A Study on Solar-driven Water-saving Irrigation Equipment

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Contents

Background

- Lack of electricity in remote areas
- The development of water-saving irrigation is blocked
- The pollution of diesel pump irrigation system is serious
- Solar-driven Irrigation

Background

- Solar spray drip irrigation is widely used
- Solar energy is used to lighting
- China 's cultivated land accounts for 69.3% in mountainous, and only 30.73% in plains and basins.
- Photovoltaic irrigation supply and demand need to adjust measures to local conditions

2. Solar-driven hard hose traveler

- ✓ Stand-alone PV system
- ✓ Hose reel cart
- ✓ Fertilizing device
- ✓ Traction device

Traditional system composition

FIGURE 1

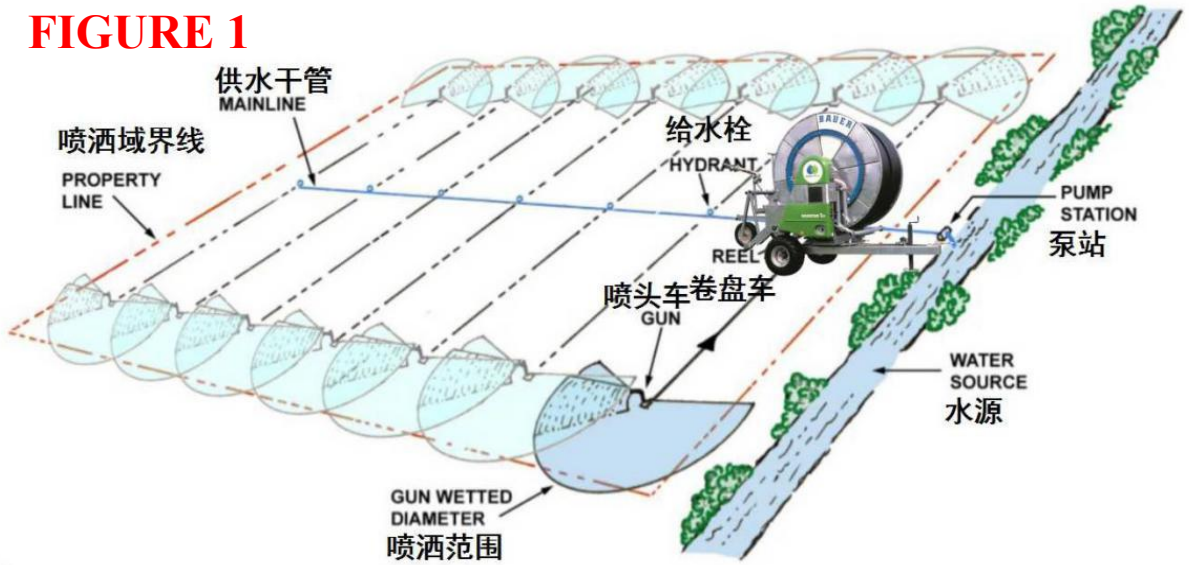


FIGURE 2

FIGURE 3

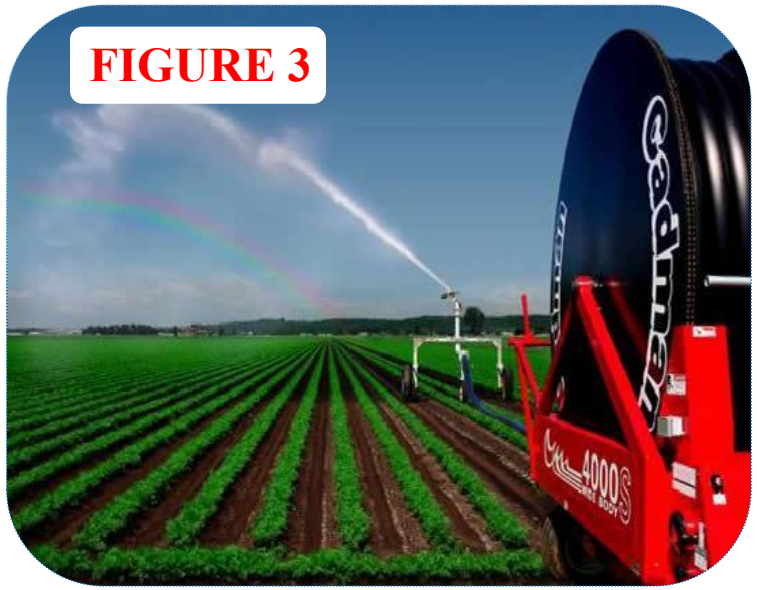
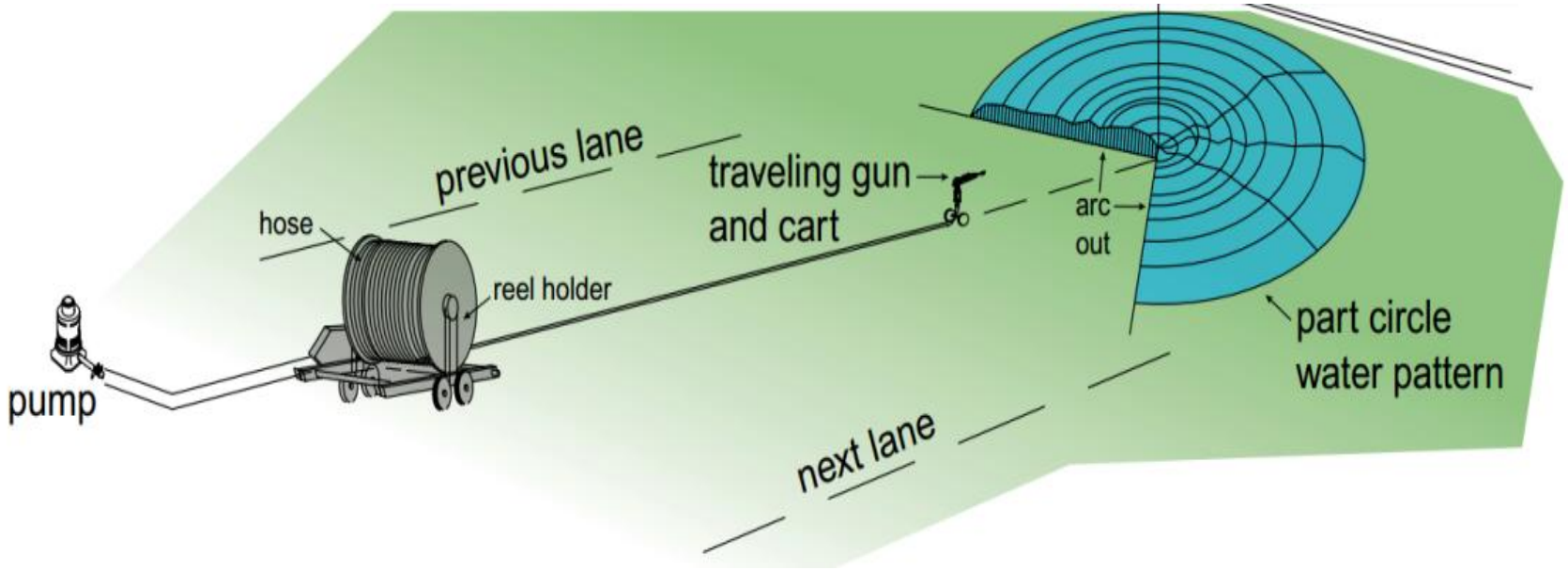


FIGURE 4

1. Pump station
2. Multi sprinkler (or single gun sprinkler) cart
3. Hose reel cart
4. Tractor

Problems of traditional hard hose traveler



Operation schematic diagram of hard hose traveler

- ✓ High inlet water pressure (0.7 MPa): tractor-dragged ; waterturbine
- ✓ Sandy water block waterturbine
- ✓ Relative short truss（<30 m）
- ✓ Lack electric power supply; automatic control can not be used

Objective of newly developed devices

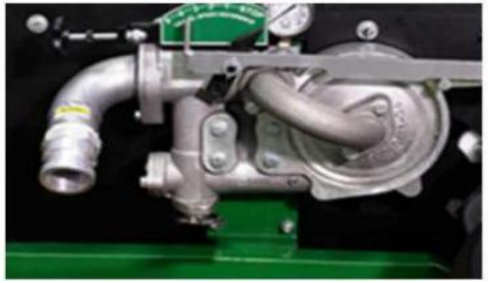
- ✓ Solar driven: energy saving, environmental friendly and high reliability.
- ✓ Optimized truss structure size. Decrease cost; save driving energy
- ✓ Low energy consumption： <0.3MPa for multi-nozzle type and <0.5MPa for single sprinkler type
- ✓ Automatic starting up, shutdown and walking
- ✓ Integration of water and fertilizer

Characteristic of new device

- ✓ **Solar-driven instead of water turbine and inlet water pressure down from 0.8 MPa to 0.5 MPa.**
- ✓ **Annual cost decrease by 20%**
- ✓ **Speed control system ensures a constant moving speed of sprinklers cart and high irrigation uniformity.**

Composition of solar driven system

Motot drive

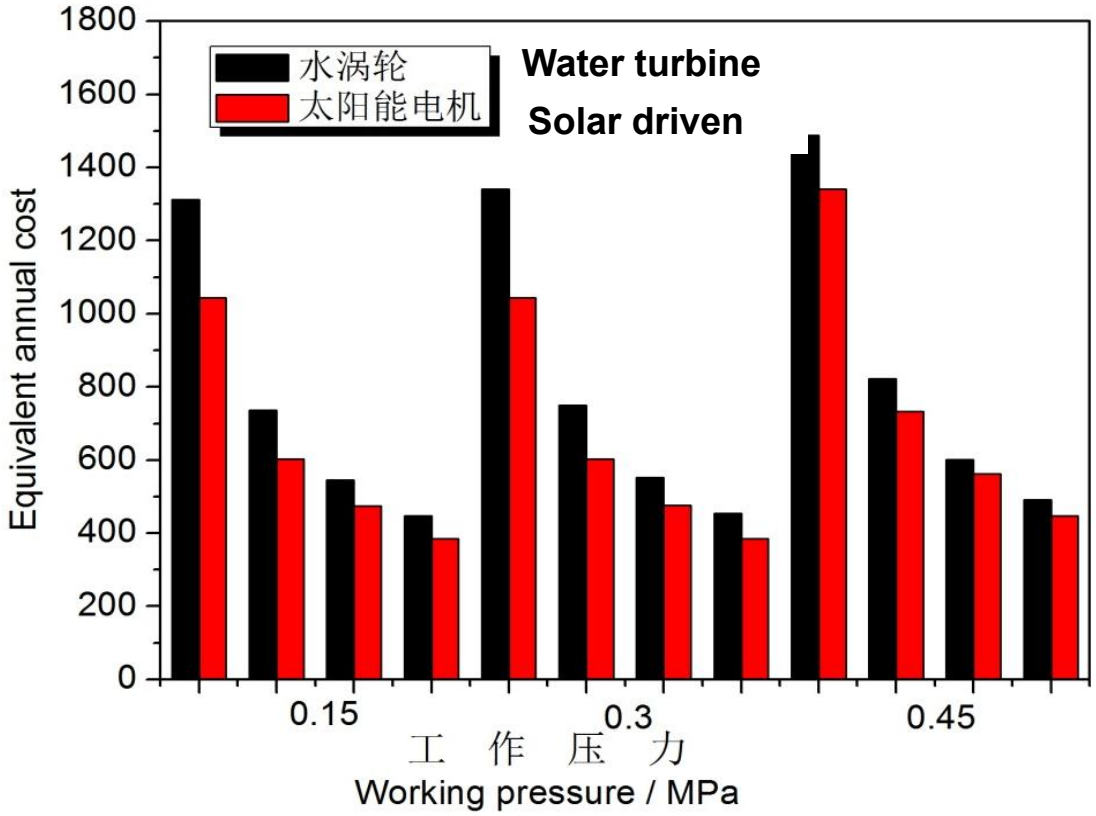


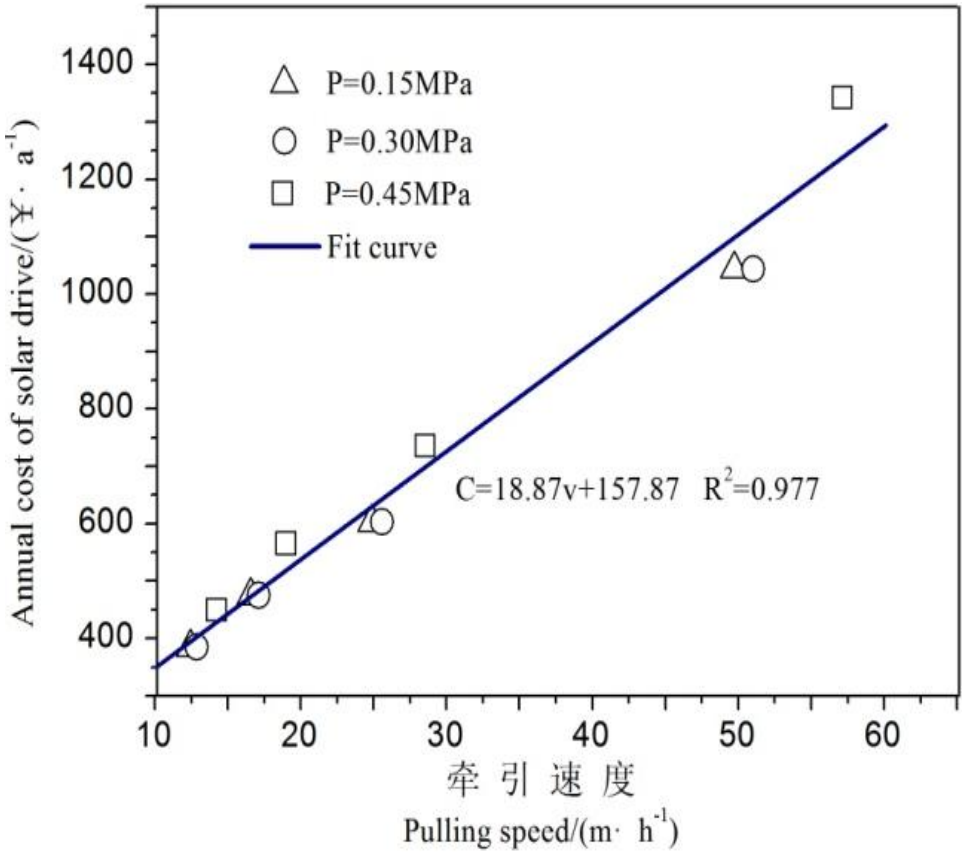
Water turbine driven

Control system of hard hose traveler

- ✓ **Intelligent control: Start/Stop, automatic alarm, speed regulation, irrigation account**
- ✓ **Automatic monitoring: power generation, battery storage stage, load power, walking speed**

Comparison of Equivalent Annual Cost



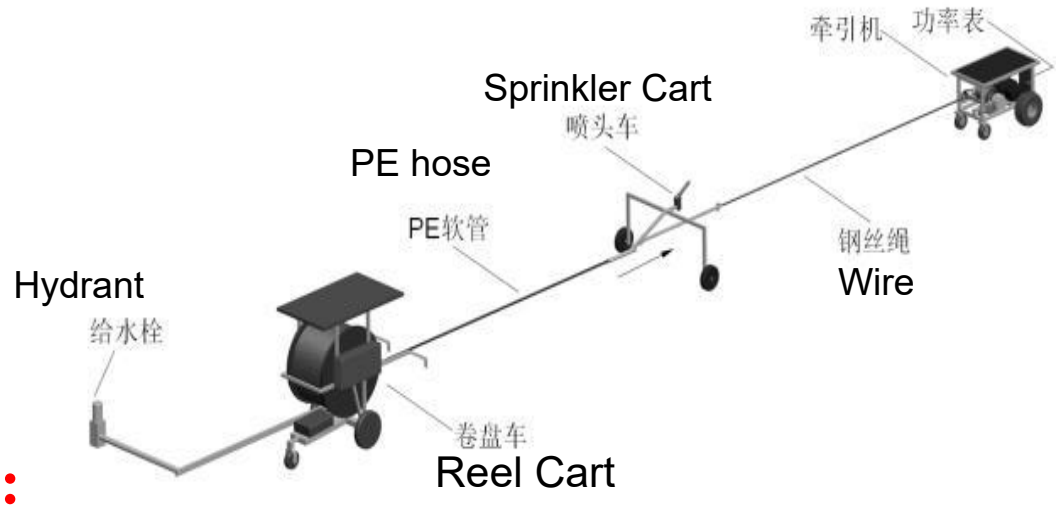


- ✓ **EAC of solar driven system is 10%~20% lower than EAC of water turbine system under various moving speed and water pressure.**
- ✓ **Relationship between pulling speed and EAC under various operating pressures**

Solar-driven traction device

Objective：

- ✓ instead of farm tractor to avoid harm of crops; diesel oil and labor saved



Characteristic:

- ✓ Adjustable moving speed (0-15 m/min)
- ✓ Control device: control moving speed monitoring solar electric charge
- ✓ steel wire was twined uniformity

Three-in-one integration equipment

Pressure boosting-Traction-Fertilization

Objective：

- ✓ Decrease cost
- ✓ Easy to manage

Characteristic:

- ✓ Traction of gun cart
- ✓ Water pressure booster
- ✓ Fertilizer injection
- ✓ Traction of hose reel cart

Solar-driven fertilizing device

- ✓ **Applicable to integration on water and fertilizer in any pressurized pipe irrigation**
- ✓ **Easy to operate and move**

Fertilizer flow

Fertilizer flow under different pressure and pump stroke

Stroke(%) / Pressure(m)	20	40	60	80	100
10	40	66.7	89.5	113.5	130.4
20	39.1	65.3	87.1	111.3	127.3
30	38.4	64.9	85.3	108	126.3
40	36.5	62.7	86.3	108	124.5
50	35.2	61.3	84.7	106	122
Average	37.8	64.2	86.6	109.4	126.1

- ✓ Fertilizer amount can be regulated by electrical frequency of pump
- ✓ Main pipe pressure shows little effect on fertilizer amount

3. Solar-driven canal feeding lateral move sprinkler

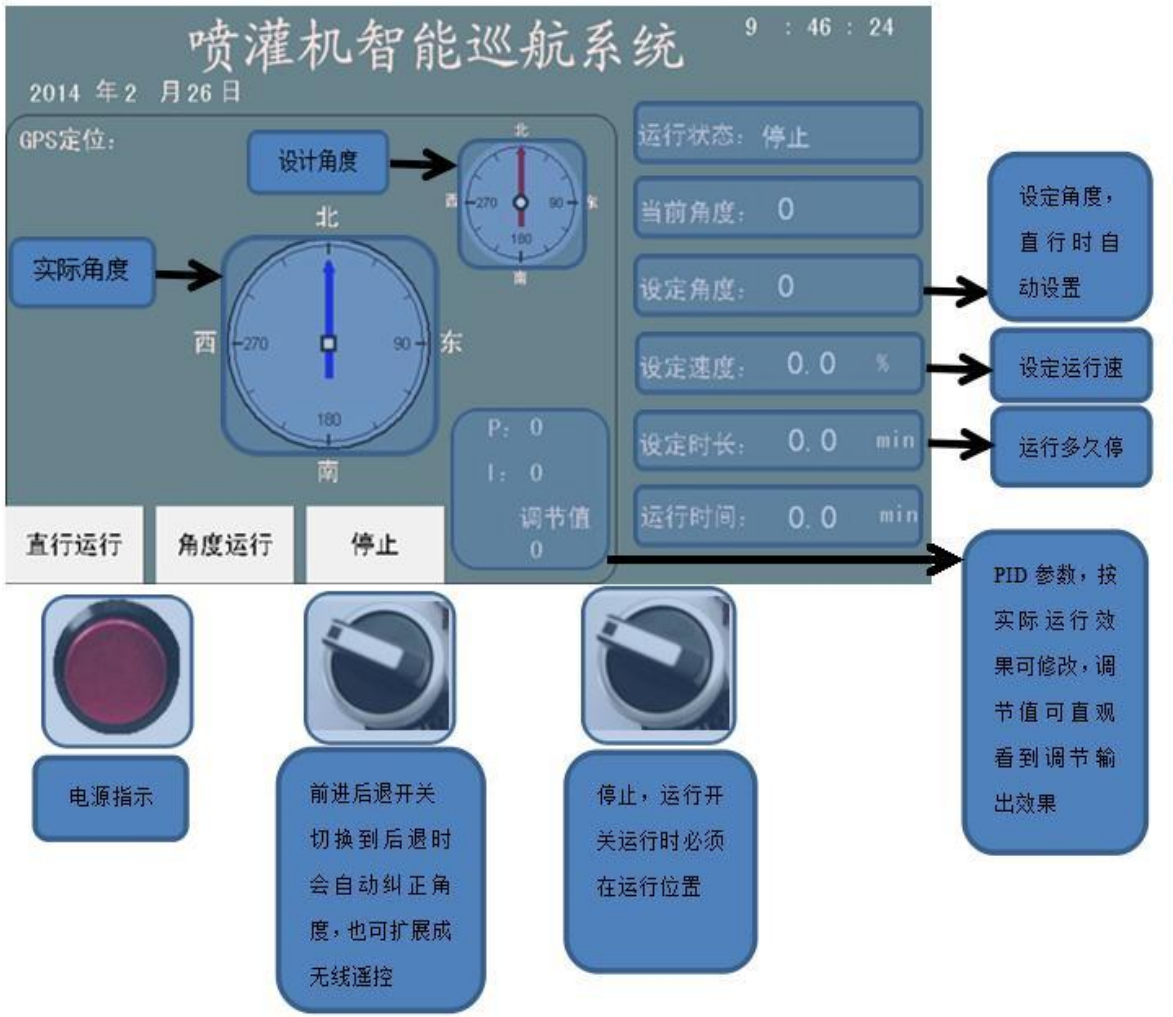
- ✓ GPS navigation
- ✓ Pecision irrigation
- ✓ Truss structural optimization
- ✓ Low pressure sprinkler nozzle

Characteristic:

- ✓ Canal transport water instead of reel cart and decrease water head friction loss
- ✓ Composed by PV system, body frame, canal, pump, filter, navigation system.
- ✓ Pumping head reduces to less than 0.2 MPa, totally solar powered, intellectual control and low cost.

Function of intelligent control system

- ✓ GPS navigation
- ✓ Intelligent control: Start/Stop, automatic alarm, speed regulation, quantitative irrigation.
- ✓ Automatic monitoring: power generation, battery storage stage, load power
- ✓ Pricise irrigation



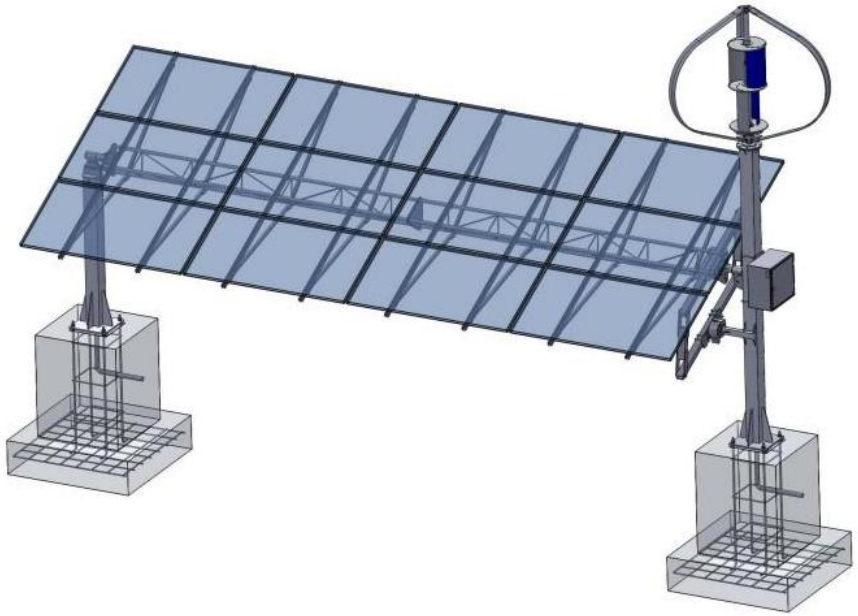
Intelligent cruise control interface

Solar-powered fertilizer device

- ✓ Fertilizer is injected to irrigation pipe without electric
- ✓ The flow rate is regulated by pump frequency converter. It is accurate and stable

4. Photovoltaic sun-tracking device

- ✓ Physical design
- ✓ Entity construction and performance verification
- ✓ Applicative prospect



Two point support

Single axis sun tracing structure diagram

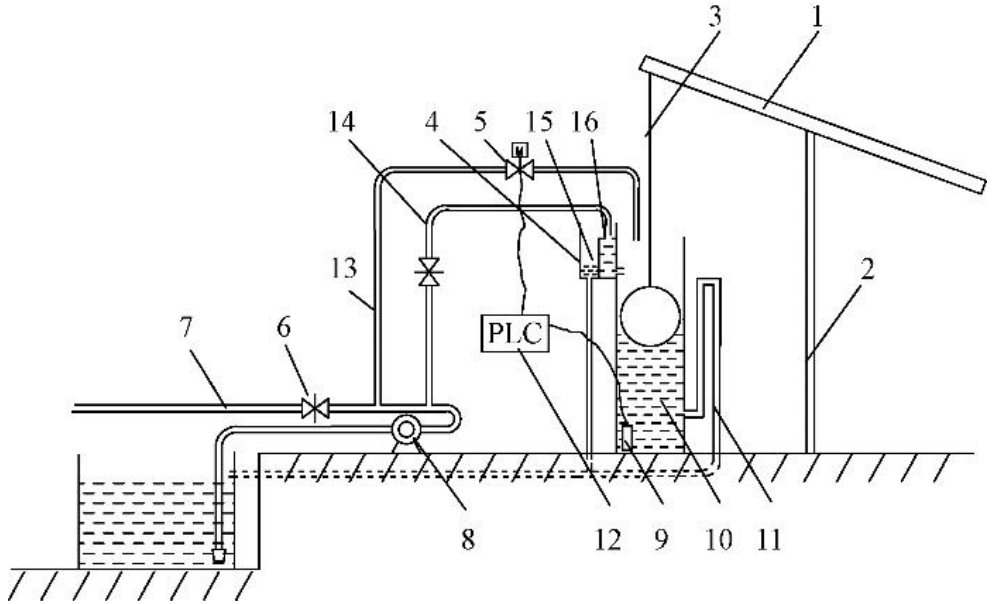
Single point support

Physical picture of two-axis tracking device

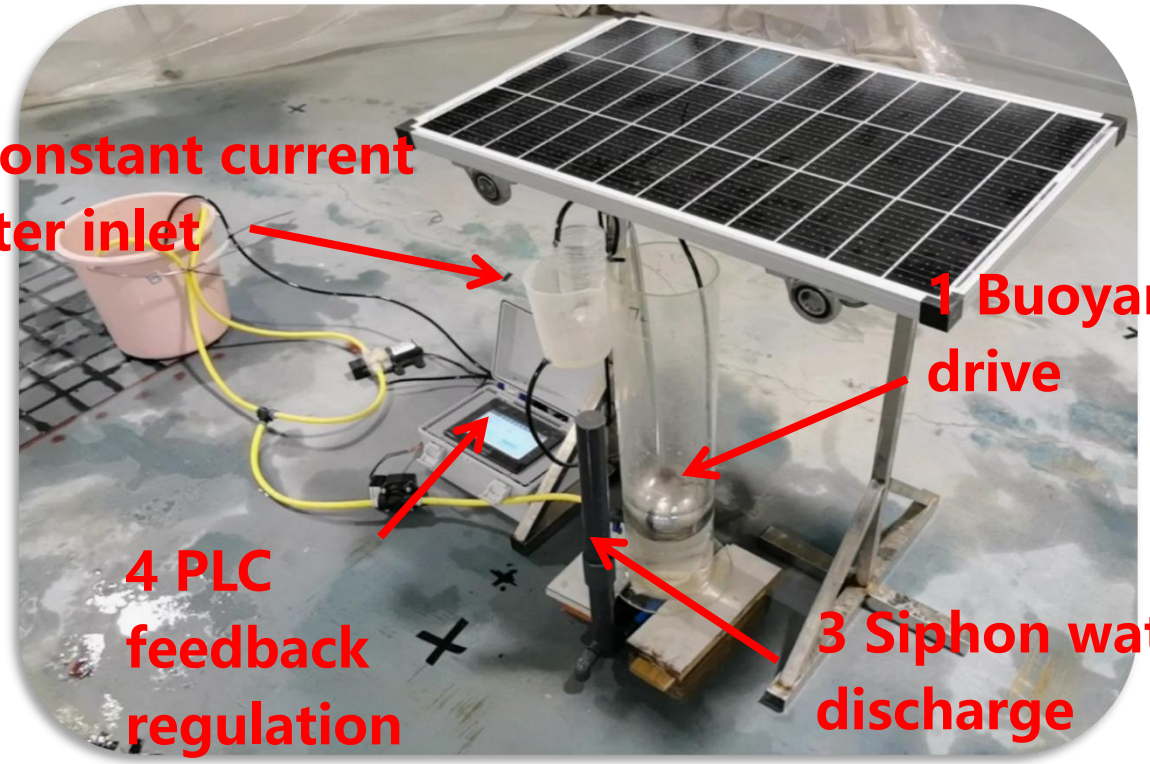
At present, the energy utilization rate of photovoltaic irrigation system is less than 5%. In order to make photovoltaic panels receive more solar energy and improve energy utilization rate, single-axis or double-axis brackets are often set up to realize the sun-tracking function.

Physical design

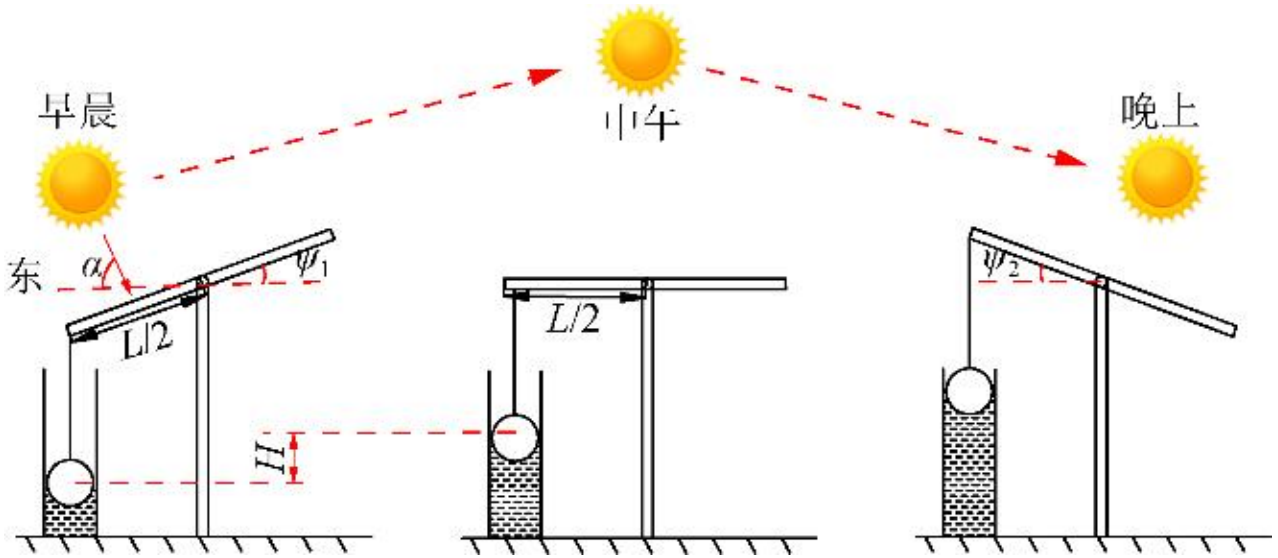
- ✓ **Design points: High stability, full energy utilization, simple structure and low cost**
- ✓ **Design principle: Buoyancy drive; Constant current water inlet; Siphon water discharge; PLC feedback regulation**



1. Solar panel 2. Bracket 3. Steel rod 4. Constant flow water inlet device 5. Solenoid valve 6. Gate valve 7. Water main 8. Photovoltaic pump 9. Liquid level sensor 10. Float 11. Siphon drain pipe 12.PLC 13. Secondary water refill pipe 14. Constant current water supply pipe 15. Drain tank 16. Overflow tank



Relationship between liquid level and solar position



- ✓ Determine the relationship between the rotation angle of the photovoltaic panel and the solar azimuth angle.
- ✓ Calculate the rising height of the float
- ✓ Determine the change rule of water tank replenishment flow with the position of the sun

Solar azimuth angle

$$\cos\varepsilon = \sin\alpha$$

Angle of photovoltaic panel

$$H = \frac{1}{2}L(\sin\psi_1 + \sin\varepsilon)$$

$$(\psi_1 \le \varepsilon \le \psi_2)$$

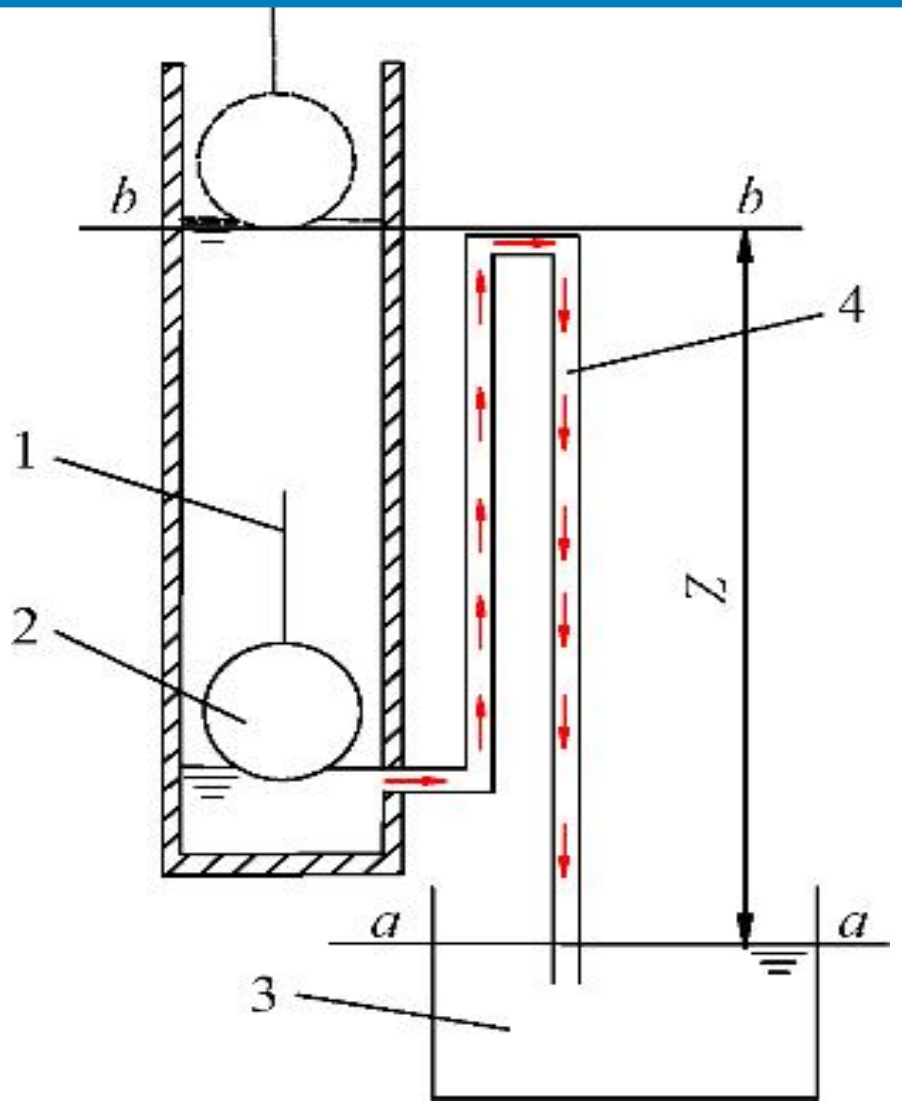
Height of rise of float

$$Q = \frac{\pi r^2 H}{t_{s2} - t_{s1}}$$

Water tank replenishment flow

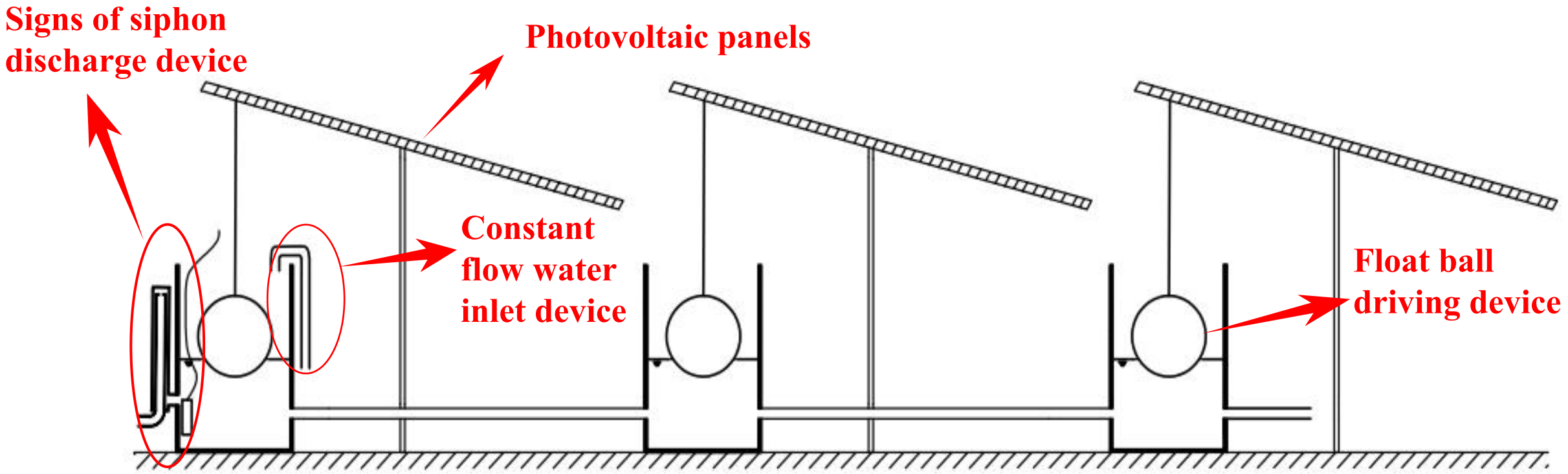
Siphon drainage device

- ✓ The device is composed of right-angle bends with the end leading to the reservoir
- ✓ When the liquid level of the water tank rises to the highest position of the siphon pipe, the siphon effect is generated and the water tank is automatically emptied

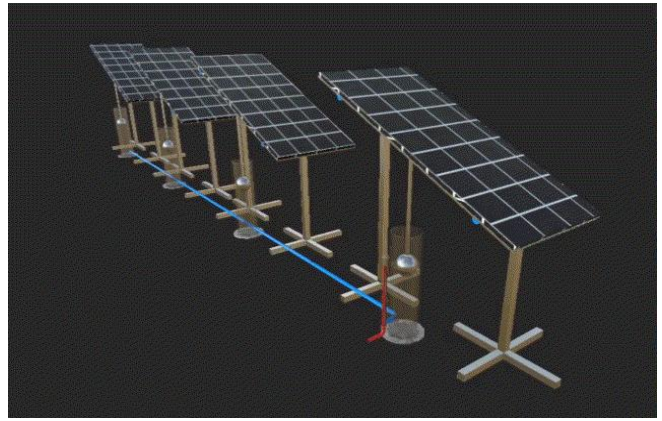


Signs of siphon discharge device

Multi-photovoltaic plate connection device

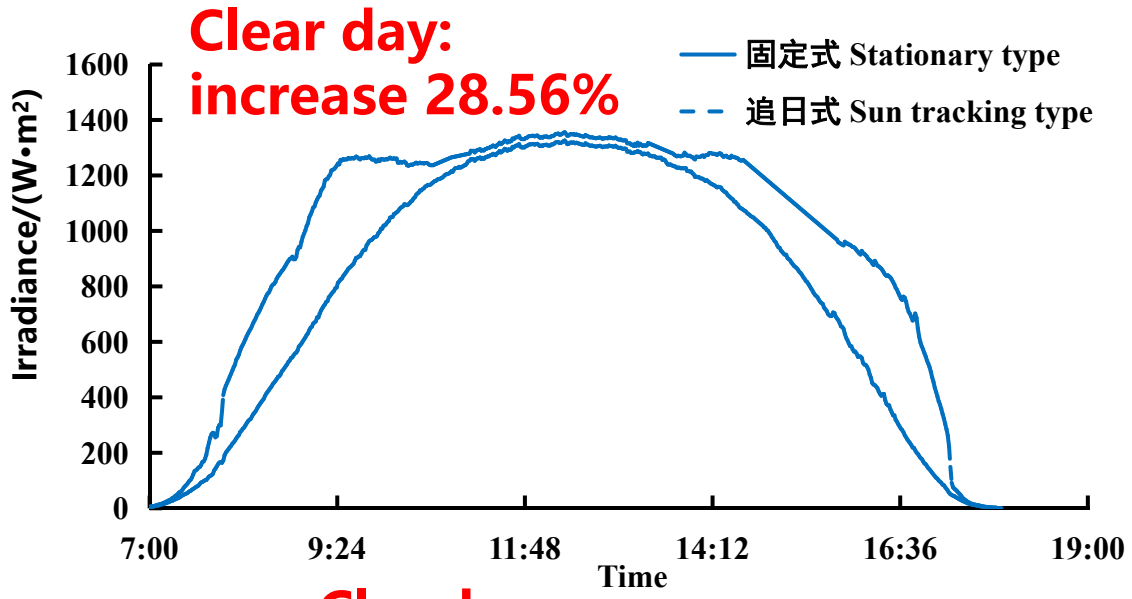


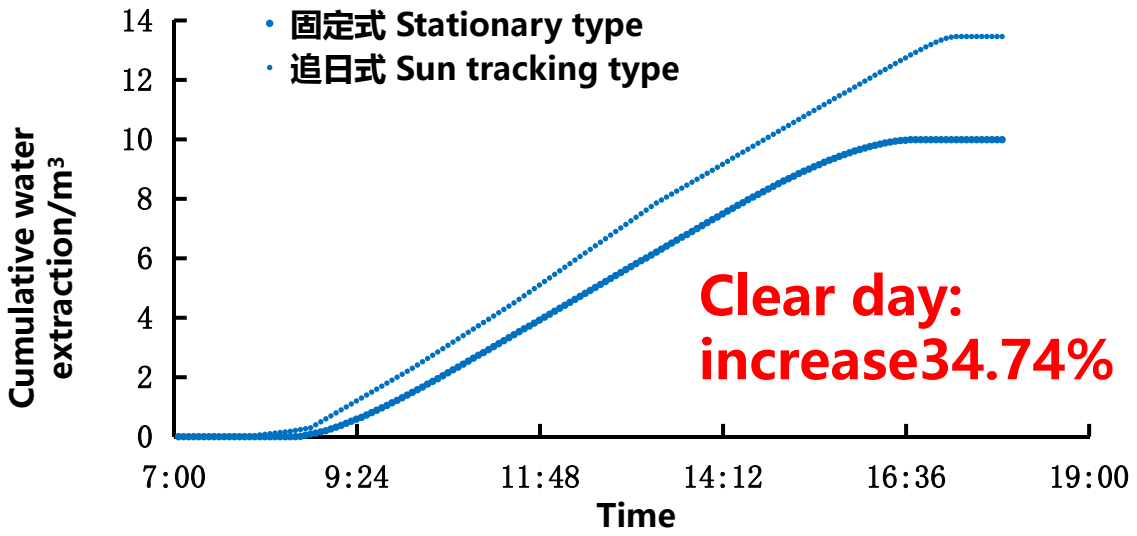
Structure diagram of multi-photovoltaic plate connection device

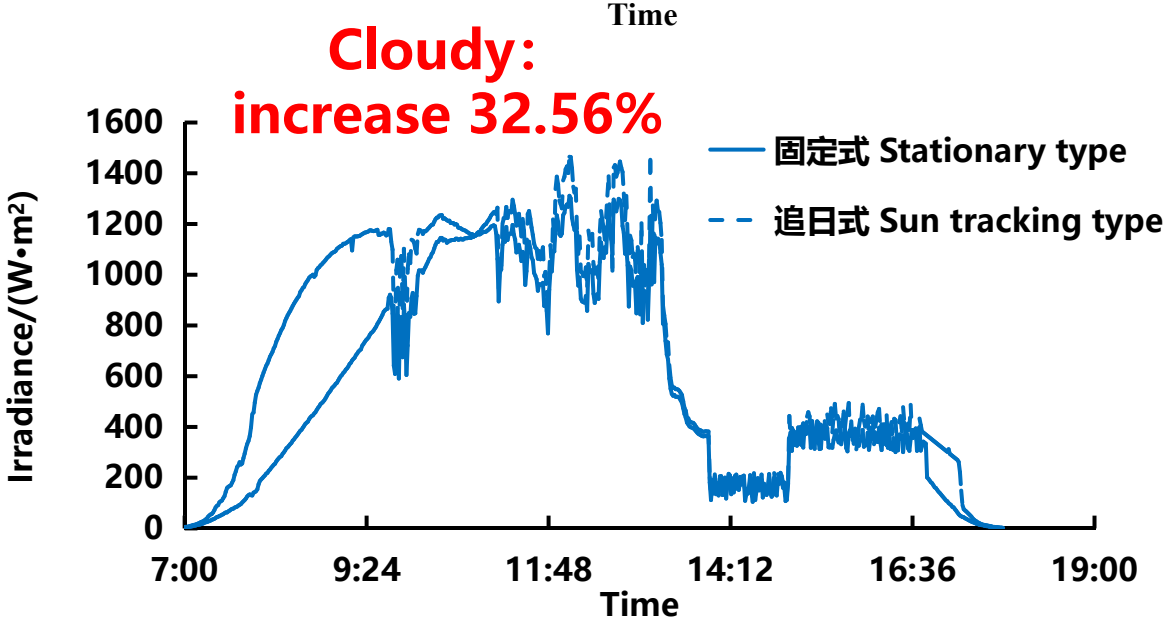


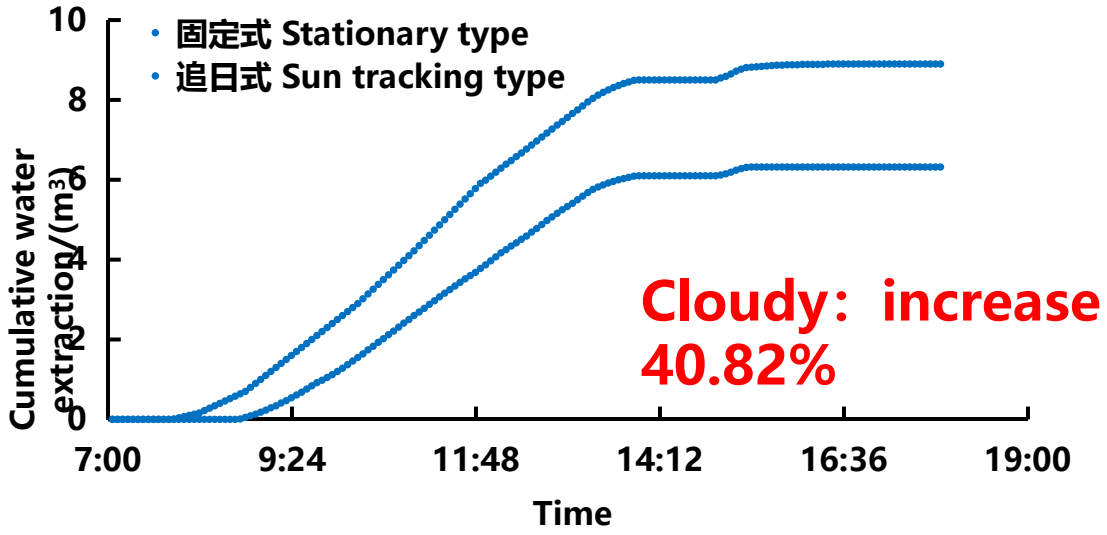
The principle of connecting pipe : multiple water tanks are connected to form an isobaric surface

Comparative analysis of radiation reception and water extraction









5. Field application

Field application

Field application

Centre pivot springkler irrigation

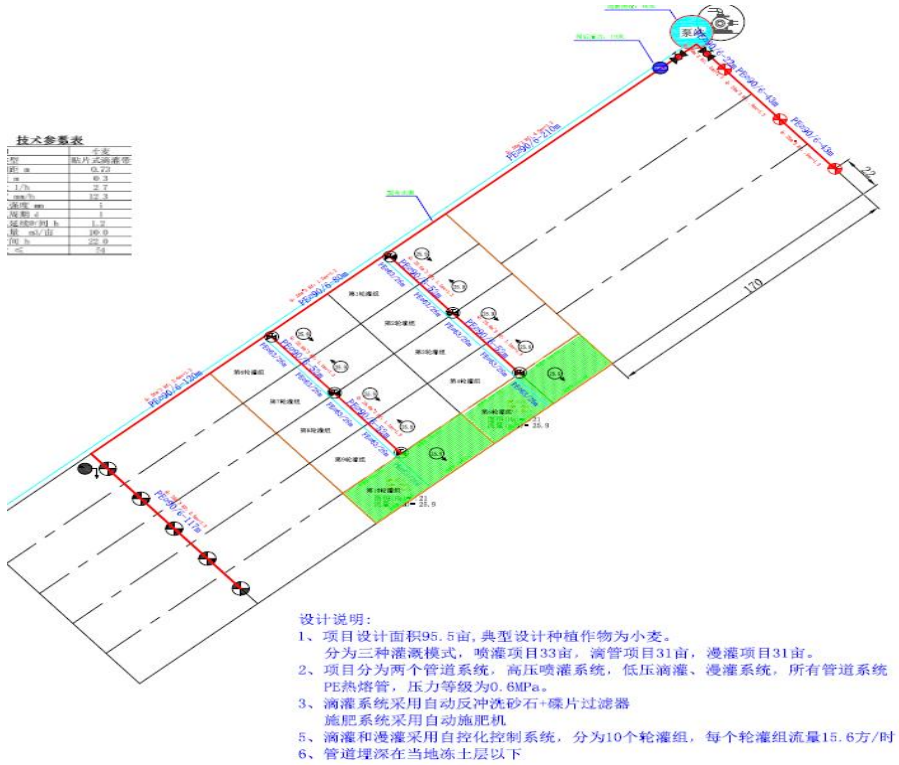
Line-moving springkler irrigation with solar-powerd

- ✓ Suitable for densely planted crops (forage, wheat, corn, potatoes, vegetables, etc.)
- ✓ Water, fertilizer and pesticide integration
- ✓ Low energy consumption (20 m inlet pressure)
- ✓ High degree of automation and precision

Application of irrigation technology in Uzbekistan

- ✓ Automatic irrigation and fertilization
- ✓ Solar-driven sprinkler irrigation
- ✓ Low pressure drip irrigation
- ✓ field experiment

Demonstration park of NR U-TIIAME



6. Research prospect

Research prospect

Power requirement analysis

- ✓Walk power on considering soil density, soil moisture,slope, barrier, weight, wheel type.
- ✓Pump power on considering nozzle pressure, flow rate, working hour, pipe diameter and length.

Energy consumption optimization

- ✓Minimize the energy consumption and meet crop water requriement.

Intelligent control

- ✓Improve walk, start/stop, navigation function
- ✓Remote control and real-time minitoring
- ✓Variable rate irrgation and precise irriation

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