الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحري

Arab Academy for Science, Technology & Maritime Transport

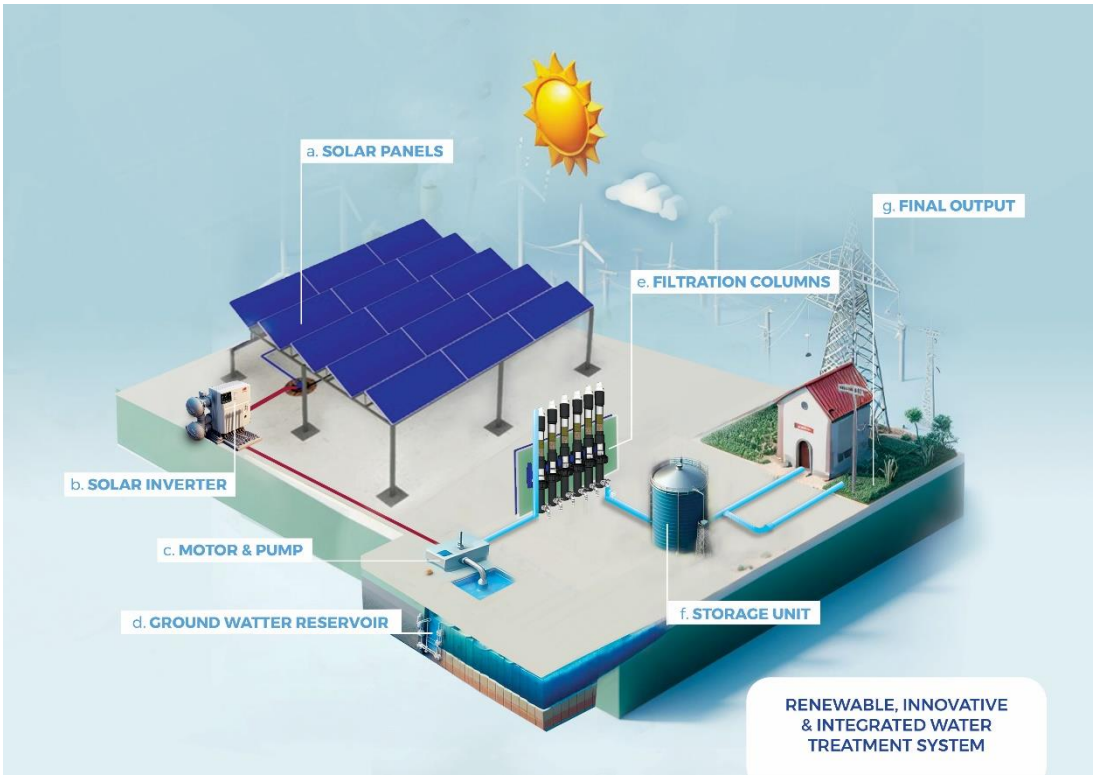
Technical Report on

MoniToRing, AssEssment and InnovAtive Treatment Technology to Enhance of Groundwater Quality for Irrigation Purposes toward CliMatE ChaNge AdapTation

TREATMENT

Proposal ID: 2075

Renewable, Innovative & Integrated Water Treatment Unit



May 2024

Solar Pumping System Block Diagram

Introduction

The primary purpose of this section is to provide a comprehensive overview of the design and components comprising a solar photovoltaic (PV) system. This system has been specifically engineered to power a three-phase pump, serving the dual function of lifting water from a well and subsequently channeling it through a state-of-the-art four-stage nano-filtration system, thereby ensuring its purity and suitability for various applications, including cultivation and drinking.

System's Function

At its core, the solar PV system serves as the sustainable energy source for the three-phase pump. The solar panels convert sunlight into electrical energy, which is then transformed by the solar inverter into a form compatible with the pump's operation. This energy is harnessed to lift water from a well, and subsequently, the water is directed through the four-stage nano-filter, where it undergoes a rigorous purification process. The end result is clean, potable water or water suitable for irrigation and cultivation.

Components Used

The pivotal components selected for this solar pumping system are the JA Solar Mono-455 W panels and the ABB ACS550-01-05A4-4 solar inverter. These components were carefully chosen based on their compatibility with the system's requirements, efficiency, and reliability. The solar panels, with a rated output of 455 watts, efficiently capture solar energy, while the ABB solar inverter ensures the seamless conversion and management of this energy to power the three-phase pump which is already exists at the selected location inside AASTMT main campus.

System Block Diagram

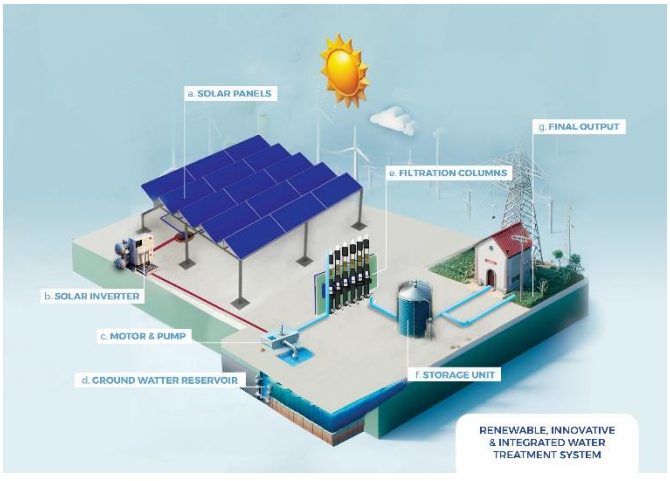


Figure 1: Solar Pumping System - Block Diagram

The block diagram shown in figure 1 summarizes the main system components starting from the load side which is a 3-phase pump to the PV modules that will deliver enough energy to the solar inverter that will convert the DC voltage from the PV modules into 3-Phase AC

voltage suitable for the pump. The system also contains a storage unit for water storage used in irrigation purposes.

Solar PV Modules

Selection Criteria

The selection criteria used to determine the suitable modules can be summarized in the following parameters:

1. Efficiency: One of the primary selection criteria for the JA Solar Mono-455 W panels was their high efficiency in converting sunlight into electricity. These panels are known for their impressive efficiency ratings, which ensures maximum energy generation from the available sunlight. With an efficiency of 21% they can harness a significant amount of solar energy even in less-than-optimal conditions.
2. Power Output: The rated power output of the JA Solar Mono-455 W panels played a pivotal role in their selection. With a power output of 455 watts per panel, they align perfectly with the power requirements of the three-phase pump, providing ample energy to power the system efficiently.
3. Durability: Durability and longevity are critical considerations for any solar panel installation. The JA Solar Mono-455 W panels are renowned for their robust build quality and resistance to environmental stressors. They are designed to withstand harsh weather conditions, UV exposure, and temperature fluctuations, ensuring a prolonged operational lifespan.
4. Technology: The panels employ monocrystalline technology, known for its high efficiency and space-efficient design, making them a suitable choice for installations with limited roof or ground space.
5. Warranty: The JA Solar Mono-455 W panels come with a [12 years for the product and 25 years for the output power] warranty, providing peace of mind regarding their performance and reliability over an extended period.

PV Module Specifications

Specifications of JA Solar Mono-455 W Panels

- Efficiency: 21%
- Power Output: 455 watts
- Open-Circuit Voltage (Voc): 53.87 V
- Max. Power Voltage (Vmpp): 45.83 V
- Short Circuit Current (Isc): 10.56 A
- Max. Power Current (Impp): 9.93 A
- Dimensions (mm): 2180x996x40

Power System Calculations

Pump Specifications

- Power: 3hp (2.2Kw)
- Current: 6A
- Speed: 2830 rpm
- Power factor: 0.71
- Protection: IP68
- Thrust load: 3000 N
- Min. flow: 0.3 m/s

PV Sizing

The total power generation capacity of the JA Solar Mono-455 W panels is a key factor in the design of the solar PV system. With a total of **15 panels** installed, the system can generate a maximum power output of **6,824 watts** under ideal solar conditions and **808 V** for open circuit conditions as they will be connected in series.

- No. of PV strings (pump current * 1.25)/Impp = 6 * 1.25 / 9.93 = 4.9 = 0.75 = **1 string**
- No. of PV modules/string = 380*sqrt(3) / Vmpp = 600/45.83 = 8.2 = 14.4 col = **15 PV module/string**

Accordingly, the PV power system will be connected so that the **15 modules** will be in series to sum up the voltage to exceed the **600 V**. The generated voltage by PV modules will be varying due to the change of the solar irradiation, this will affect the frequency of the generated 3-phase AC voltage, and this will affect the pump speed and the gained water flow. The frequency will change from **0 to 50 Hz** due to the solar irradiation, so the speed of the pump will change from **0 to 2830 rpm**.

The selection of the JA Solar Mono-455 W panels and the ABB ACS550-01-05A4-4 solar inverter was made with careful consideration of the power requirements of the pump. The solar PV system's total power generation capacity comfortably meets and exceeds the pump's power demands, ensuring reliable and uninterrupted operation.

The compatibility extends to the electrical specifications, such as voltage and frequency, to ensure seamless integration between the solar PV system and the three-phase pump.

This alignment between the solar PV system and the pump's requirements not only guarantees the efficient operation of the water lifting and filtration process but also contributes to the sustainability and cost-effectiveness of the entire system.

Solar Inverter

Selection Criteria

The ACS355 solar pump inverter is a low voltage AC drive of 0.3 to 18.5 KW rating designed to operate with energy drawn from photovoltaic cells (PV). The inverter is customized to operate in dual supply mode, so the grid connected supply is used in the absence of energy from PV

cells. The inverter functions with the latest in technology maximum power point tracking (MPPT) algorithm to derive maximum power from the PV cells at any instant.
The inverter is specifically designed to meet the requirements of pump manufacturers and the original equipment manufacturers (OEM).

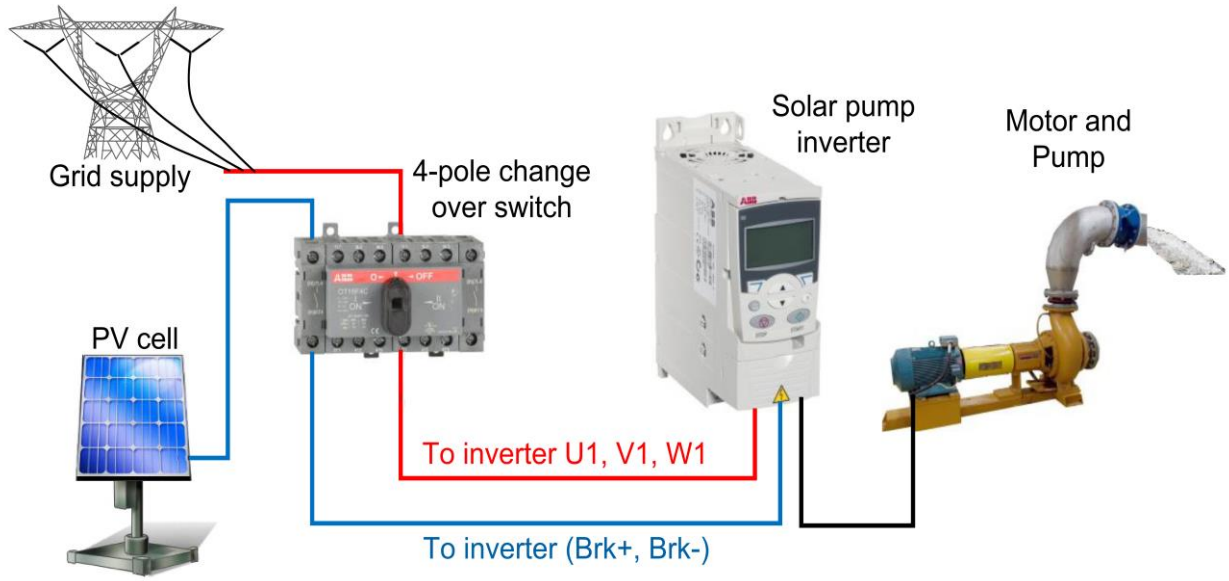


Figure 2: ABB Solar Inverter Block Diagram

Solar Inverter Specifications

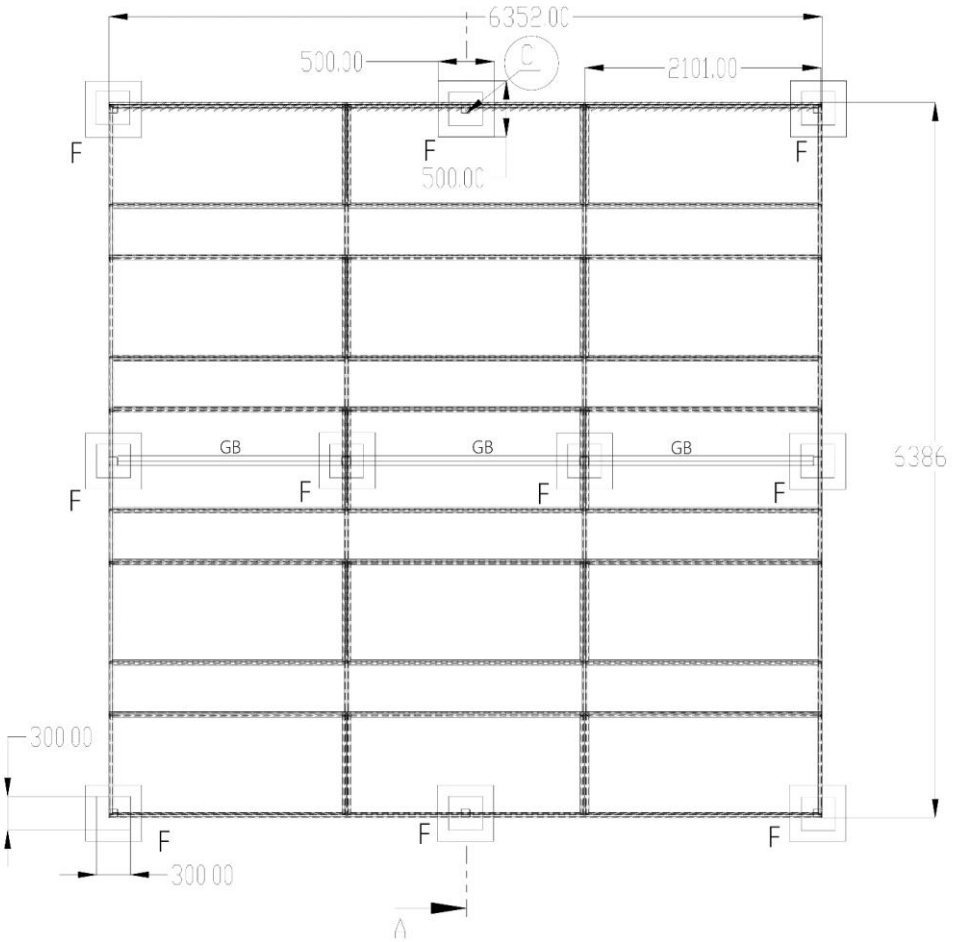
Table 1: ABB Inverter Specifications

Brand	ABB
Model Name/Number	ABB ACS550-01-05A4-4
Motor Power	3KW/4HP
Input Voltage	400 VAC
Input Phase	3 – Phase
Input Frequency	50/60 Hz
Output Current	5.4 A
Ambient Temp.	50 DEGREE
Warranty	1 year
Degree of Protection	IP21
Communication Ports	MODBUS
Minimum Order Quantity	1

Solar Mounting

Figure 3: Solar PV Modules Mounting Structure

Figure 4:



Mounting Structure - Top View

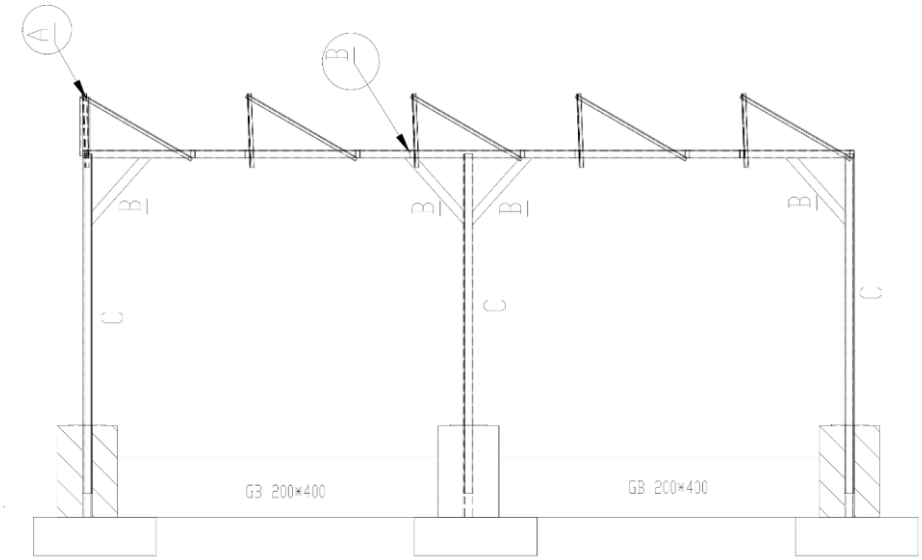
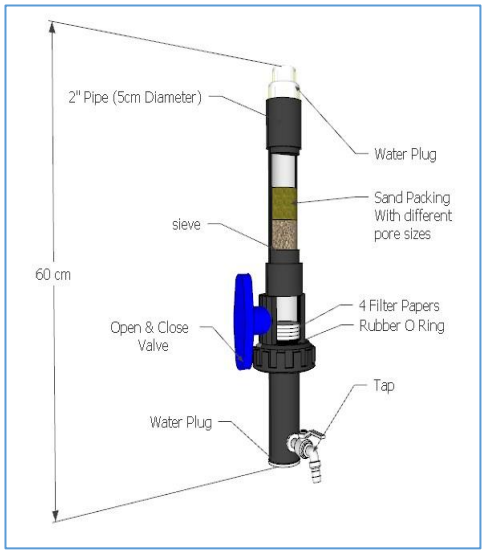


Figure 5: Mounting Structure - Side View

Water Treatment Filter

The filtration column is designed for water treatment; it was made of PVC material which was chosen because it doesn't react with chlorine or the water itself.
Two columns are used; the first (control) was packed with sand with different pore sizes, while the second is packed with composite Ag/AC that was embedded in the sand media.
The water drawn to be treated (Inlet) enter the column from the upper opening then passes through the control and Ag/AC amended sand filters for 3 - 6 cycles (turnover) and collected after treatment from the bottom tap of the column as a well-treated water.



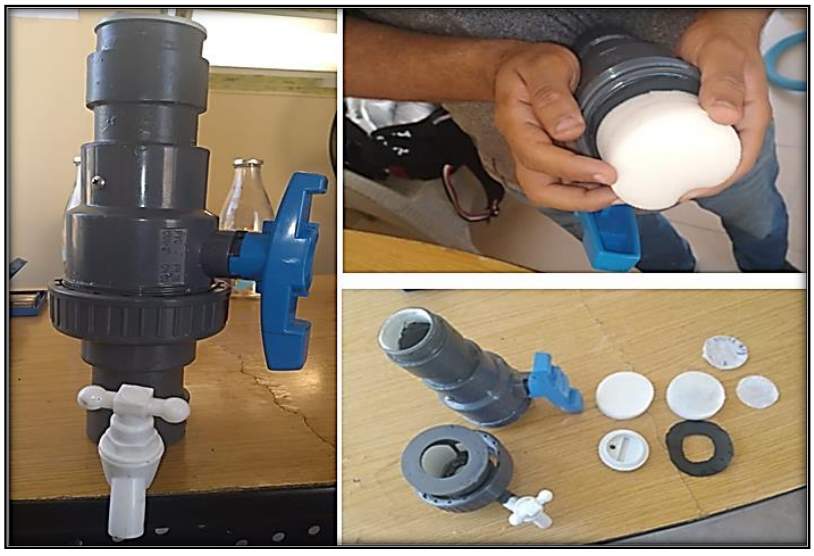


Fig. XXX: Components of the Proposed Ag/AC NC - Amended Sand Filters

نظام معالجة المياه المتجددة والمبتكرة

يهدف هذا النظام إلى تقديم تصميم شامل ومتكامل يعتمد على الطاقة الشمسية لتشغيل مضخة ثلاثية الطور ونظام ترشيح نانوي متطور لضمان نقاء المياه.

مكونات النظام

1. **الألواح الشمسية الكهروضوئية**
   - **النوع:** JA Solar Mono-455 W
   - **الوظيفة:** تحويل ضوء الشمس إلى طاقة كهربائية بقدرة تصل إلى 455 واط.
2. **العاكس الشمسي**
   - **النوع:** ABB ACS550-01-05A4-4
   - **الوظيفة:** تحويل الطاقة الكهربائية من الألواح الشمسية إلى شكل يتوافق مع تشغيل المضخة ثلاثية الطور.
3. **المضخة ثلاثية الطور**
   - **الوظيفة:** رفع المياه من البئر باستخدام الطاقة المحولة من العاكس الشمسي.
4. **نظام ترشيح نانوي رباعي المراحل**
   - **الوظيفة:** تنقية المياه لضمان نقائها وجعلها صالحة للشرب أو للري والزراعة.

عملية التشغيل

1. **توليد الطاقة:**
   - الألواح الشمسية تلتقط الطاقة الشمسية وتحولها إلى طاقة كهربائية.
   - يتم تحويل الطاقة الكهربائية بواسطة العاكس الشمسي إلى طاقة متوافقة مع المضخة ثلاثية الطور.
2. **رفع المياه:**
   - الطاقة المحولة تُستخدم لتشغيل المضخة التي ترفع المياه من البئر.
3. **تنقية المياه:**
   - المياه التي تُرفع تُوجه إلى نظام الترشيح النانوي، حيث تخضع لعملية تنقية صارمة تتكون من أربع مراحل.
   - المياه الناتجة تكون نظيفة وصالحة للاستخدامات المختلفة مثل الشرب والزراعة.

التطبيقات

- **الزراعة :**توفير مياه نقية للري، مما يزيد من إنتاجية المحاصيل.
- **الشرب :**ضمان مياه نقية وصحية للشرب.

اختيار المكونات

- **الألواح الشمسية :**تم اختيارها لكفاءتها العالية في تحويل الطاقة الشمسية.
- **العاكس الشمسي :**اختير لتحويل الطاقة بكفاءة وضمان تشغيل المضخة بشكل سلس.
- **نظام الترشيح النانوي :**لضمان نقاء المياه وجودتها العالية.

هذا النظام يوفر حلاً مستدامًا وفعّالاً لتلبية احتياجات المياه، مستفيدًا من الطاقة الشمسية ومتطلبات الطاقة المتجددة لتحقيق كفاءة وموثوقية عالية في معالجة المياه.