THE MANGROVE PLATFORM TECHNOLOGY

OPTIMIZATION AND INTEGRATION OF A PREHEATING SYSTEM

Abstract: Planet is an Italian startup aiming to tackle afforestation in dryland areas, leveraging saltwater sources as a sustainable solution. This report centers on my role in the company, tackling a bio inspired analysis of ideas to optimize the Mangrove Technology Platform. Our chosen strategy involved the design and integration of a preheating system. Throughout testing, this preheating system encountered various challenges, including the inability to reach the most efficient water temperature stipulated in literature. Simultaneously, we conducted an array of experiments, altering unit configurations with the introduction of wick material and reducing its flow rate. The most promising results emerged when incorporating wick material, decreasing the flow rate to 1 L/h, and feeding the units with a water temperature of 65 degrees Celsius — the maximum achievable temperature with the system's current layout constraints. This work shed light on how to proceed with the next steps for the optimization of Planet's technology.

Key words: biomimicry, afforestation, desalination, carbon credits.

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1. INTRODUCTION

CONTEXTUALIZATION

41.3% of the global terrestrial area is categorized as Dryland, being home to 40% of the global population, holding 35% of the global Biodiversity Hotspot Areas, and containing 28% of the total World Heritage Sites. Land degradation in the drylands, also known as desertification, is a major global concern because Dryland encompasses some of the most important land use systems (Davies et al., 2015; Stringer et al., 2021). In fact, live is difficult in the drylands, considering that 72% of these dryland territories occur in developing regions. What is more, almost 100% of the hyper-arid lands are found in developing countries (Davies et al., 2015).

Drylands are tropical and temperate areas that are currently experiencing temperature rises higher than the global average, with a projection of an increase of 2°C to 4°C by 2100 under higher emissions scenarios. Besides, water availability is key limiting factor in drylands, as precipitation balances evaporation from the land and vegetation surfaces and shapes their extension (Stringer et al., 2021). In fact, 50% the world's population already experience severe water scarcity during the year, and most of these people live in drylands (Calvin et al., 2023; Stringer et al., 2021).

These upcoming challenges of climate change combined with crucial water management decisions will have profound impacts on drylands and their inhabitants. Thus, new approaches are required to solve or mitigate the presented prospect. Investing on reforestation is proven to have a positive impact on dryland given by the large amount of ecosystem services it provides (Löf et al., 2019). To be more precise, practices of protective reforestation can prevent soil erosion, regulate water fluxes, enhance biodiversity and biomass production and protect reservoirs and other infrastructures from siltation (Del Campo et al., 2020).

In the last decade, initiatives aimed to combat the effects of climate change have entered the carbon credit market as a source of funding. This has created a new economic flux between innovation and carbon sequestration from enterprise activities.

CARBON CREDIT MARKET

Removing carbon from the atmosphere and cutting our greenhouse gases emissions to stay within the 1.5 °C warming target set by the UNFCCC Paris Agreement is a global urgency. Nevertheless, some industries are not able to completely decarbonize now and must make use of the carbon credit market. The concept of carbon credits has emerged as a pivotal instrument in the global effort to mitigate climate change (Lehner & Moya, 2023). Carbon credits are tradable permits that allow organizations and individuals to offset their greenhouse gas emissions by investing in carbon reduction projects. One carbon credit represents the reduction or removal of one metric ton of carbon dioxide (CO2) or its equivalent in other greenhouse gases. Initiatives that reduce emissions, enhance carbon sequestration, or promote renewable energy sources generate carbon credits (Kenton, 2023; Ren et al., 2022).

The carbon credit market plays a crucial role in several aspects, encouraging emission reduction activities by providing financial incentives when sustainable practices and projects are carried. Still, it is multifaced system that depends on a strong scheme to generate trustworthy carbon removal credits. According to Lehner & Moya, 2023, high-quality carbon credits must follow a validated methodology under a recognized Standard, undergo third-party verification, and be retired on a public registry. Starting in the supplier level, a project that conducts carbon removal activities is validated and verified by accredited entities (VVBs). Then, these activities are followed in the long term by digital Monitoring, Reporting, and Verification (dMRV) platforms. Finally, these carbon credits are ready to be purchased by the buyers. This collaborative system fosters trust, transparency, and scalability in the carbon credit market (Figure X).

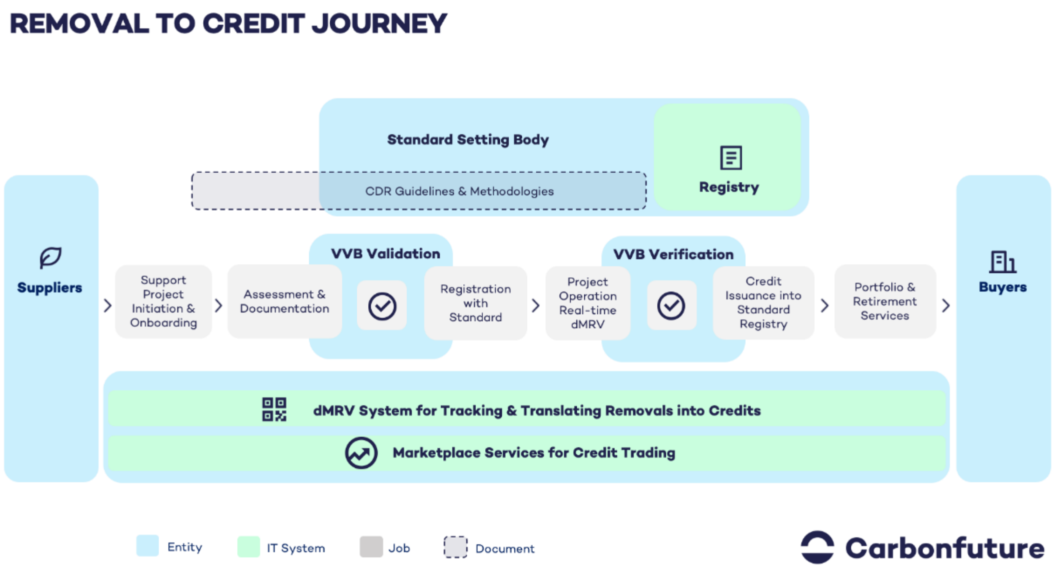

Figure X. Scheme of the carbon credit market (Lehner & Moya, 2023).

As previously stated, reforestation and afforestation projects are often funded by carbon credits, because they contribute to biodiversity conservation and carbon sequestration. At the same time, they encompass an essential tool in helping nations achieve their emissions reduction targets as outlined in international agreements. Embedded in this mindset, this internship was performed in the company Planet, which positions itself in this scheme as a supplier and technology provider for afforestation projects. In the following section, its activity will be explained in depth.

THE ROLE OF PLANET AND THEIR TECHNOLOGY

Planet is an Italian company positioned in the "bio-inspired engineering" sector, which is actively engaged in European and international collaborative projects. The focal point of PLANET's is the development of new technologies for afforestation in dryland areas. For that reason, they have created the Mangrove Technology Platform (MTP). The MTP is a system of chained mechanisms that, in broad strokes, can capture saline water and transform it for effective irrigation and plant growth (Figure X).

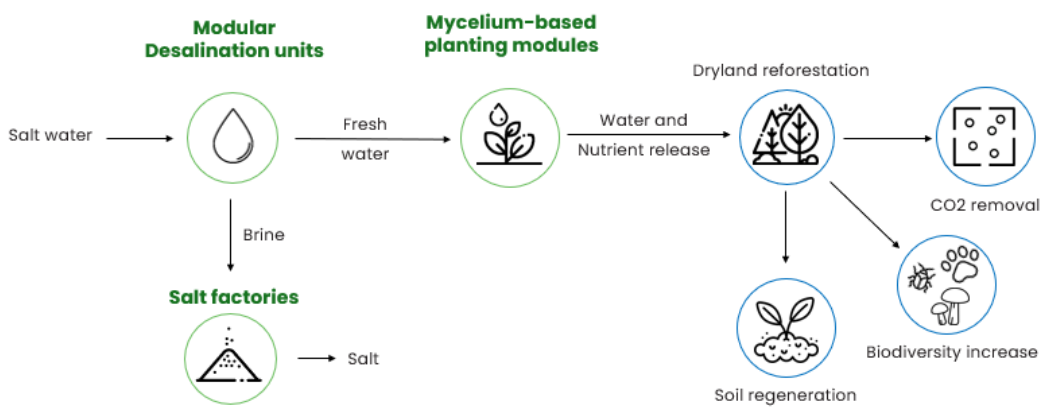

Figure X. Scheme of the MTP.

The field work of this research was carried in one of their testing sites: HYDRO5 in Tinos Island. Next to the reverse osmosis (RO) plant of the island, they installed a system of water desalination (the Mangrove Still System, MSS) for the irrigation of a greenhouse, providing a small-scale and more environmentally sound alternative to the RO plant (Figure X). The MSS consist in rows of solar still units that take seawater from a natural reservoir and enhances its evaporation across multiple levels, condensing the vapor in a glass lid on top of the units and collecting the freshwater at the bottom. The non-evaporated portion, referred to as brine, leaves the system through a different output and undergoes further treatment (Figure X).

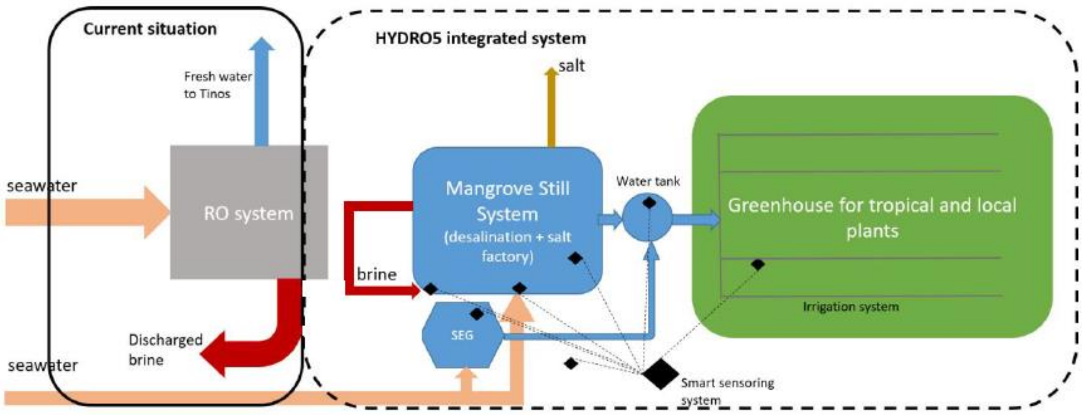

Figure X. Scheme of the HYDRO5 site in Tinos.

Figure X. The MSS of HYDRO5.

The design of the HYDRO5 was carefully tailored to the specific conditions of Tinos Island and the pre-determined Tinos Desalination Plant area. This context informed a range of technical and operational decisions and drove numerous installation improvements after extensive research, all with the goal of reaching a production target of 200 L/day of freshwater and 2 kg/day of salt. Currently, the MSS occupies an area of approximately 250 m2 with 80 units installed and a designated buffer zone of at least 2 meters in width to facilitate installation and equipment movement (Figure X).

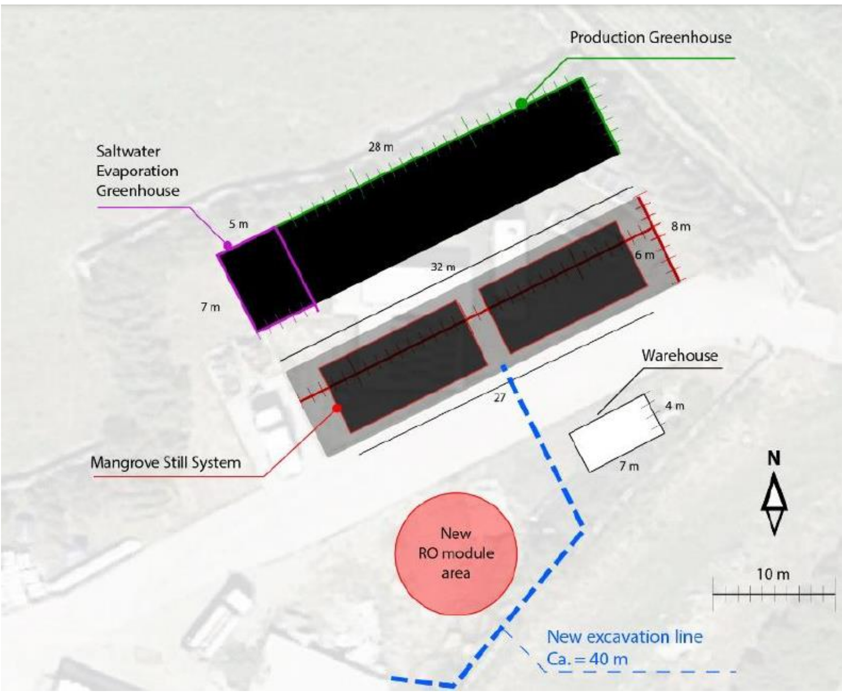

Figure X. Upper view and description of the elements present in HYDRO5.

2. RESEARCH CONDUCTED

MY ROLE IN PLANET AND RESEARCH QUESTIONS

The target of my internship was enhancing the efficiency of the MSS. Different alternatives were previously analyzed and proposed in an initial study, but the idea of implementing a preheating system was the one that made the cut. This final proposition aligned with previous research of the company and its most urgent goals, being also supported by literature. Although there is not extensive literature on the matter, the direction to follow during the experiment was clear.

Essentially, the experiment conducted addressed the following research questions: (1) how does the temperature of the feeding water (saline water) that enters the passive desalination system affect freshwater production? (2) What is the effect of the flow rate input and presence of wick material on freshwater production? (3) Among all the studied parameters, what is the most impactful one? And lastly, linking again to the first question and main topic of the research: (4) is it worth the implementation of an active preheating system to increase the efficiency of the Mangrove Technology Platform?

LIMITATIONS

One of the main constrains of the research was the limited time available and unreliability of the designed preheating system. A tight schedule was prepared for these two months of field work. Nevertheless, it is hard to predict the setbacks that one will encounter in the process. Initiating the experiment took one week longer than expected, mainly because we depended on external work to fix some general components of the installation. This resulted on less available days to generate replicates and collect more data. Besides, not all the replicates turned out good for the data analysis due to sporadic events: brine leaks that got mixed with the freshwater and gave inflated productions; microdripper and pipe obstructions that hampered the water flow inside of the units; or temperature sensors that stopped recognizing the hub for hours. This resulted in rounds of experiment with more robust data than others.

At the same time, it was not possible to control the temperature of the preheated tank with precision. The vertical shape of the tank and the short length of the electrical resistances created a drastic temperature gradient between the water surface and the bottom of the tank. The thermostat regulated the action of the electrical resistances, but the probe of the thermostat was located next to the water outlet of the tank while the electrical resistances were placed at the top of it. This led to a delay in time between the moment where the desired temperature for the experiment was achieved and the shutting down of the electrical resistances. To keep track of this, an extra temperature sensor was added inside the water tank, giving us information about the average temperature during each replicate. In fact, even though we gathered the results of each replicate in groups, each day had its own temperature average.

On the other hand, the electrical resistances were not powerful enough to perform the high temperature experiments. As an example, it was needed half a day to achieve 65° with the current layout. These hours during the morning while the temperature was slowly increasing might not have a strong effect in the overall water production, but it would have been better to achieve the desired temperature since the very beginning of each day. Besides, bringing the system to the maximum of its capacity resulted in the dead short of one of the electrical resistances and the melting of the other one. In the beginning, the aim was to test as well at 85°, temperature said to give the best results, but these previously described issues happened already in the 65° experiment and we had to stop the activities.

3. EXPERIMENTAL DESIGN

In this section, the experimental design is explained. As a general perspective, several temperatures were proposed to analyze the impact on freshwater production of the preheated system. Besides, units were installed with a specific internal configuration: different flow rate and wick material, allowing us to understand how the system evolves in each specific case.

Precisely, the design of the preheating system was based on the work of Abdennacer & Oualid, 2016; Al Shabibi & Tahat, 2015; and Pansal et al., 2020.

CONFIGURATION OF THE SYSTEM

In total, 8 units are used to carry this experiment. They were named to easily recognize the configuration they have: **A** for the units fed by the normal tank and **B** for the units fed by the preheated tank; **1** or **2** depending if their flow rate was 1 l / h or 2 l / h; and **W** if their installation contained wick material. The general scheme is drawn in Figure X, indicating the spatial position of these units as well in the installation of Tinos. The description of each unit is stated in the following list:

· A solar still with preheated water + flow rate of 1 l / h + wick material **(MONITORED)** = **B1W**

· A control unit (same configuration but with NO preheating) = **A1W**

· A solar still with preheated water + a flow rate of 1 l / h + no wick material = **B1**

· A control unit (same configuration but with NO preheating) = **A**

· A solar still with preheated water + flow rate of 2 l / h + wick material = **B2W**

· A control unit (same configuration but with NO preheating) = **A2W**

· A solar still with preheated water + flow rate of 2 l / h + no wick material = **B2**

· A control unit (same configuration but with NO preheating) = **A2**

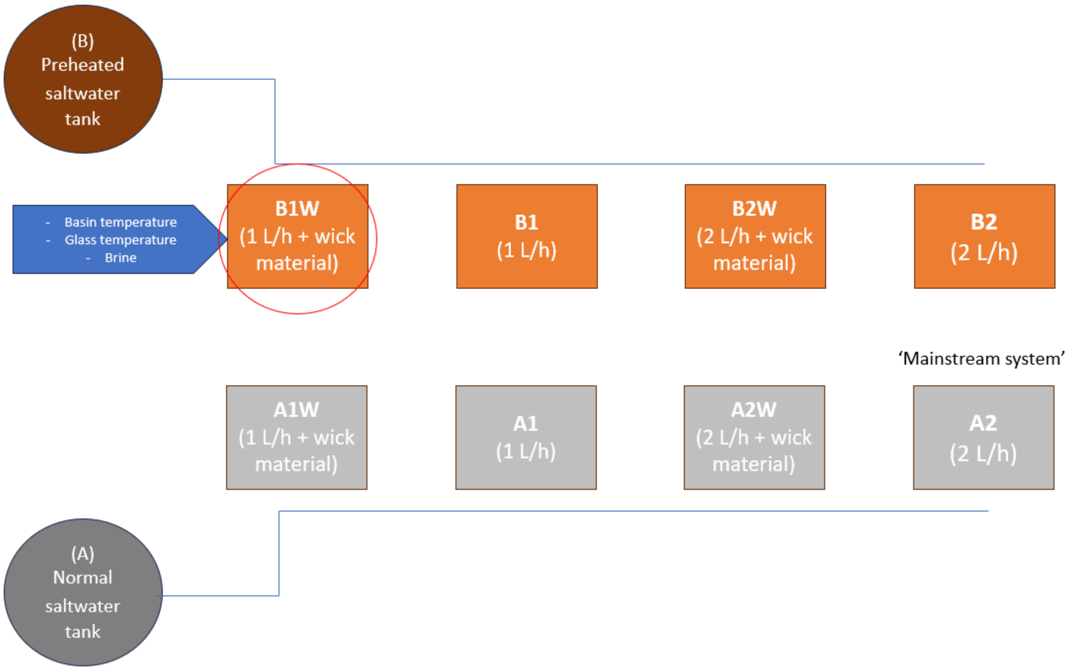

Figure X. The upper image shows the general scheme of the units that will be used for this experiment. Below, their location in the Tinos installation.

Besides, it was performed a 'night configuration' test, in which the units were insulated with two layers of (name the white material) and covered with (name the blue cover) to simulate night conditions to perform the test at 35°C and 65°C (Figure X). In this way, production without sun irradiation was studied using preheated water. The duration of this experiment was dependent on the outcomes.

Figure X. Night configuration.

PROTOCOL

The system runs every day from 9 am to 18 pm. In the morning, the preheated tank is filled up to the top and the electrical resistances were turned on. At the end of the day, water is collected from each unit and weighted to note its water production. Besides, the conductivity of that water is tested to spot the presence of brine leaks.

Temperature sensors collect constant data points in the monitored unit. As well, solar irradiation and air temperature is collected by sensors that were already present in the installation, controlled by the webpage 'Ardeusy'. The average per hour and per day is be calculated from these datapoints.

In total, the parameters measured per day are: (a) temperature of water of the preheating system; (b) temperature of the basin of the monitored unit; (c) temperature of the glass of the monitored unit; (d) freshwater production of the units; (e) freshwater conductivity; (f) brine production and conductivity of the monitored unit; and (g) solar irradiation and temperature of the location.

VARIABLES OF TEMPERATURE, FLOW RATE AND WICK MATERIAL

According to Abdennacer & Oualid, 2016, the warmer the preheater water is, the higher the efficiency, but beyond 85°C production starts to decrease. For that reason, the units of the experiment were fed with water of the following temperatures: 35°, 45°C, 55°C and 65°C. It was not possible to test at higher temperatures because the electrical resistances of the setting could not work make it further safely. In contrast, the control units were fed with the normal tank of saline feeding water, which had an average temperature of 31 - 33 °C. For each temperature, the experiment was aimed to last for 5 days. Nevertheless, in some cases it was not possible to make so many replicates or to get completely valid ones for the data analysis.

On the other hand, flow rate of the water running in each unit was controlled with two different microdrippers: one of 1.1 l / h and another of 2.1 l / h. For the wick material, felt fabric was cut, humidified and placed on the vertical side of each water lane.

SCHEDULE

Table X is the final schedule followed in the field experiment, affected by the development of the results and adaptation to the coming setbacks.

Month	June																														July																											
day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
week	week 0				week 1							week 2							week 3							week 4							week 5							week 6							week 7							week 6				
Installation of the experiment																																																										
Experiment of 35°																																																										
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Night experiment 35°																																																										
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Table X. Schedule of the preheating experiment.

EXPECTED RESULTS

Studies suggest that freshwater production efficiency when feeding the system with preheated water is increased by 25 - 50%, based on the literature proposed in the biography and linked in the drive folder. As well, some previous experiments point out that the decrease in flow rate and use of wick material could improve the efficiency of the system.

4. RESULTS AND DISCUSSION

I. STUDY OF THE IMPACT OF SOLAR IRRADIATION

A. EFFECT OF SOLAR IRRADIATION ON WATER PRODUCTION (CONTROL UNITS)

To understand how the system evolves according to the weather conditions, water production of the control units was analyzed along the days. As it can be seen in Figure X, when solar irradiation increases (x axis), water production follows a polynomial trend (y axis). The configuration with wick material (blue and grey) shows the highest production. Besides, with the increase in solar irradiation, the difference in production among the configurations seems to be more extreme. An alternative explanation for this later fact is that the highest peaks of solar irradiation were achieved in the first days of the general experiment, when the wick material was new and could absorb more water (more information in section III.b).

The polynomial equations that plot water production vs solar irradiation are also shown in Figure X. The unit with the configuration of 1 l/h and wick material (blue) seemed to show the most stable results (R =

83%), while the trend of the mainstream system (2 l/h and no wick material, in yellow) had an R of 60%. The general instability of the results is explained by the following conditions:

- Most of the units presented saltwater leaks, decreasing the water volume available inside them to be evaporated.

- During some days, brine leaks contaminated the freshwater collecting points, giving a misleading increase in water production. Large brine contaminations were spotted and removed from the dataset when measuring the conductivity of the produced water at the end of the day, which was not done in the first week and a half of the experiment. Nevertheless, conductivity increase can be given both by brine leaks or just by the entrance of the salts crystallized in the pipes or surrounding surfaces, being innocuous for the water volume count. For this reason, water production was considered legitimate when the conductivity was lower than 0.3 g/l (distilled water is around 0.003 g/l, so it only gives a small room for a few ml of brine contamination).

- Solar irradiation doesn't necessarily mean high ambient temperature, which also plays a role in water evaporation and condensation inside of the units.

- As previously mentioned, it could be that the wick material lost efficiency along the experiment. Besides, more salts accumulated inside of the solar units, possibly hampering water evaporation.

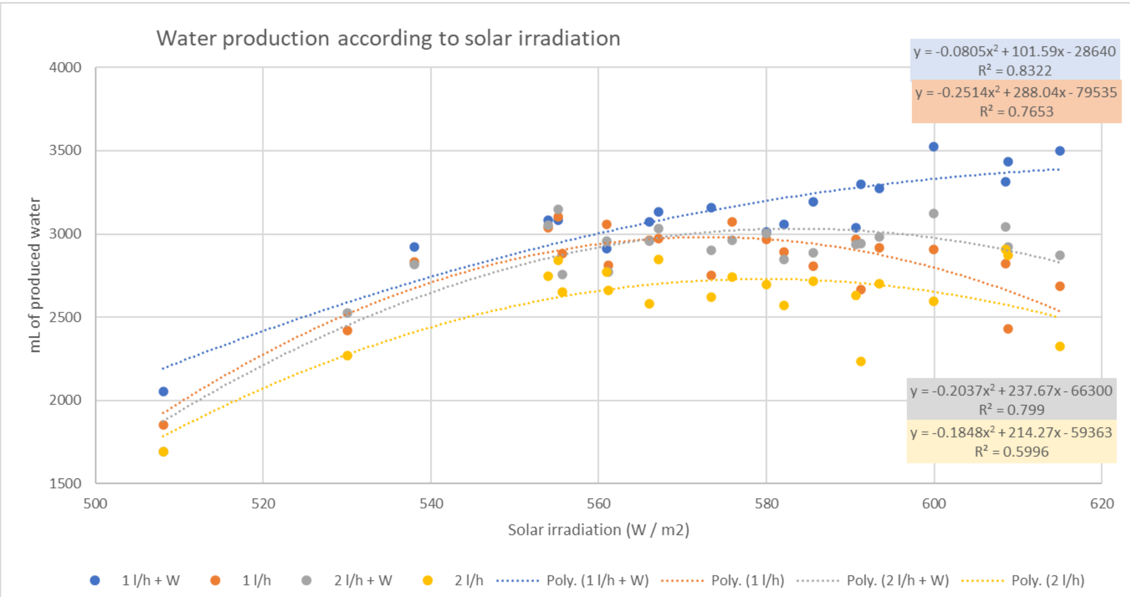

Figure X. Plot of solar irradiation vs water production of the units. The formula of the polynomial trend they follow is expressed in the right side of the graph.

As an overall, these formulas could be of use to predict the water production in future experiments. Still, more replicates could make them more accurate.

B. EFFECT OF SOLAR IRRADIATION IN THE COMPONENTS OF B1W (MONITORED UNIT)

The aim of Figure X is to show whether the temperature of the basin and the glass is mainly affected by air temperature, preheated water temperature or solar irradiation. (1) Air temperature (light blue) seemed to remain stable during the whole experiment, while the temperature of the glass and basin changed (yellow and grey). Thus, ambient temperature did not show a clear impact on them. (2) The temperature of the preheated water had a bigger increase from the 29th of June onwards, but the trend of the two studied elements did not show a clear response to it. (3) Finally, observing the evolution of the solar irradiation (in red), the temperature of the basin and the glass clearly follow the same trend, appearing to be the main affecting parameter.

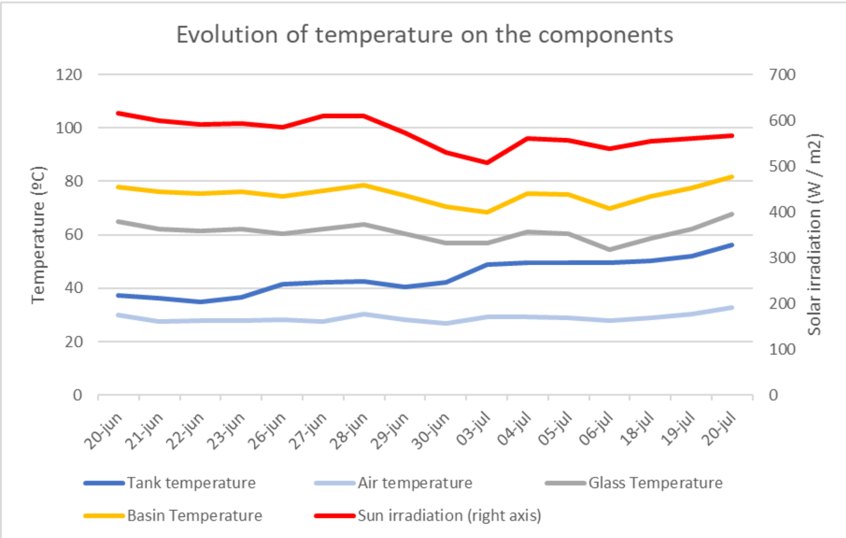

Figure X. Plot of the preheated tank temperature (blue), glass temperature (grey), basin temperature (yellow), air temperature (light blue) and sun irradiation (red, follows right x axis) along the days.

One important aspect to consider is that the ambient temperature and preheated water temperature reached the highest values in the last two dates of the experiment (19th of July and 20th of July). It is a fact that sun irradiation is the main parameter affecting the temperature of the basin and glass, but we cannot be certain if the impact of ambient temperature and preheated water will still be little if they were pushed to reach warmer values.

C. EFFECT OF SOLAR IRRADIATION AND PREHEATED WATER IN THE PRODUCTION OF B1W

Water production of B1W appears to be mainly affected by solar irradiation rather than by the preheated water temperature, as they both follow the same trend (Figure X Left). Nevertheless, a dim effect can be observed after the 30th of June, where water progressively increased from 42° to 56° on average. As an example, on the 6th of June there was a decrease in sun irradiation so it should have been a decrease in productivity, but the increase in water temperature kept the production constant. Besides, the 29th of June and the 20th of July had a similar solar irradiation, but the later one produced almost 0.3 l more (temperature difference was approximately 12°). Lastly, it is important to consider the wear and tear of the system along the experiment: the progressive accumulation of salts and deterioration of the wick material possibly had a negative impact on water production.

In the right side of Figure X, water production is plotted on the x axis, indicating the water temperature (green dots) and sun irradiation (orange dots) for each registered entry of water production. This graph reinforces the idea that, when a higher water production was registered (x axis), the reason behind was mainly due to the high solar irradiation rather than the preheated water temperature. Nevertheless, the highest water production recorded coincided with the day of the highest preheated water temperature. Probably, beyond that point we could observe a larger effect of water temperature on water production, but the experiment stopped after that measurement.

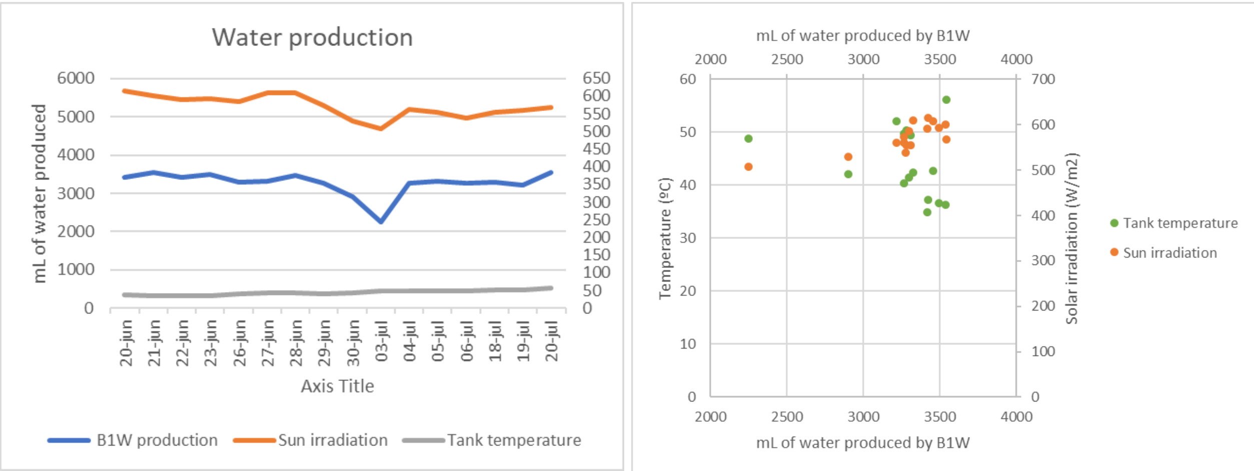

Figure X. On the left, water production (blue) of the unit B1W (flow rate of 1 l/h and wick material) in contrast to solar irradiation (orange) and water temperature (grey). On the right, water production is plotted on the x axis, indicating with two dots what was the sun irradiation (orange) and preheated water temperature (green) of each registered water production.

D. CONCLUSION OF THE IMPACT ON SOLAR IRRADIATION

According to the previous results, it can be stated that solar irradiation is the main affecting parameter in water production. The preheated water of the tank did not have a significant impact on the temperature of the basin, glass and freshwater production when the water temperature was below 45°. During the few replicates in which it was possible to run the system with a higher temperature than 50°, some little changes are seen. Still, it is hard to obtain clear conclusions with not so many replicates, but previous literature confirms the increasing positive effect of preheated water when it is warmed up, achieving its maximum at 85°.

II. STUDY OF THE IMPACT OF THE PREHEATING SYSTEM

A. WATER PRODUCTION OF THE PREHEATED UNITS

Figure X portraits the average water production per experiment. 'P' stands for preheated unit and 'C' for control unit. Besides, each configuration is written explicitly to facilitate the reading of each graph, indicating the flow rate and the presence of wick material ('W').

One of the first points that can be highlighted is the general low production of 'P 1 l/h', also known as B1. This unit was repaired many times, but it was only possible to find the source of the problem (lack of water pressure) during the last days of the experiment, being the reason why we achieved a more reasonable production in the end.

When it comes to rest of the configurations (in exception of the case of ‘P 2 l/h’ in the 45° experiment), the preheated unit produced more freshwater than its control, confirming the hypothesis that the preheating system increases efficiency (Abdennacer & Oualid, 2016). It is important to mention again that salinity was not being checked during the first few weeks of the experiment, as brine contaminations in the water tanks were unknown at that moment. This might have led to inflated results in the 35° experiment. Finally, general water production seemed to decrease in the 55°C experiment in comparison to the others, but it was led by the low solar irradiation presented during the week of the experiment.

Figure X. Average water production in each experiment. ‘P’ stands for preheated, while ‘C’ for control. ‘W’ indicates the presence of wick material.

B. COMPARISON OF WATER PRODUCTION OF B1W AND A1W (CONTROL UNIT) IN CONTRAST TO B2 AND A2

When comparing water production of the preheated units to its respective control units, we see they follow a similar trend. The left graph of Figure X compares the production of B1W to A1W, showing that the preheated unit did produce slightly more water after the 3rd of July (beginning of 55° Experiment). On the contrary, when comparing the mainstream configuration A2 with its preheated unit B2 (Figure X, right graph), it was not possible to claim a strong positive effect on the preheated system, as they both produced almost the same. This could give us a clue that the preheated system is more effective when there is wick material involved.

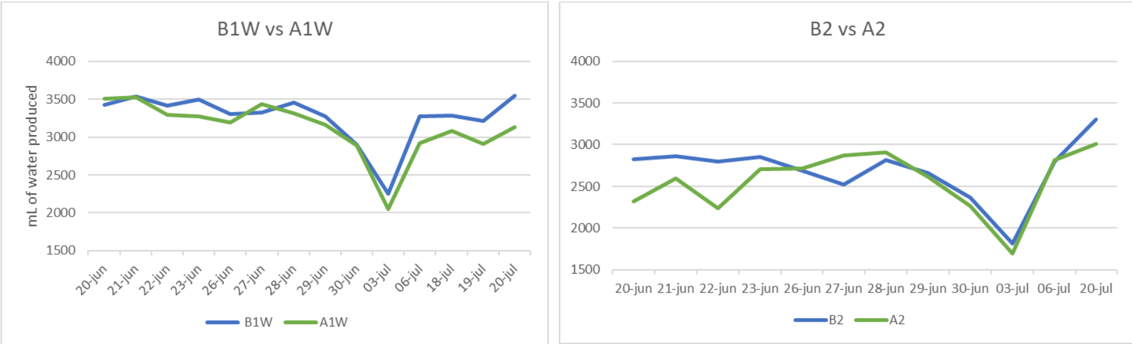

Figure X. On the left, a comparison of water production of B1W (preheated, flow rate of 1 l/h and wick material) with its control unit (green line). On the right, a comparison of B2 (flow rate of 2 l/h) to A2 (green line), which is the configuration present in the rest of the installation of Tinos.

C. WATER PRODUCTION IN THE 'NIGHT' CONFIGURATION

The temperature of the basin and glass were measured at day and night to check if they reached the same temperature. Even though solar irradiation was blocked by the configuration of these units, ambient temperature did indeed play a role in heating the basin and the glass up. Nevertheless, this increase was not of a large magnitude (Figure X).

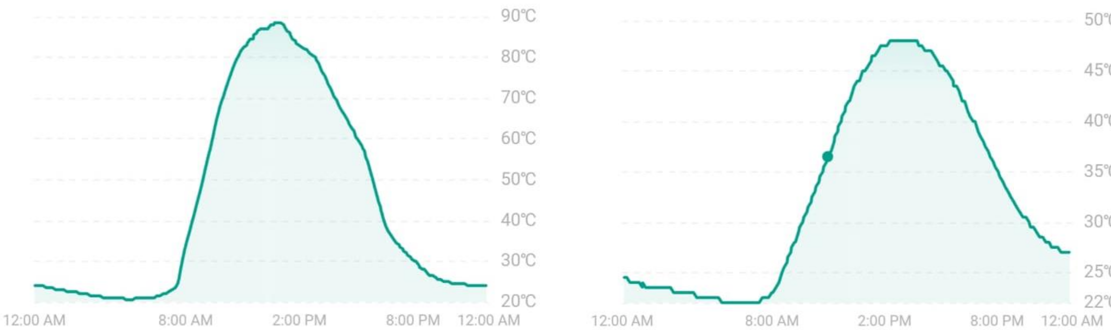

Figure X. On the left, the temperature of the basin during one replicate of the 65°C experiment. On the right, temperature of the basin during the 35°C experiment.

Units with the 'night' configuration were fed with water at 35°C and 65°C, but none of them produced freshwater. This confirms the fact that solar irradiation is the most important parameter for water evaporation.

D. GENERAL OUTCOMES OF THE PREHEATING SYSTEM.

In Figure X it is shown the efficiency of the different preheating experiments. There, we can differentiate three bars: grey, which compares the unit B2 with A2; orange, which compares the unit B1W and A1W;

and blue, which compares the efficiency of all the preheated units vs all the control ones. The blue bar gives misleading results because it considered the unit B1, which had an abnormally low production during the first 3 experiments. The grey bar shows an inconsistent trend, probably caused by the fact that water salinity was not being tested in the first 2 weeks and this hampers us of knowing if these results were contaminated with saltwater. Considering that the units B1W and A1W worked correctly and steadily during the whole experiment, the orange bar gives the most trustworthy result, stating a 9% of improvement during the Experiment of 65°C (50-55°C of average temperature of the water tank).

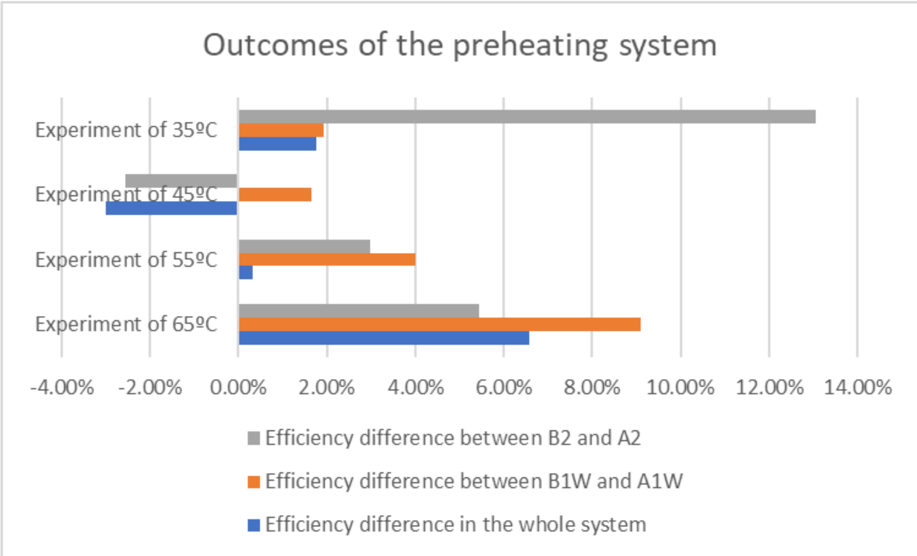

Figure X. Efficiency increases during the different preheating experiments.

When we consider the energy required to preheat the water tank, some conclusions can be drafted. It took around 6 hours with two electrical resistances of 3 kW to heat the water up during the 55° Experiment. In the case of the 65° Experiment, 7 hours were needed with two electrical resistances with the power of 2.5 kW. This means that around 18 kW can be used just to increase the efficiency of the system by 9%, being such a large investment for a change of less than a 10%.

III. STUDY OF THE IMPACT OF THE FLOW REDUCTION AND USE OF WICK MATERIAL AT DIFFERENT TEMPERATURES

A. EFFECT OF WICK MATERIAL AND FLOW RATE IN THE CONTROL UNITS

When we study the individual effect of each change in the configurations of the control units, the system evolves positively after decreasing the flow rate and adding wick material (Figure X). These percentages were taken by the average production of each unit along the experiment. As expected, when both configurations are present at the same time, the efficiency of the system evolves as addition of the individual efficiency of each configuration. This efficiency was obtained by the sum of the water produced by the control units for 6 weeks approximately, and these percentages changed if we compare the first weeks to the lasts. The efficiency of the wick material was decreasing along time, probably caused by its deterioration (possible to see in Figure X). Thus, we can claim that the efficiency of the wick material, when new, is higher than the one stated in Figure X.

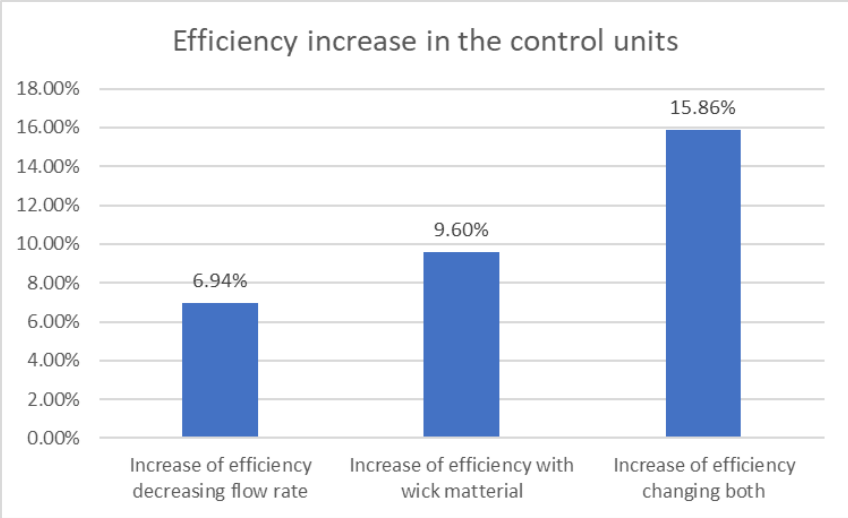

Figure X. Efficiency increase when each configuration is applied in the units.

Figure X. Wick material after 6 weeks of work.

B. EVOLUTION OF THE EFFECT OF WICK MATERIAL AND FLOW RATE AT DIFFERENT TEMPERATURES

In this case, the effect of the flow rate and wick material is analyzed at different temperatures (Figure X). Flow decrease seems to give steady results under different temperatures, while the wick material shows a decrease in efficiency when the temperature increases. As previously stated, this effect is not provoked by the temperature itself, because the decrease was also present in the control units, so we can confirm that the wick material deteriorates after some weeks, decreasing its productivity.

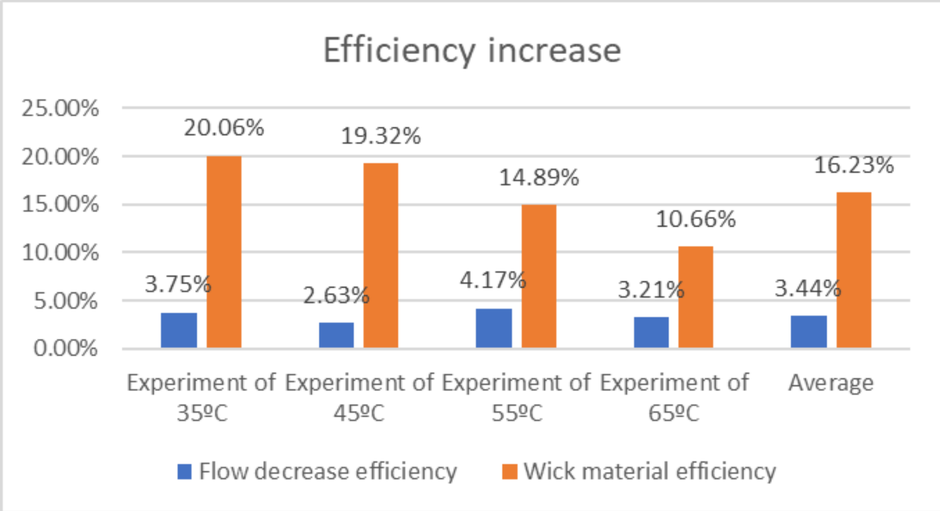

Figure X. Effect of the flow ratio and wick material during the different experiments.

In Figure X, it is compared the efficiency of the preheated unit to its control unit, using the same configuration. Following the previous results, B1 (P 1 l / h) produced less than it should but the last experiment. Finally, the best outcome is achieved in the experiment of 65°C. It is important to mention that, for the creation of this graph, it was only possible to consider 1 out of the 3 replicates. This also explains why it has a different value than the one expressed in Figure X, in which the 3 replicates were considered.

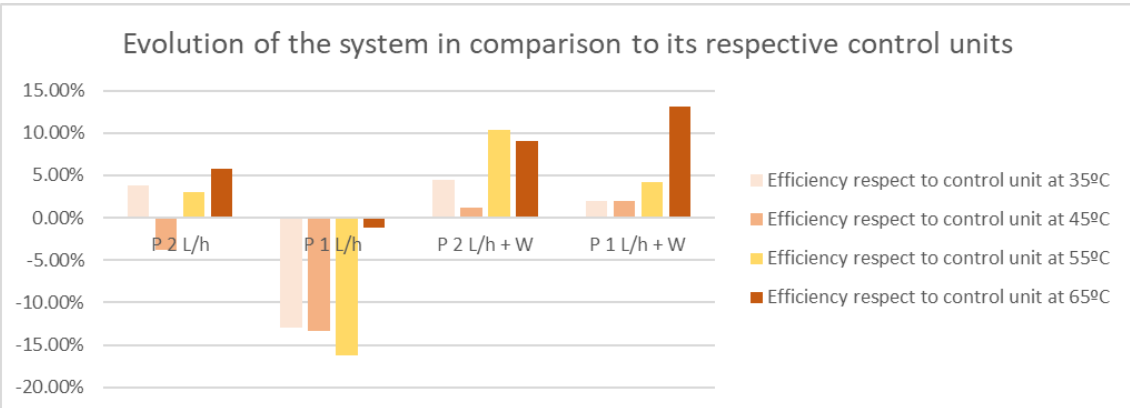

Figure X. Efficiency comparison of the preheated units vs its control units.

C. GENERAL EVOLUTION OF THE SYSTEM WHEN THESE THREE PARAMETERS INTERACT IN COMPARISON TO THE MAINSTREAM CONFIGURATION.

In this last graph (Figure X), we can see the evolution of the efficiency in comparison to the mainstream system (C 2 l / h) when the three parameters are taken into account. Aligning with the previous results, the units fed with preheated water in the 65° experiment, which had a decrease in flow to 1 l/h and used wick material, gave the best outcomes. It might appear that, sometimes, the 35° experiment gave a better outcome, but two facts should be taken into account: (1) brine contamination in the freshwater was not being check during this experiment, which was a common problem; and (2), as it was the first experiment performed, the wick material was fresh and worked at its highest efficiency.

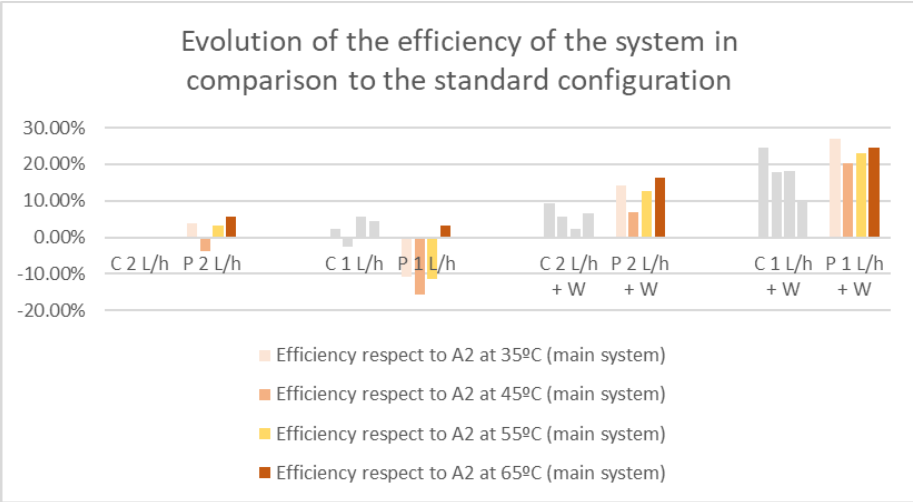

Figure X. Comparison of the efficiency of each configuration to the mainstream system (no preheated water, 2 L / h and no wick material).

5. CONCLUSION

Even though solar irradiation is explicitly the most affecting parameter in water production, the expected hypothesis has been confirmed: the use of a preheating system, wick material and flow decrease are conditions that enhance the efficiency of the system. Wick material enhanced the efficiency by 16%, but this value has been affected by the progressive deterioration of the material itself (ranging from a 20% in the first weeks to 10% in the latest). Flow rate of 1 l/h increased the efficiency by 3-7%. Finally, the preheated system showed a more significant impact when pushed to 65°C (average temperature of the preheated water was 53°), increasing the system by 9%.

The instability of the system at high temperatures made it hard to achieve robust data. Most of the replicates were discarded in the 55° and 65° experiment due to different setbacks. Nevertheless, the outcomes align with the expectations.

If the preheated technology is proposed to be used in further research, a better setting needs to be applied: a horizontal tank for easier temperature distribution and a more powerful electrical resistance. With the current layout, it was not possible to achieve the so-called 'best temperature' of 85°, which gives the best efficiency. Still, in the latest experiments it was clear that the efficiency increase would only come at a high price. One of the main advantages of the solar units is their passive functionality, but to heat the water up to 65°, 18 kW of power were needed. If this possibility is pursued, it is uncertain that the energy investment is worth the enhancement it provides, but a passive heating system could always help. Which is true, the basin inside the units achieves temperatures of 90° during the day, probably not leaving a big room of improvement in this direction.

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