the lifetime of the product?
    - Is it user-friendly?
    - Which quality standard should be met?
    - Is servicing needed and how often?
    - Which materials are required?



- Economic specifications
    - Financing
        - Production
            - How to finance the needed machines/tools?
            - How to finance the needed workers?
            - How to finance the bought parts?
            - Which materials shall be preferred, concerning the costs?
            - Which fix costs exist?
    - Economy
        - Is the product competitive?
        - What's the target group for the product?
        - How large is the existing demand?
        - Which market shall be entered?
    - Are there any predictions for the future?
    - When will the break-even point of the investment in the new product be reached?
- Marketing specifications
    - Who is the target group?
    - What are the costs for effective marketing and advertisement?
    - Which marketing approaches make sense?
    - On which location should marketing be focused?
- Legal specifications
    - Recycling
        - How does the product perform cradle-to-grave and regarding the usage of power and materials?
        - Is it possible to recycle the product cradle-to-cradle?
    - How to file a possible patent?
    - Is there any requirement (e.g., from the government)?
    - Which guarantees must be fulfilled?

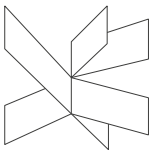


Table 1: Caracteristics evaluation

Characteristics	Evaluation Criteria
Applicable for a big market	Applicable for different types and sizes of solar panels Profitable for private use
The selling price of the product must not exceed the lost profit due to a low efficiency of the panel	Low usage of short resources No usage of resources from areas of conflict Low price
Reliable product for a long period of time (once/monthly?)	Lifetime of 20+ years High reliability Resistant to central-European weather conditions Easy to maintain / replace broken parts Protected against corrosion (salty sea air) Maximizing the usage of standard parts
Easily accessible for private households	Easy installation Lightweight Automatized No maintenance needed or very easy to maintain
Environmentally friendly	Recycling possible Low usage of resources (water/energy) No toxic materials / chemicals used No contamination of the environment due to e.g. leakage of oil
High safety measures	May not cause short-circuits May not drop from the rooftop May not damage the PV-system Protection against extreme weathers (e.g., lightning, storms...)

4 Delimitation

Due to the limited time frame, limited resources and the education of the team members, this project will only deal with a part of the questions asked in the problem statement. The following table 2 lists the problems which *will not* be researched:

Table 2: Delimination

Main Problem	Sub-Problem	Comment
Technical specifications	Production	This sub-problem shall be excluded due to the tight time frame of the project.
Economic specifications	Financing	This topic shall be excluded due to the tight time frame and missing knowledge in the team.
Economic specifications	Are there any predictions for the future?	This topic shall be excluded due to the tight time frame and missing knowledge in the team.
Economic specifications	Calculation of the break-even point	This topic shall be excluded due to the tight time frame.
Marketing specifications		This topic shall be excluded because of the tight time frame and the fact that no team member has any experience with creating a marketing campaign
Legal specifications		This topic shall be excluded because of the tight time frame and the fact that no team member has any experience with solving legal problems

5 Choice of models and methods

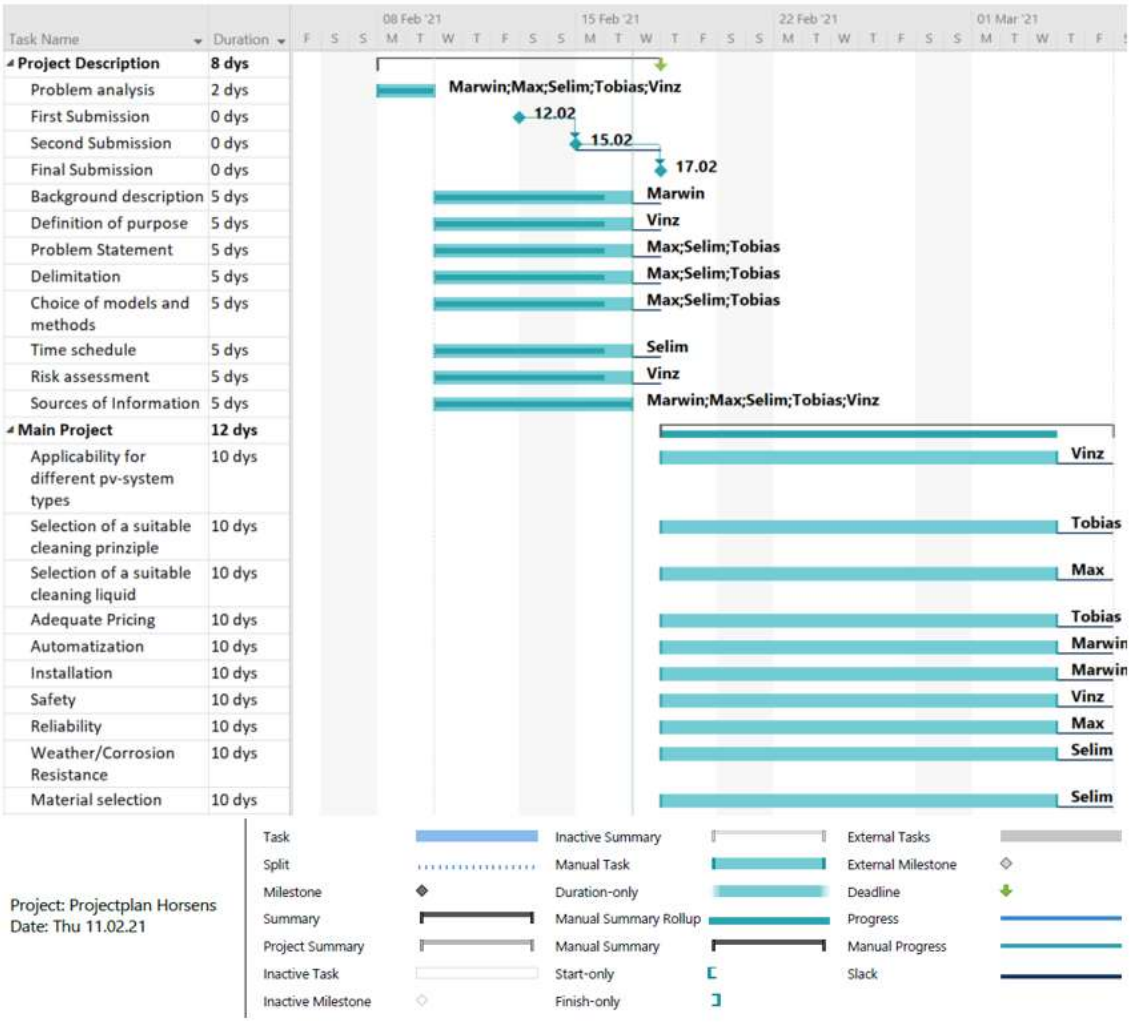
Table 3: Choice of models and methods

What?	Why?	Which?	Which?	Who?	What?
partial problem	study this problem - related to the purpose of the project	level of outcome is expected	methods/models/theories will be used	in the group is responsible for this point	is the estimated workload (hours)
Applicability for different pv-system types	Increase of the projects potential market	Adaptable for different pv-systems - compatible with common german water/power supply connections	data research - mechanical engineering knowledge	Vincenz Egner	50
Selection of a suitable cleaning prinziple	Define functioning prinziple of the product	A suitable prinziple	mechanical engineering knowledge - data/ research - existing competition market comparison	Tobias Metzger	50
Selection of a suitable cleaning liquid	The use of a suitable luqid is necessary for the products success	The Selection of a suitable liquid for the cleaning system	data research - mechanical engineering knowledge	Maximilian Binz	50
Adequate Pricing	Affordable and profitable for customers	Simple effective design - Cheap to manufacture	market analysis - cost calculation - mechanical engineering knowledge	Tobias Metzger	50
Automatization	Simplification of functionality to generate more customers	Automatized cleaning process possible	mechanical/electrical engineering knowledge	Marwin Seifert	50
Installtation	System must be attached to the pv-system	Cheap and simple installation design	mechanical engineering knowledge	Marwin Seifert	50
Safety	Low Risk for customers	Secure handling/attachment - low risk of damage to the pv system - no risk for short-circuits	mechanical engineering knowledge	Vincenz Egner	50
Reliability	Product must be able to function for 20 years+ (pv-system lifetime)	Long lifetime - high reliability - easy to maintain	material science - mechanical engineering knowledge	Maximilian Binz	50
Weather/Corrosion resistance	Useability under hard weather conditions	Harsh weather conditions and corrosion resistant cleaning system	mechanical engineering knowledge	Selim Saglam	50
Material selection	Cheap, ecological design	Selection of suitable materials and parts for system construction	Material Science	Selim Saglam	50

6 Time schedule

The temporal documentation and classification of the tasks as well as milestones is done with the help of the software MS Project and is shown as a Gantt chart in Figure 6.

Figure 6: Time schedule

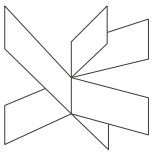


Task Name	Duration
Project Description	**8 dys**
Problem analysis	2 dys
First Submission	0 dys
Second Submission	0 dys
Final Submission	0 dys
Background description	5 dys
Definition of purpose	5 dys
Problem Statement	5 dys
Delimitation	5 dys
Choice of models and methods	5 dys
Time schedule	5 dys
Risk assessment	5 dys
Sources of Information	5 dys
Main Project	**12 dys**
Applicability for different pv-system types	10 dys
Selection of a suitable cleaning prinziple	10 dys
Selection of a suitable cleaning liquid	10 dys
Adequate Pricing	10 dys
Automatization	10 dys
Installation	10 dys
Safety	10 dys
Reliability	10 dys
Weather/Corrosion Resistance	10 dys
Material selection	10 dys

7 Risk assessment

Table 4: Risk assessment

Risk Assessment							
Risk	Description	Likelihood Scale: 1-10 10 = high risk	Severity Scale: 1-10 10 = high risk	Product of Likelihood and severity	Risk mitigation e.g. Preventive & Responsive actions	Identifiers	Responsible
1	Lack of time	5	10	50	Strict control of time schedule; Work on weekends;	Stress; Blaming others; Project can´t be finished	Team
2	Data Migration	6	7	42	Using same/ co-operating systems/programes	Data loss; data transfer difficult or impossible	Team; everyone himself/herself
3	Lack of communication	4	8	32	Regular & frequent meetings; adressing any problem instantly	Individual project-parts don´t fit together; misunderstanding	Team
4	Getting ill	5	6	30	Avoiding contacts; taking care of immune system	Time pressure; inability to work	Everyone himself/herself
5	Lack of documentation	4	7	28	Keeping logbook; keeping strict order of notes	Misunderstanding; doubled work; no documentation	Team; everyone himself/herself
6	Planing a too laborious product	3	7	21	Keeping track of time schedule; sorting out unimportant work	Project can´t be finished; stress; time pressure	Team
7	Internet breakdown	3	6	18	Keeping internet contracts updated; paying bills	Inability to work; inability to comunicate properly	Everyone himself/herself; internet provider
8	Fails of systems or programs	3	5	15	Keeping programs/systems updated; double save files	No access to systems/programs; no access to files	Everyone himself/herself
9	No access to necessary systems	2	7	14	Keeping accounts updated; staying aware of what systems are necessary	Individual steps can´t be carried out; project not complete	Everyone himself/herself
10	Nature force	1	5	5	None	Lack of electricity; effects of natural desasters	Nature



8 Sources of Literature

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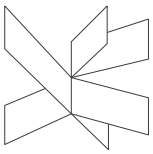


9 Appendices

Group Contract

Group Name (optional): Date: **10.02.2021**

These are the terms of group conduct and cooperation that we agree on as a team.

Participation: We agree to....
split the work equally and work as a Team.

Communication: We agree to...
communicate in a good manner and let everyone speak their mind and listen to them. Then we decide together.

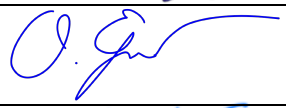
Meetings: We agree to....
meet on a daily basis. At least One meeting in the morning and one in the afternoon from Monday to Friday.

Conduct: We agree to....
act polite and stay fair and help each other.

Conflict: We agree to....
help each other if problems come up.
If there are conflicts in the group, we stay calm and hear all arguments, before deciding together.

Deadlines: We agree to....
stay in time and keep the following deadlines as well as new ones.
12.02.2021: first submission of the problem description
15.02.2021: second submission of the problem description
17.02.2021. submission of the final document “problem description”
09.03. 2021: submission of the final project report

Other Issues:
none

Group member's name	Student number	Signature
Maximilian Binz	311199	
Vincenz Egner	311200	
Selim Saglam	311268	
Marwin Seifert	311202	
Tobias Metzger	311201