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# Innovative Monitoring System for Solar-Powered Water Generator

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***ABSTRACT***
*Solar-powered water generators work by converting sun rays (photons) to electricity that will operate the water pump. It uses solar panels to collect the photons (units of light) from sunlight, producing the direct current (DC) that provides the energy for the motor to pump water out from its source. An inverter is used if the pump motor needs alternating current (AC) rather than DC. The system is composed of solar panels, water pump motor, inverter, pipes, water tank, battery, sensor, and Arduino uno. Solar panels, also called the solar photovoltaic (PV) system, take the sun's photons and convert them into electricity. Water pump motor takes water from water source that can be used for irrigation, household or other purposes. Inverter that converts the electricity from the original DC to usable AC. Pipes that transport water from the original source to wherever it goes. Water tank to store water that maybe used when sunshine isn't available. Battery stores the energy from the solar panel. Sensor tracks the sunlight. Arduino uno contains programs that control solar panel rotator.*
***KEYWORDS:*** *Water generation technology, Innovative monitoring system, Solar energy management, Sustainable development.*

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## I. INTRODUCTION

[1]A solar generator generates energy by capturing the energy of the sun using the solar panels installed in the generator. This captured energy is then stored in the battery, which is released through an inverter. Solar power is an excellent source of alternative energy because it is renewable, it is economical, and it does not pollute the environment. [1](Wikipedia) But what most people mean when they say 'solar generator' refers to a portable power station that uses solar panels, instead of fossil fuels, to provide electricity.

[1]This solar can be described as off- grid solar system with utility backup power, or grid-tied solar system with battery storage. Solar tracker, a system that positions an object at an angle relative to the Sun. The most-common applications for solar trackers are positioning photovoltaic (PV) panels (solar panels) so that they remain perpendicular to the Sun's rays and positioning space telescopes so that they can determine the Sun's direction. [3]PV solar trackers adjust the direction that a solar panel is facing according to the position of the Sun in the sky. By keeping the panel perpendicular to the Sun, more sunlight strikes the solar panel, less light is reflected, and more energy is absorbed. [2]That energy can be converted into power. Trackers can be either active or passive in nature. Active trackers use gears and motors to move solar panels while passive trackers utilize compressed fluid that switches sides when warmed by the sun causing them to change their tilt.

[2]A solar generator can be used at any time to offset your energy consumption at home or in the office. A solar panel is one component of a photovoltaic system. They are constructed out of a series of photovoltaic cells arranged into a panel. They come in a variety of rectangular shapes and are installed in combination to generate electricity. Solar panels sometimes also called photovoltaics' collect energy from the Sun in the form of sunlight and convert it into electricity that can be used to power homes or businesses. These panels can be used to supplement a building's electricity or provide power at remote locations.

## II. BACKGROUND

This section is presenting an additional level of details and procedures for the system user. The information discussed in this section allows for further intuition regarding the motivation for the methods as a guideline of its uses.

[1]The Solar-powered Water Generator has been developed based on the user's need. It is also a way for the researchers to map out necessary actions connected to the system to help the user lessen their manual workload.

**Functional Chart**

This section illustrates the functional chart of Solar-Powered water generator.


Figure 1. Functional Chart

**System:** Designed to produce water.
**Manual:** Serves as guidelines of the system to the user.
**User:** Generates the system.

## III. LITERATURE REVIEW

In this chapter presents the related literature and studies from the researchers, online sources and existing systems developed and implemented by systems developers.

**Water Generator**

(https://solarsolutions.com/solarwatermaker)

[3]Water generator that can be powered solely by the sun or the grid. This freshwater generator pulls moisture from the air to produce clean drinking water.

On our off-grid model, the solar panels not only power during the day but also charge the battery at night. This battery lasts up to 15 hours before needing a recharge. With only heat, moisture, and sunlight this water generator, depending on the model, creates 30 gallons to 1000 gallons of water each day and up to 2,300 lbs. of ice.

**Advantages of Solar Energy**

(https://www.constellation.com)

[6]The more we can capture the benefits of solar energy, the less we will rely on fossil fuels. Adding a solar energy system to your home allows you to tap into these solar energy advantages: Solar energy is a renewable energy source, meaning you don't ever use it up. Solar energy is clean. It creates no carbon emissions or other heat-trapping "greenhouse" gases. It avoids the environmental damage associated with mining or drilling for fossil fuels. [1]Furthermore, solar energy also uses little to no water, unlike power plants that generate electricity using steam turbines.

[2]A solar energy system for your home can reduce your reliance on the grid and help you save on your electricity bill. Some owners of residential solar energy systems may even have excess power that they can sell to the utility. Instead of paying a utility for electricity, homeowners get paid by the utility. You may not have to buy an entire solar energy system to cut your home's electricity bill. Simply choose solar lights, lights that are powered by the sun instead of your home's electrical system, to help save money.

[2]Some states offer solar renewable energy certificates (SREC). Each one represents a megawatt-hour of electricity generated through solar energy. Electricity suppliers buy these certificates to satisfy their state's Renewable Portfolio Standard, a requirement that a certain amount of their renewable energy comes from solar. You can sell SRECs for your system's output, which is another way to earn money from your investment.

[3]Home buyers will likely pay more for a house with solar panels installed. Considering solar energy pros and cons, the savings on electricity bills and the money earned selling power back to the utility, all count in the plus column. Residential solar energy systems are highly valued and can increase a home's resale value. The property value of a home with solar panels can be worth up to $15,000 more than its neighbors.

[1]Solar systems are easy to install and require very little maintenance. Both are handled by your solar provider if you opt for a solar lease or power purchase agreement (PPA). Consider this as you ask yourself is solar energy worth it.

[1]Solar panels are easy to maintain, as they have no moving parts that wear out over time. Just keep them clean and in good physical condition to keep them working properly. Between their low maintenance costs and average lifespan of 25 years, it can be easy to get your money's worth when investing in solar panels.
[2]Solar energy systems can generate electricity in any climate. One of the disadvantages of solar energy is that it's subject to temporary weather disruption. Cloudy days reduce the amount of electricity you produce. Cold, however, doesn't affect productivity. Snowfall can help your solar system, as the snow cleans the panels as it melts, and sun reflected off the snow increases the amount of light hitting your panels. The result is more electricity production.

**Disadvantages of Solar Energy**
(https://www.constellation.com)
The disadvantages of solar energy are becoming fewer as the industry advances and grows, creating economies of scale. Technological advances are helping solar go mainstream. Here are how the disadvantages of solar energy and the pros and cons stack up.
1. The high initial costs of installing panels
The most cited solar energy disadvantage, cost, is declining as the industry expands. The initial cost to buy and install the equipment is not cheap. Still, if cost is an issue, leasing options may reduce the amount of your initial outlay. If you do choose to buy, you will need to live in your home for several years before the system pays for itself. It's a long-term investment better suited to property owners than renters.
2. Solar energy storage is expensive
Of the disadvantages of solar energy, the temporary decline in energy production during bad weather has been a major issue. Days with low solar energy, however, are having less of an effect due to advances in battery technology. Old technology for storing solar energy, like lead acid batteries, are being replaced by alternatives. Lithium-ion batteries offer greater power at a lower cost. Nickel-based batteries have an extremely long life. New technologies, like flow batteries, promise scale and durable power storage.
3. Solar doesn't work for every roof type
Not every room will work well with solar panels. Orientation matters. If your roof doesn't face the sun, you won't be able to capture enough solar energy. Roofs that angle into the sun tend to work better than flat roofs.
Roofing materials like asphalt shingles, metal and tiles make installing solar panels easier. If your room is made with other materials, installation may be more expensive. Part of what makes energy-efficient roofs is their ability to support solar panels.
4. Solar panels are dependent on sunlight
It's obvious that solar panels need sunlight to generate electricity. They won't produce electricity at night when you need it for light, and they can be inefficient during storms and gloomy days. Your solar energy system needs batteries if you plan to fully depend on solar energy to power your home.
Batteries are one of the more expensive components of your system. Unlike solar panels, they do wear out and need careful maintenance to lengthen their lives. Comparing wind power vs. solar power, wind will keep generating electricity at night and during storms, as long as there is enough wind. Many people use both in residential systems.

**Power Supply and Irrigation**
(https://www.researchgate.net)
[3]Innovative monitoring system for solar-powered water generator is one of the most common technical processes, and they are mainly used to supply water to houses, private resident, farms, agricultural irrigation, etc. In modern conditions with a lack of fossil fuels and increasing emphasis on environmental protection, innovative monitoring system have become one of the most common applications of solar powered water generator, especially in developing countries, for domestic applications in remote areas.

[3]In remote areas, it is recommended to combine solar powered water generator with electrical energy storage and power supply for other forms of consumption. In such a complex system, each subsystem has its own local control, and the general automatic control of the system in different operating modes is carried out according to the energy management strategy. [3]The EMS is constructed in such a way that, for all modes, only two PBC systems are developed, which switch according to the state of charge of the battery and the current levels of the two main disturbances. For each system, two control influence former structures were synthesized and their operation was investigated by computer simulations.

[3]Irrigation is an essential part of agriculture which helps to sustain crop growth and increase food productivity. Most of the nations around the globe have adopted diesel fuel-based pumping units to irrigate their farmlands. [6]However, increased fuel cost and strict emission laws have made these nations to look for alternate and clean energy powered pumping units. Solar water pumping units are more promising alternate to address these concerns. In this review work, types and concepts of available solar thermal and electric energy-based water pumping units are discussed. Suitability of solar PV pumping units in comparison to thermal

energy-based units has been listed out. [6]Detailed procedure for sizing solar PV pumping units by considering crop water requirement, head of pump, and local climatic conditions like solar radiation intensity and rainfall have been provided based on inputs from available literatures. In addition, step by step procedure to estimate economics and environmental impacts associated with solar PV water pumping units along with results of latest studies in these areas have also been presented. Solar PV water pumping units are highly recommended for regions with at least 300 to 400 mm rainfall per year and 2 km away from local grid power supply. Moreover, operation of solar PV water pumping units in on-grid mode can reduce its payback period significantly. Pumping cost associated with diesel units are 300.0% higher than solar PV units. Hence, solar PV water pumping units can be considered as an effective and sustainable option to irrigate farmlands. Advantages, limitations of solar PV water pumping, and strategies to improve its acceptability among farmers have also been provided.

**Solar Water Systems and Installations**
(https://www.researchgate.net)

[1]Solar water systems are a promising solution to improve water access in isolated rural areas in developing countries. Each system must be carefully sized to satisfy local demand while being as affordable as possible. Indeed, the life cycle cost is the biggest barrier to installation of such systems and poor sizing can lead to overpricing or unmet needs. Techno-economic optimization is the most commonly used way to size such a system, as it allows the price to be minimized while meeting the technical requirements of the system. Most of the system used today for extracting drinking water include a water tank. [2]In this architecture, the motor-pump is connected to PV panels and pumps water into the tank, from which users can collect water at any time during the day. Nevertheless, installations of tanks are very expensive and tank-less may be significantly cheaper.

[7]A Solar Panel with a battery bank storage is designed in this thesis, using a techno-economic optimal sizing methodology that we developed. This methodology is applied to the village of Gogma, in rural Burkina Faso. The results show that an optimized system with batteries has a life-cycle cost (LCC) of 6.4 k$ instead of 12.9 k$ for an optimized system with a tank. This new result is interesting because tank architecture is much more common, and most authors do not even consider the option of battery architecture. These novel results show that the battery may be a valuable alternative to tank, as it could allow significant economic savings and could thus be accessible to a larger share of rural communities.

[8]A literature-based analysis of viability (i.e., capacity of being operated and sustained) of the tank and battery is then carried out. Indeed, the life cycle cost is the biggest barrier to installation, but viability is essential for ensuring satisfactory and sustainable water access. The operation and maintenance (O&M) requirements of the systems are investigated because they have a strong impact on the viability and the durability of a system: the more difficult the O&M is, the less viable it is. The analysis brings to light several significant challenges associated with using batteries, principally because lifetimes of batteries are relatively short which leads to significant maintenance and replacement needs. The installation of battery thus appears to be viable only if a strong O&M network is present or developed locally.

**System Design and Monitoring**
(https://www.researchgate.net/publication/304929498_Solar_powered_wireless_monitoring_system_of_environmental_conditions_forearly_flood_prediction_or_optimized_irrigation_in_agriculture)
[7]This paper describes the system design and realization of a smart electronic system, based on a Wireless Sensor Network, for wide area monitoring of availability level and rapid changes of the water presence in the monitored system, in order to guarantee, depending on application, water savings optimal use of water resources where its availability is low.

The designed sensor node, equipped with a small PV panel to recharge the Li-Ion battery for feeding the entire system, by means of the different embedded sensors, is capable of detecting environmental parameters, the solar radiation level and soil temperature and moisture (i.e., water volume content) values. The sensors communicate with a central processing unit located on board, the ESP8266 SoC module, used both as data processing unit and as Wi-Fi transceiver to receive/transmit sensors data; the user near a sensor node, by a tablet or smartphone with an appropriate app, can collect information provided from sensors and share them with all users who use the same app, through peer-to-peer Wi-Fi or other internet connections.

## IV. RESEARCH METHODOLOGY

Agile software development include requirements discovery and solutions improvement through the collaborative effort and self-organizing and cross-functional teams with their customers, adaptive planning, evolutionary development, early delivery, continual improvement and flexible responses to changes in requirements, capacity and understanding of the problems to be solved. Agile software development methods support a broad range of the software development life cycle.

Agile project management is an iterative development process, where feedback is continuously gathered from users and stakeholders to create the right user experience. Different methods can be used to perform an agile process, these include scrum, extreme programming, lean and kaban. The term agile management is applied to an iterative, incremental method of managing the design and build activities of engineering, information technology and other business areas that aim to provide new product or service development in a highly flexible and interactive manner, based on the principles expressed in the manifesto for agile software development. Agile project software metrics

## V. FINDINGS, CONCLUSION AND RECOMMENDATIONS

**FINDINGS**

Making an evaluation is an effective way to disseminate findings of an evaluation to the people concerned and ensure its transparency, to be able to properly use such a conclusion in the future. This is also to properly understand the purpose of the evaluation plan, and of course, know the outcomes and possible effects of the system being developed to determine whether it has met the software and hardware requirements. With this, the commonly used Likert scale (1932) was employed. The Likert scale which is used to allow individual to express how much they agree or disagree with the statement (simplypsychology.org).

While introducing a new system its benefits and drawbacks as compared to the old processes should be carefully evaluated. It must be ensured that the objectives for which the new system has been planned, have been achieved.

Thus, the Innovative Monitoring System of Solar Powered Water Generator was subjected for evaluation by the Authorized user who is identified as respondent. Authorized user rated the system based on the following criteria: Rating Scale for Software Evaluation and Rating Scale for Level of Satisfaction. The rating are as follows: (1.00-1.80) Strongly Disagree, (1.81-2.60) Disagree, (2.61-3.40) Undecided, (3.41-4.20) Agree, (4.21-5.00) Strongly Agree. To get the overall rating of the end-user's evaluation, the mean and the grand mean was computed.

**User-Friendly**

In designing and creating system, we are to consider the vital part of the end-users.

User-friendly describes a hardware device or software interface that is easy to use (https://techterms.com/). It is "friendly" to the user, meaning it is not difficult to learn or understand. When you say user-friendly interface, it is Simple providing quick access to common features or commands. Secondly, Clean means it is well-organized, making it easy to locate the options. Third, the system requires a Minimal explanation of how to use it, and the last is, Reliable.

The system was designed in such a way that codes could not be accessed immediately by the users to avoid system malfunction.

**Table 3.** User-Friendly Environment Evaluation Results

| USER-FRIENDLY | MEAN | DESCRIPTIVE INTERPRETATION |
|---|---|---|
| System has a user-friendly interface | 5 | Strongly Agree |
| System is easy to use | 5 | Strongly Agree |
| System is easy/simple to install | 5 | Strongly Agree |
| Easy to control and monitor | 5 | Strongly Agree |
| System is affordable | 5 | Strongly Agree |
| **TOTAL MEAN** | **5** | **Strongly Agree** |

The overall rating of the end-user as to the User-friendliness of the system was 5.0 or strongly Agree. This implies that a user having little knowledge about computer can run this system effectively. Also the system is easy to have, giving them a one-of-a-kind user experience.

Based on the study of Jitnupong and Jirachiefpattana entitled, "Information System User Interface Design in Software Services Organization: A Small-Clan Case Study", a user interface (UI) is one of the most significant parts of an information system (IS). A user-friendly UI helps users to carry out their tasks with efficiency, effectiveness, and satisfaction. The designer must carefully select and design each element to be appropriate for the users. Their research also examines the influential process named user-centered design (UCD), a well-known process to raise product quality. The findings show that a small family team is proper with a UI design that concerns usability for the user. Even though some UCD processes or UI elements are quite

unclear, the clan culture helps the team to design UI with flexibility and unbiased obtain comments from the user.

Furthermore, the purpose of any product development is to create tools that enable users to carry out their jobs accurately and easily and should be fun to interact with. Such is the definition of usability as clearly laid out in the ISO9241-11 standard: "The extent to which a product can be used by specified users to achieve goals with effectiveness, efficiency, and satisfaction in a specific of use". In the same manner, a usable product helps users to be more productive by reducing human error and the learning curve. Moreover, usability helps to reduce user resistance by encouraging positive user and client interaction. A UI provides the look (presentation) and feel (interaction) of a system, and a good UI will help users to carry out their tasks with satisfaction and productively. Hence, with a user-friendly interface and easy navigation, the user decreases search time and increases satisfaction, fulfilling his needs in a fast and efficient way (https://www.mindseo.com).

**SPEED**

Speed is one of the essential factors that users are looking for in any system in the execution of various functionalities. According to Hoxmier and DiCasare, lengthy system response times may cause lower satisfaction and poor productivity among users. Lowered user satisfaction may lead to discontinued use of an application. Table 4 presents the user's evaluation as to the monitoring and control of the system. The less time it takes the better.

Table 4. Users Evaluation as to the Speed of the System

| SPEED | MEAN | DESCRIPTIVE INTERPRETATION |
|---|---|---|
| System loads in 5 seconds | 5 | Strongly Agree |
| System controlled in 3 seconds | 5 | Strongly Agree |
| Solar panel rotation immediately after 5 seconds depending on sun direction | 5 | Strongly Agree |
| Water pump generate in 3 seconds | 5 | Strongly Agree |
| System battery automatically charge in 3 seconds | 5 | Strongly Agree |
| **TOTAL MEAN** | **5** | **Strongly Agree** |

Results show that the end-users Strongly Agree to the Speed of the system in the execution of the built-in functionalities having a numerical mean rating of 5.0. This implies that speed is considered as the biggest advantage of computers because it can perform all operations with an incredible speed which can reduce the amount of time spent when working manually (https://www.chtips.com).

**ACCURACY**

Accuracy is to be ensuring that the information is correct and without any mistake, and buttons or commands function as intended. To have quality of information, it should be accurate.

Table 5. System Accuracy Evaluation Result

| ACCURACY | MEAN | DESCRIPTIVE INTERPRETATION |
|---|---|---|
| System produced efficient battery watts | 5 | Strongly Agree |
| System immediately functions all parts | 5 | Strongly Agree |
| System does not display any errors | 5 | Strongly Agree |
| Solar panel displays according to the sun's direction | 5 | Strongly Agree |
| System is high efficiency using sunlight to usable energy | 5 | Strongly Agree |
| **TOTAL MEAN** | **5** | **Strongly Agree** |

It can be noted from the results presented in Table 5 that the system Accuracy got a mean rating of 5.0 with a descriptive interpretation of Strongly Agree. The results imply that information, total system performance has no flaws, whereby correct information and function were observed.

Accuracy is one of the most important characteristics of an automated control system (https://encyclopedia2.thefreedictionary.com). This was supplemented by Shazia, Muhamamd, and Muhammad that accuracy is the ratio of correct information to the total amount of information produced over a period. The accuracy level depends on the type of information produced. In the new development system, level of accuracy is nearly hundred percent i.e; unless there are errors in data entry, the new system is accurate.

**Summary Table**

Table 6 below presents the summary table of the over-all system evaluation categorized to user-friendly, speed, and accuracy.

| SYSTEM EVALUATION | MEAN | DESCRIPTIVE INTERPRETATION |
|---|---|---|
| User-Friendly | 5 | Strongly Agree |
| Speed | 5 | Strongly Agree |
| Accuracy | 5 | Strongly Agree |
| | 5 | Strongly Agree |
| **GRAND MEAN** | **5** | **Strongly Agree** |

**Table 6.** Summary Table of the System Evaluation

The system got an overall rating of 5.0 or Strongly Agree. Based on the end-user's rating, it can be concluded that the Innovative monitoring system of solar powered water generator has met their requirements. This is evident in their ratings from all the system capabilities being defined by the researchers since from the very first criterion until the last, they gave consistent rating of 5.0. Therefore, they fully understood the over-all functionality of the system and has acknowledged its worth as an aid in managing and organizing their monitoring and control.

## LEVEL OF SATISFACTION

Satisfying Users is one of the crucial objectives of information system success. This shows the total acceptance of the system in relation to users' satisfaction as they test over all functionality of the system. Also, trust has been found as an important factor in information system studies. (kassim,et al).

Early models of user satisfaction in information system were mostly concerned with performance of the technical system and the quality of delivered information in determining the user satisfaction (Vaezi, 2013).

Kassim et al. opened that evaluating satisfaction and its determinant is an important exercise to gauge the value and effectiveness of the information system investment. In the past, user satisfaction has been used to surrogate information system success. It is an assessment made by a user, along a continuum from positive to negative, about certain qualities of information system. Furthermore, various determinants of user satisfaction have been assessed and investigated on how users perceive their acceptance rate on the fit of the information system characteristics and user's needs.

**Table 7** Summary Table on the end-user's level of satisfaction

| SYSTEM CAPABILITY | MEAN | DESCRIPTIVE INTERPRETATION |
|---|---|---|
| Usefulness of the system | 5 | Very Satisfied |
| Ease in using the system | 5 | Very Satisfied |
| Simplifies and lessens workload | 5 | Very Satisfied |
| | 5 | Strongly Agree |
| **GRAND MEAN** | **5** | **Very Satisfied** |

The level of satisfaction is the most difficult aspect to rate. However, when end-users are given the direction and, on their capacity, tried their best to manipulate the system without the researcher's intervention and guidance, they would know whether they are satisfied as to the over-all performance and functionality of the system. Considering the evaluation result, the end-users were Very Satisfied as to the usefulness of the system, comfortable in using the system, security of the information, and that it simplifies and lessens their workload. The results imply total acceptability of the system.

## CONCLUSION

The study was evaluated based on its usefulness, performance, and functionalities of the system, "Innovative Monitoring System for Solar Powered Water Generator". As a strategy used to gather the ratings from the end-users, survey questionnaires were used by the Authorized user. To analyze the data collected the researchers determined the meaning of the responses of each user.

The result revealed that the system is getting a lot of attention. As to the user-friendliness of the system, a user's having little knowledge about the system manual can run this system effectively. Also, the system is easy to use giving them a one-of-a-kind user experience.

As to the level of satisfaction, the end-user where very satisfied as to the usefulness of the system and comfortable in using the system that it simplifies and lessens their workload. The results imply total acceptability of the system.

## RECOMMENDATIONS

Based on the conclusions, the following recommendations are made for the improvement of the system:

- Monitor the Solar Temperature
- Its Battery Percentage
- Solar panel rotation pointing to the sun.
- Enhance the introduction about the system.

## IMPLEMENTATION PLAN

Upon implementation of the system, the researchers join the exhibit as to the functionalities and expected flaws of the system when incorrect data are provided, and commands are issued. This is to give the end-user a clear view of the system and its purpose.

Users should know the importance of system management and how to generate the system. They have to bear in mind that system management is the administration of the information technology (IT) systems. An effective systems management plan facilitates the delivery of IT as a service and allows an organization. Therefore, an effective system management improves the overall function. It also organizes important data.

## BUDGET RECOMMENDATION

For implementation purposes, the budgetary aspect regards to the software and hardware requirements is necessary as a guide for the beneficiary of the system as shown in table 5.

**Table 5.** Recommended Budget for the Implementation of the System

| PARTICULARS | QUANTITY | COST/UNIT(PHP) |
|---|---|---|
| Hardware: | | |
| Complete Set (Solar Tracking Kit) | 1 | 2,000.00 |
| Battery | 1 | 1,850.00 |
| Water Pump | 1 | 650.00 |
| Inverter | 1 | 1,600.00 |
| Software: | | |
| Arduino IDE | | |
| **TOTAL** | | **6,100.00** |

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