



An-Najah National University
Faculty of Engineering
Department of Mechanical Engineering

Graduation Project II
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**“Experimental investigation to find
the optimum cleaning
frequency of PV panels in Palestine:
A case study-Tulkarm.”**

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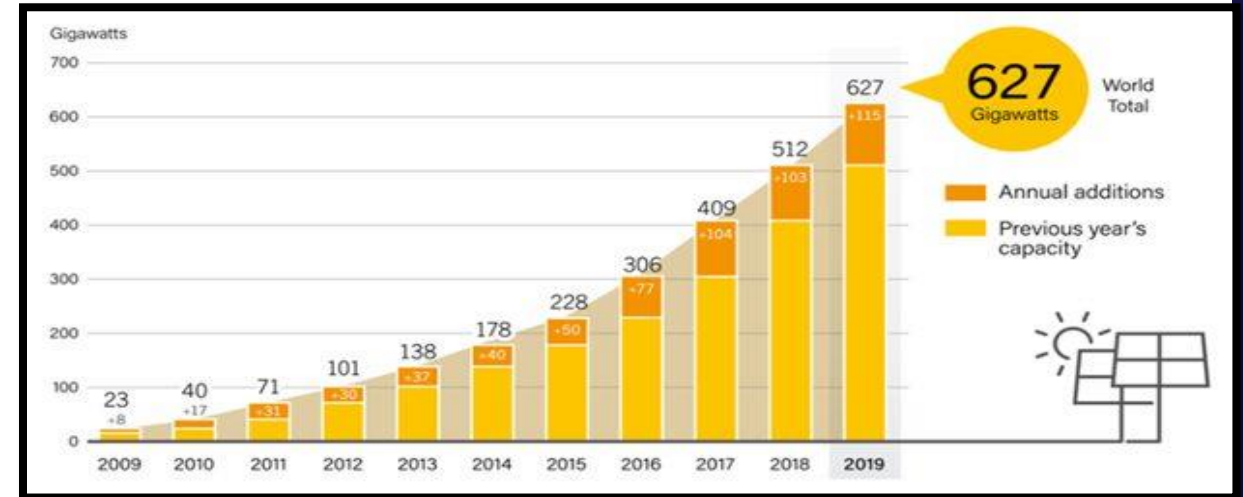
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Introduction:

- Solar energy becomes one of the most important renewable energy sources since it is clean and friendly with nature, also it does not require anything to be generated but sunshine.
- Solar energy production increased from 62.664 GW in 2015 to 115.973 GW in 2018 which is a massive growth in the industry of PV modules.

Introduction:

- Countries like Honduras and Italy have a percentage of 10.7%, and 8.6% as a share of electricity generation from PV panels in 2019.
- The improvements in the field of energy production is increasing rapidly ,that will help to protect nature from pollutants that comes from CO2 emissions when producing electricity using fossil fuels .



(Photovoltaic Power Potential ,Source : IEA PVPS Report)

Problem Description:

- As any Engineering system there are some obstacles that made a problem with a drop in the performance of PV panels' system such as : High temperatures and Dust accumulation .
- Dust can affect the efficiency of the PV panels massively specially in desert areas so the need of cleaning must be discussed.



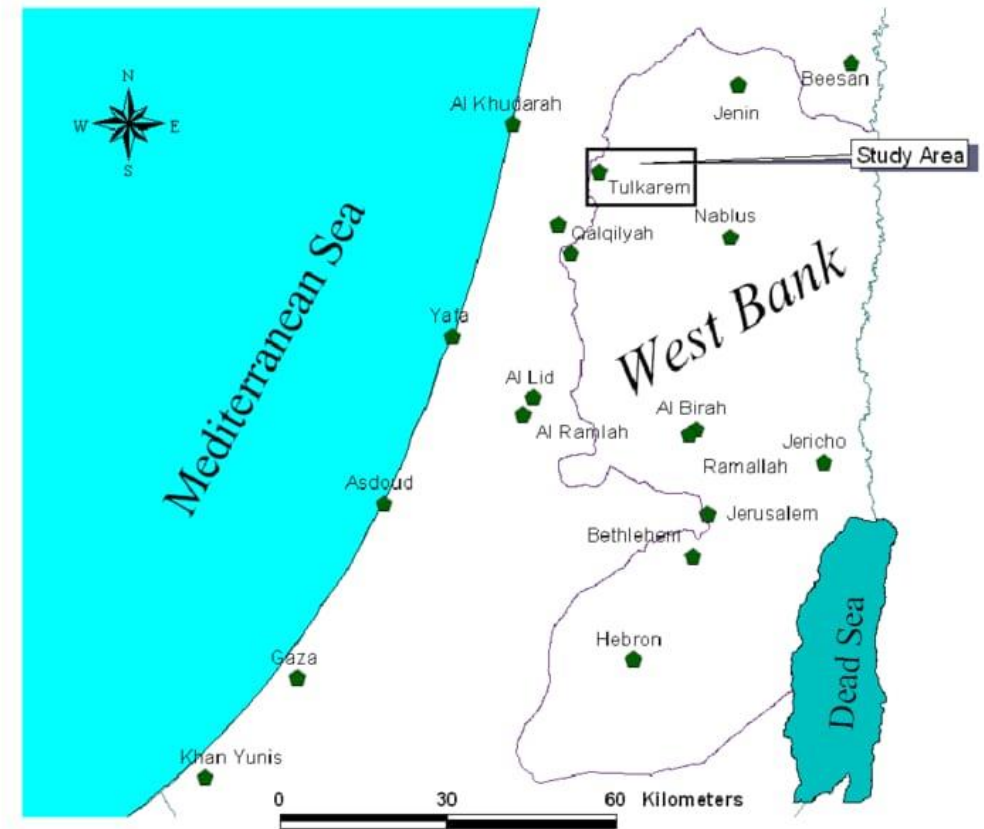
How to Find the Optimum Cleaning Frequency ?

- Many studies had put many theories and approaches to predict the optimum cleaning frequency and as it depends on many factors the predictions are not so accurate so that clearly an experimental study will give more accurate results and recommendations.
- That is what has been done in the experimental study of this Project. Methodology and Results of the experimental study will be presented in the next few slides.



About Case Study-Tulkarm:

- The experimental study was done in order to compare the difference in power production when using different cleaning frequency to PV panels in the same conditions.
- Study info :
 - Location: Tulkarm.
 - Period of study : 3 Months.
 - PV power plant capacity =84.5 kw.
 - PV modules properties : 330 W Trina poly-crystalline panels (AMERISOLAR), 4 inverters of 25 kw each one connected with 64 PV modules, Module Efficiency (%) =17.0.



About Tulkarm City Characteristics:

- Location: Latitude :32.19 °N, longitude: 35.01° E.
- Elevation: 83 m.
- GHI of Tulkarm is less than 2200 Kw.h/m².Year

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ref
Monthly Total Rainfall(mm)	305.9	122.9	6.7	28	1.8	0	0	0	0	14	65.4	329.8	[44]
Mean Monthly Maximum Temperatures(°C)	17.2	20.9	22.7	23.9	29.8	29.9	31	31.1	30.7	28.2	24.6	18.4	[44]
Number Of Rainy Days	15	6	3	6	1	1	0	0	1	2	9	13	[44]
Mean Monthly Wind Speed (Km/h)	5.53	4.05	4.24	4.98	5.53	5.16	5.35	4.98	4.42	4.42	3.50	5.53	[44]
Mean Monthly Relative Humidity (%)	69	60	56	64	53	63	63	65	63	55	56	69	[44]

Climate Conditions Characteristics in Tulkarm City in 2018.

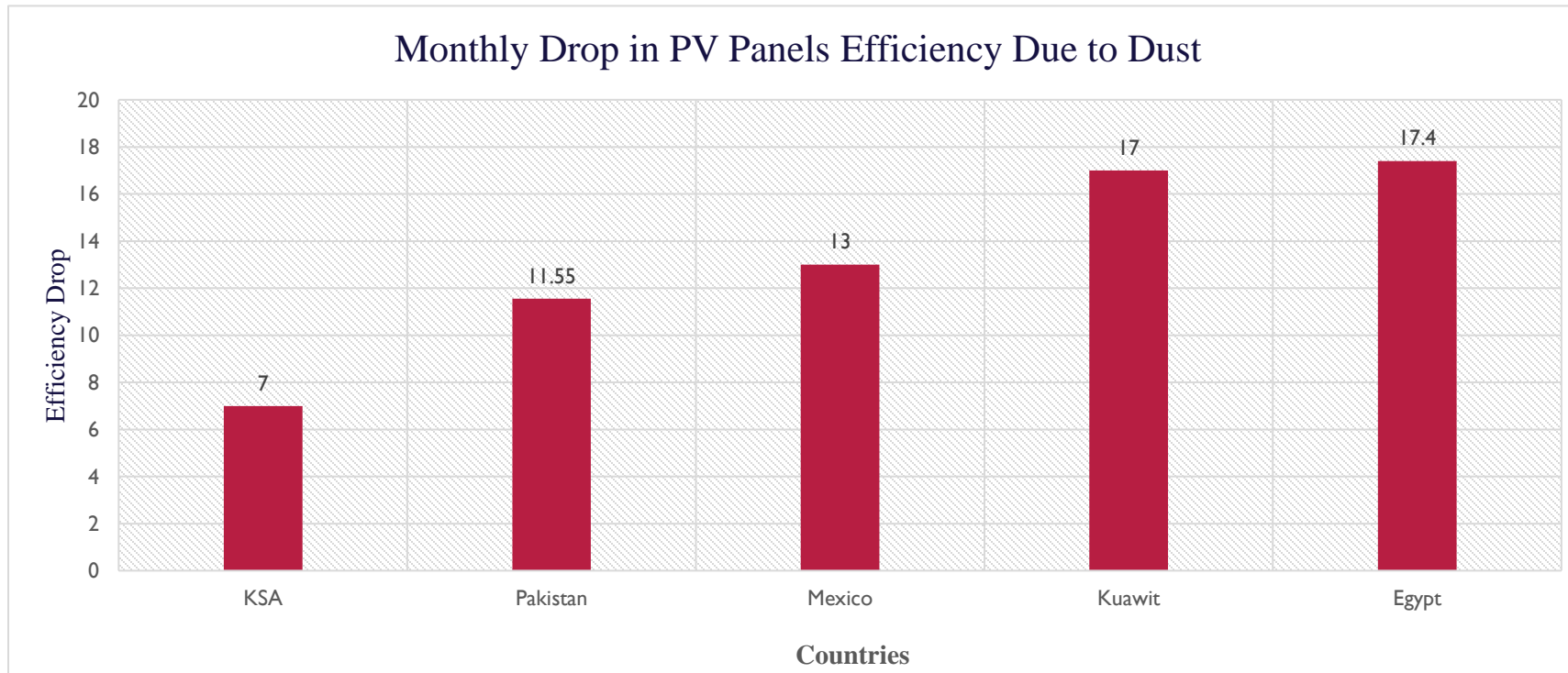
About Green House Gas Emissions in Tulkarm:

- The residential building consumes 51% of the total consumption of the city with 161 GWh/year) and GHG emission (43% with 82 ktCO₂eq/year), Transport, residential buildings and waste management are the largest emitters of greenhouse gases and account for 83% of Tulkarm's emissions.



About Literature Review:

- Effect of Dust : Dust can cause a huge drop in PV system efficiency, this was noticed through experimental studies, they also found out that desert climates affected badly because of dust.



About Literature Review:

- At Oman muscat there was an experimental study where they applied monthly cleaning by water, there was 20% difference of power production between the cleaned and the uncleaned panels .
- At Qatar with weekly cleaning manually ,they found an improvement in the power output which was 7.7% winter and 3.1% in summer compared to the uncleaned panels.

Procedure of the Experimental Study:

- The cleaning was done on 4 groups of panels, each one has a different cleaning period, the cleaning frequencies are 1 week, 2 weeks, one month and 2 months, manual cleaning was done just before sunset, water was used in this experiment and the readings of the output PV power for each group of panels were taken weekly.

PV Modules Cleaning Experiment:

- The cleaning process in Tukaram was done from 3/3/2021 until the end of May 2021.



The PV Project Used in the Experimental Section in Tulkarm.

Results Calculations:

➤ Sample of calculations:

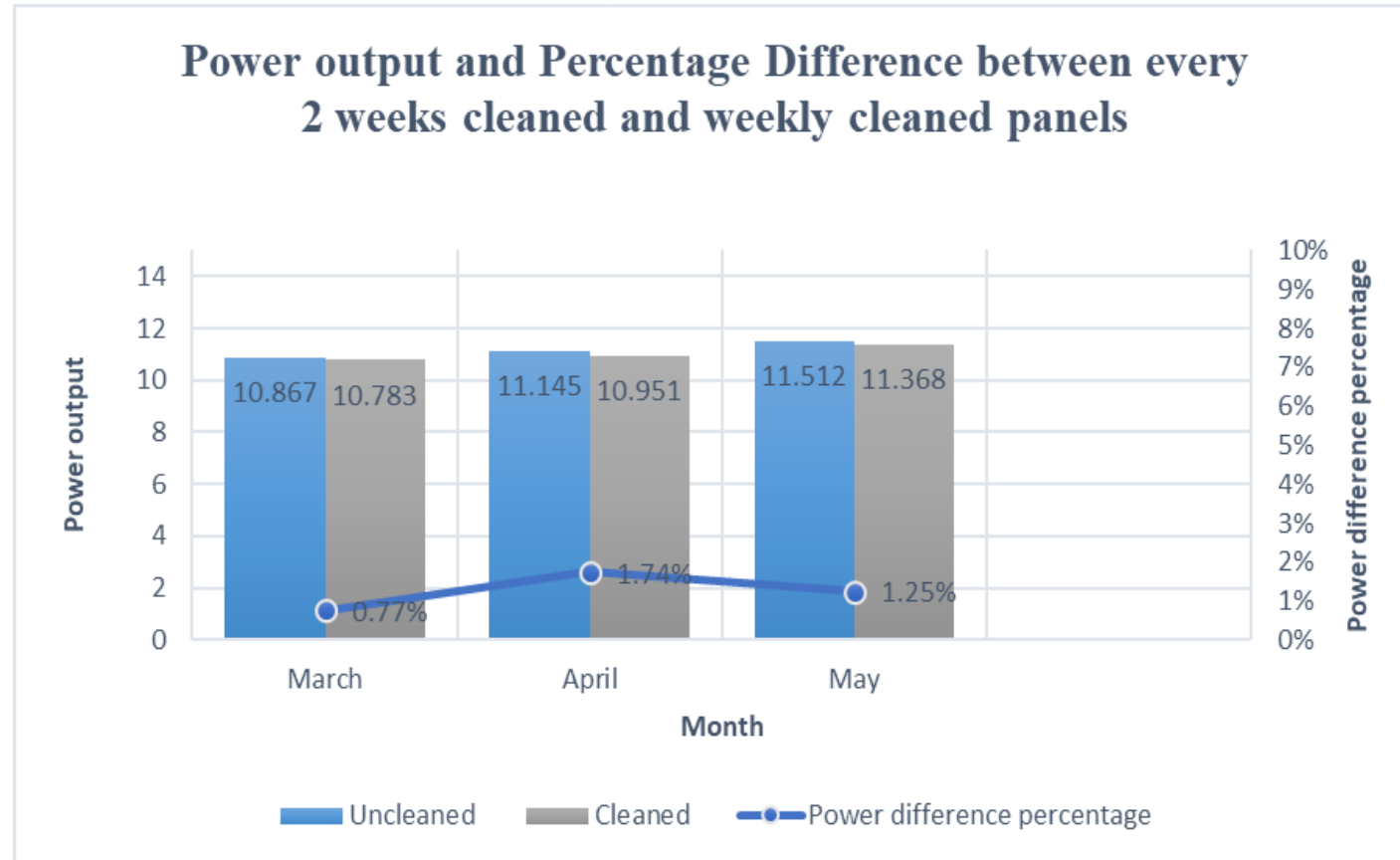
The calculation of power difference was calculated using the following equation:

$$\Delta P = \frac{P_c - P_{cd}}{P_c} \times 100\%.$$

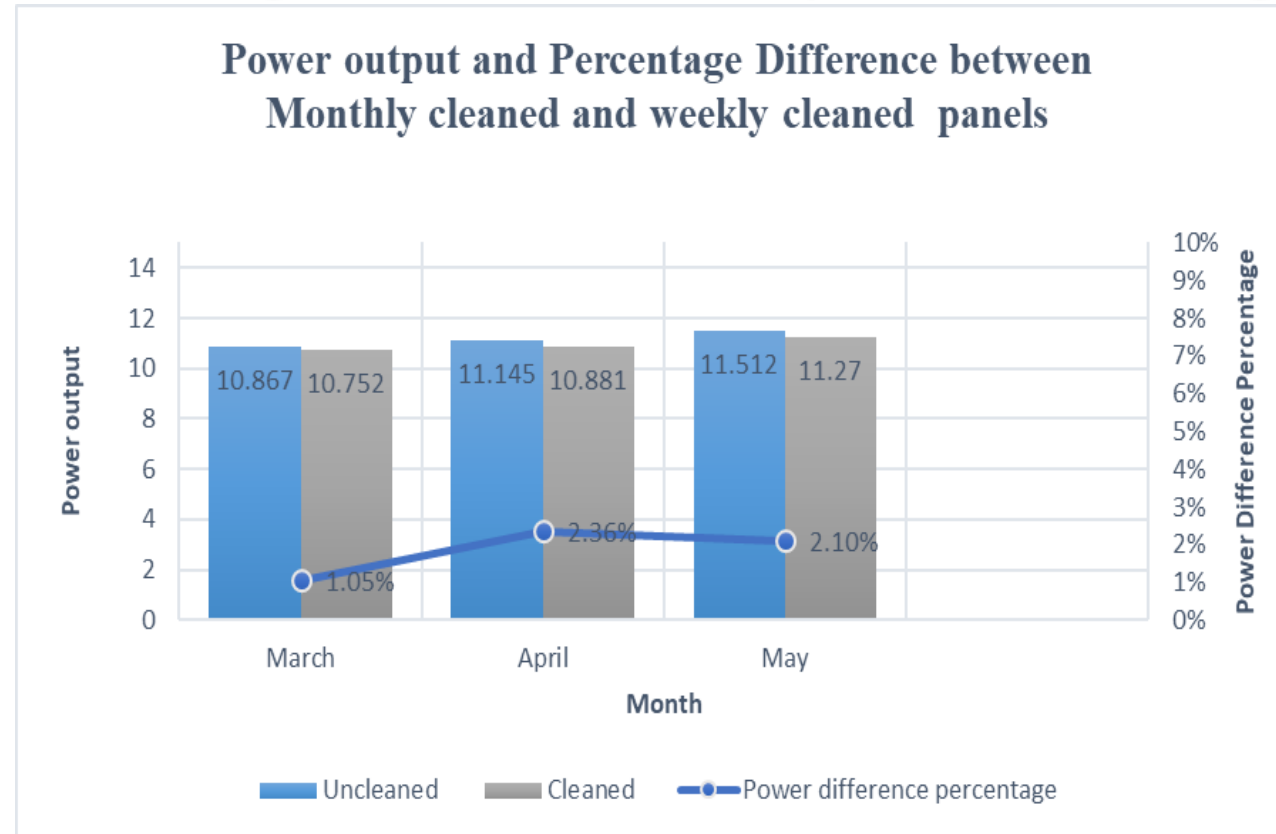
Where P_c is the weekly cleaned panels and P_{cd} is the regular cleaned panels in the following calculations it is the panels that were cleaned every 2 weeks.

$$\Delta P = \frac{10867 - 10783}{10867} \times 100\% = 0.77\%.$$

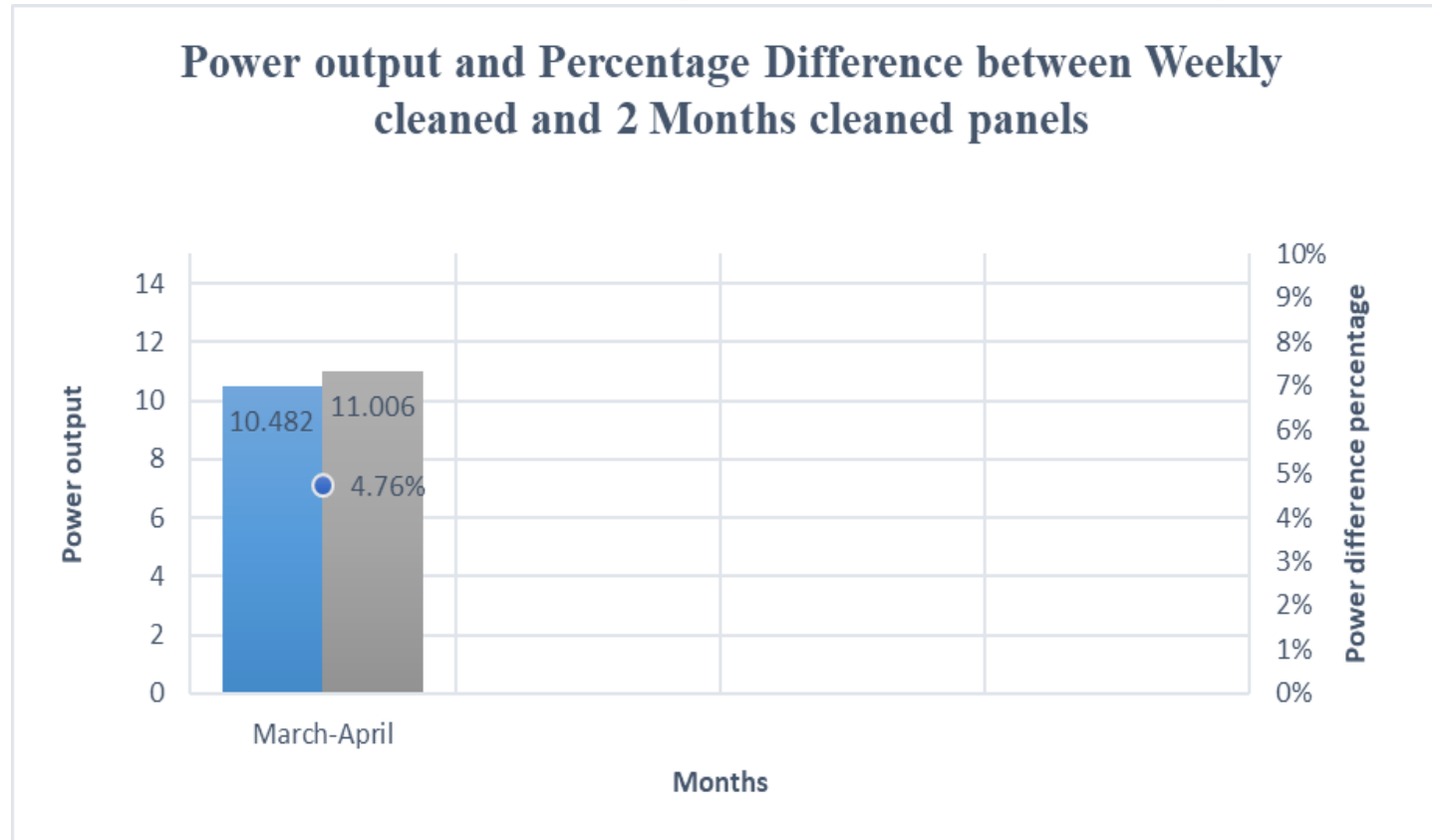
Every 2 Weeks Cleaning VS. Weekly Cleaning:



Monthly Cleaning VS. Weekly Cleaning:



Every 2 Months Cleaning VS. Weekly Cleaning:



Results Summary :

- The results show that the reduction in power don't exceed 2% (which is the operational manual instructions value) in the case of 2 weeks clearing but it has exceeded it in the case of Monthly cleaning so mainly the preferable cleaning frequency is Monthly cleaning, However other factors may change this recommendation, that will be discussed in conclusion section .

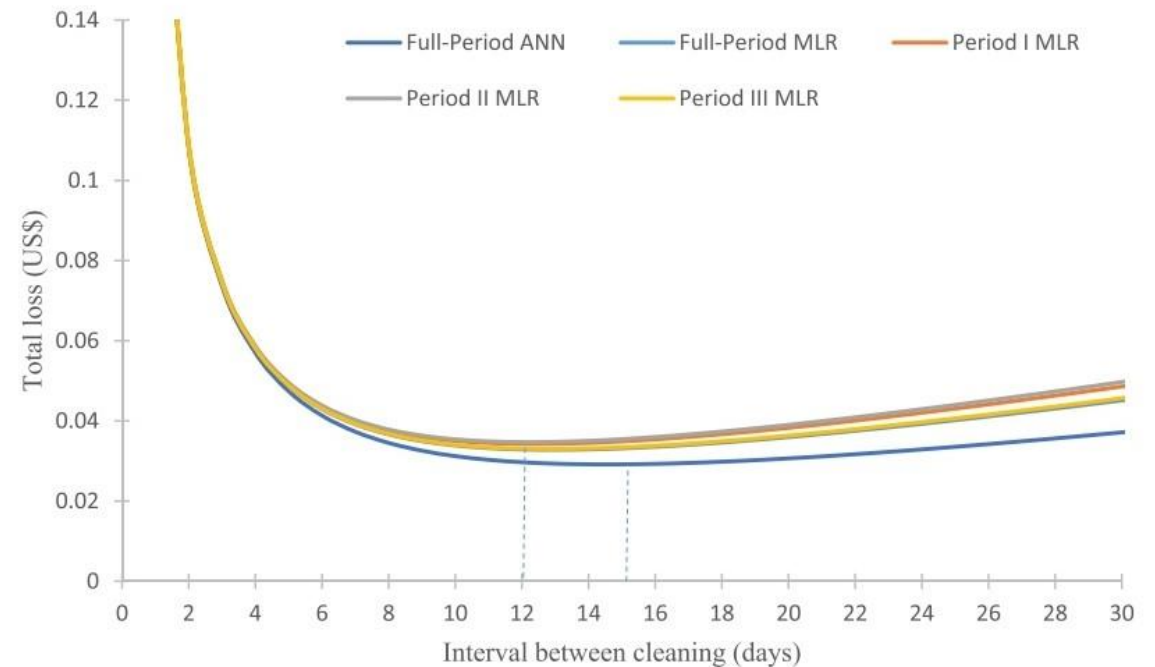
Discussion and Comparisons of Studies:

Comparing some studies with the outcomes of the presented study in this report :

- In a well-known study, Monto Mani recommended that for Mediterranean countries the Cleaning of the solar panels is recommended once a week or 2 weeks depending on the rate of dust accumulation on the surface of the PV modules, this recommendation is considered an important one but is not specific enough.

Discussion:

Furthermore comparing with the study of Bashar Hammad in Jordan, where the optimum cleaning frequency was from 12-15 days and depending on it, in graduation project 1 the expected cleaning frequency for PV panels in Palestine was 10-15 days in summer and 2-3 weeks in winter which is so close to the results found in the project experimental study.



Total Average Daily Losses Due to Cleaning Cost and Dust Accumulation, Showing Minima Between 12 and 15 Days as the Period Between Cleaning (Optimum Cleaning Frequency).

Conclusions and Recommendations:

- The experimental study which was done in Tulkarm for 3 months period shows that cleaning the panels every two weeks led to average power loss of 1.25% compared to weekly cleaning, this loss is not considered as a big loss as the operational manual instructions value told that the percentage that worth cleaning is 2% at least.

Conclusions and Recommendations:

- As for monthly cleaning the average power loss for April and May was 2.23% which require cleaning, as for March, the rain occurred in 2 different weeks of the month and this played a role in reducing power loss by natural cleaning which significantly reduced power loss.
- As for two months cleaning it was found that it will cause a massive reduction in power since the percentage power difference between two months and weekly cleaning was 4.76%, it obviously means that the panels should not be left without cleaning for a long period of time.

Conclusions and Recommendations:

- The results of the experimental study are that the optimum cleaning frequency for PV so panels in Tulkarm city in Spring is monthly cleaning and it is preferable to clean the panels every two weeks in the months where dusty storms occur., as for other cities in Palestine it is expected to have similar results as the cites are having similar climate conditions and geographical characteristics .



Limitations:

- Some randomness in the founded values in the results section in this experimental study is normal due to the short period of study, a long study period can eliminate the randomness and some other outside factors that are not intended to be included in the study.

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THANK YOU ALL!
Any Questions?