

Solar PV Pump Research and Applications in China

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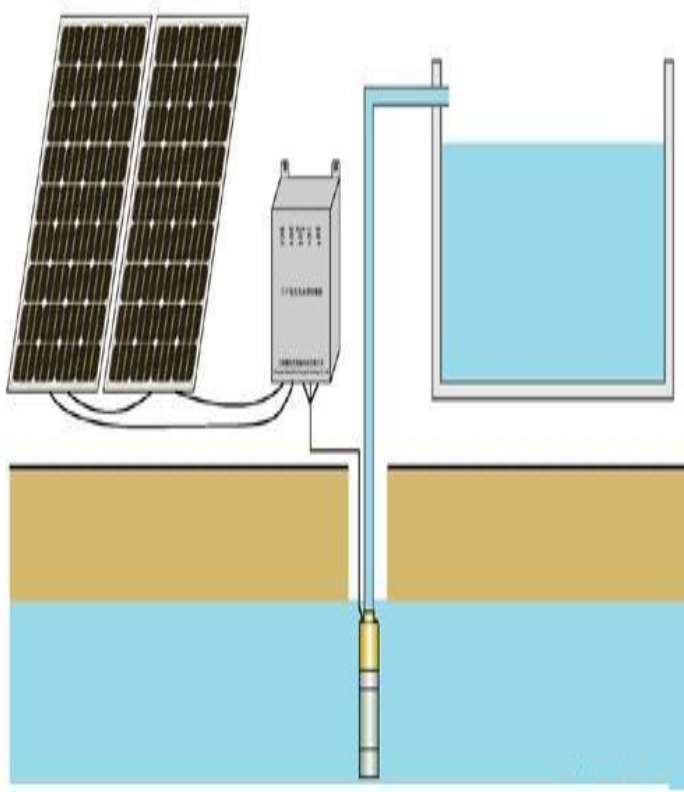


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1. A brief history of PV pump in China – the concept and key elements of a PV pumping system and characteristics



- ◆ Natural match with solar power: water is needed the most when solar irradiation is strong
- ◆ Energy storage in the form of water storage
- ◆ Off-grid and distributed energy supply with great economic benefits comparing with expensive grid supply especially in remote areas
- ◆ Reliable, affordable and clean energy
- ◆ Superior economically and environmentally comparing with grid powered and/or diesel powered pumps
- ◆ Challenges: requiring high level control technologies to use the intermittent and variable solar power effectively and safely



1. Brief history of PV pump in China

- ◆ 1980s: the first PV pump demonstration in Changping, Beijing supported by Germany.
- ◆ 1990s: Prof. Shijie YU began to research DC and AC PV pumps in Hefei University of Technology focused on DC pump and controller.
- ◆ 2000: the first PV pump application in Xinjiang
- ◆ 2010s: significant research and commercial applications represented by Yunnan ZY Energy

2. Present PV pump research and applications

- ◆ 1990s: focused on PV pump itself
 - ◆ small DC pumps ($<2.2\text{kW}$)
 - ◆ controllers
 - ◆ DC MPPT
 - ◆ inverters
 - ◆ PV modules matching with pump
- ◆ 2000: began to utilize PV pumps
 - ◆ Xinjiang for desert greening and illumination



2. Present PV pump research and applications

- ◆ 2010s: more detailed research and many new technologies developed
- ◆ From 2010 Chinese southwest part especially Yunnan, west of Sichuan suffered four years' severe drought
- ◆ PV pumps have becoming active in drought relieving and reached a new era
 - ◆ Many small, middle scale PV pumping systems have been built
 - ◆ Large systems appeared and the first MW scale project system

2. ZY Energy and our experience



- ◆ Established in 2005
- ◆ PV and applications related R&D
- ◆ Manufacturing, project development and EPC
- ◆ Solar pumping business since 2010
- ◆ Innovations & technology development
- ◆ Extensive experience in project development and implementation

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2. ZY Energy and our experience

- ◆ Strong technology capability
 - ◆ Numerous intellectual properties, including patents, softwares and technical know-hows
 - ◆ Award and fund winning technology
 - ◆ Top 10 technology award by Yunnan Province
 - ◆ Supported by New Tech Fund by Yunnan Province
 - ◆ 2014 UNIDO & ITPC “Blue-sky” Award for Global Top Investment Scenario to Apply New Technologies for Renewable Energy Utilization



3. ZY Energy and our experience

- ◆ Smart controllers/inverters
 - ◆ Dynamic MPPT (latest MPPTSL)
 - ◆ Intelligent group control technology
 - ◆ big and small pumps
 - ◆ multi pumps
 - ◆ multi-stages pumps (series pumps)
 - ◆ multi-stages multi pumps
- ◆ Complete protection: overload, dry-run, lightning, frozen
- ◆ PV & grid parallel supply, remote control



3. ZY Energy and our experience

- ◆ Super high hydraulic head technology (1000m+)
- ◆ Various types utilized
 - ◆ submersible pumps
 - ◆ centrifugal pumps
 - ◆ pistol pumps
 - ◆ etc
- ◆ PV and grid power parallel supply
 - ◆ PV will be utilized first
 - ◆ Grid power to top up
 - ◆ Not affecting the grid



3. ZY Energy and our experience



- ◆ Class on scale:
- ◆ Small scale pump (<15kW)
 - ◆ small DC pump, low hydraulic head
 - ◆ small AC pump
 - ◆ batch utilization
- ◆ Middle scale pump (15-110kW)
 - ◆ customization
- ◆ Big scale pump (>110kW)
 - ◆ customization

3. ZY Energy and our experience



3. ZY Energy and our experience

◆ Water intake



Dams



Lakes

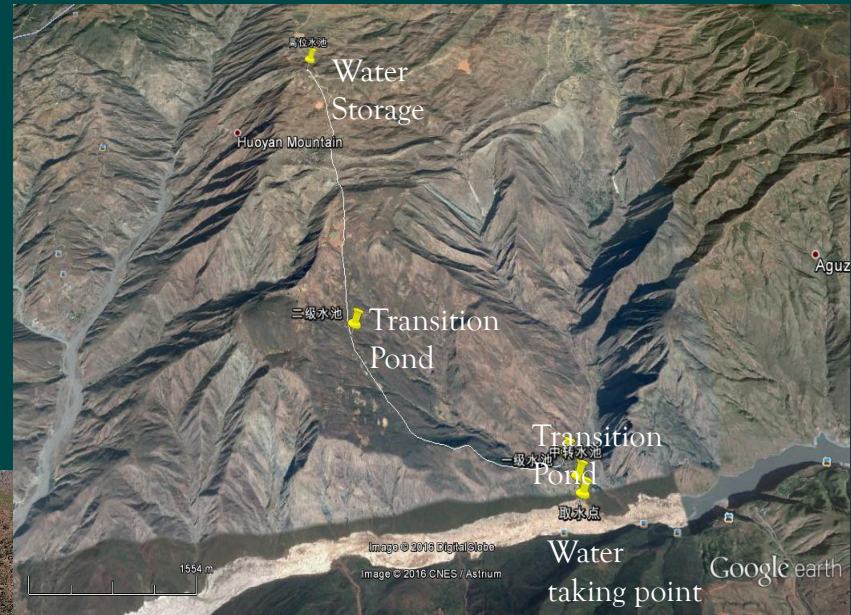


Rivers

3. ZY Energy and our experience

◆ The MW project: Jiangyi Village

- ◆ 79kWx9 pumps
- ◆ PV rating: 1,300MW
- ◆ Net head: 1,067m (3 stages)
- ◆ Pipe length: 9,700m
- ◆ Flow: 1,300m³/Day



3. ZY Energy and our experience

◆ Yishala Village

- ◆ 7.5kW x 1, 55kW x 2 pumps
- ◆ PV rating: 184kW
- ◆ Net head: 887m (single stages)
- ◆ Pipe length: 2,800m
- ◆ Flow: 220m³/Day



3. ZY Energy and our experience

◆ Shuimaotian Village

- ◆ Water supply for 364 families, livestock and irrigation
- ◆ 18.5kW pump
- ◆ PV rating: 31.2kW
- ◆ Net head: 155m
- ◆ Pipe length: 3,000m
- ◆ Flow: 100m³/Day



4. A powerful tool for development and poverty alleviation

- ◆ A versatile system with significant economic, social and environmental benefits

Before



4. A powerful tool for development and poverty alleviation

- ◆ A versatile system with significant economic, social and environmental benefits

After

Local economy enabler:
Realising farming &
small business potentials

Lifeline:
Water & energy
for better quality
of life



Electrification with
distributed energy:
Cost effective and
modular

Environment friendly:
No GHG emission and
air pollution

4. A powerful tool for development and poverty alleviation – a case study

◆ Shuimaotian Village (Tabaco farming) 2013

- ◆ 18.5kW pump
- ◆ PV rating: 24kW
- ◆ Net head: 162m
- ◆ Pipe length: 3,000m
- ◆ Flow: 80m³/Day
- ◆ Investment: RMB 660,000 (Grid supply option RMB1.3m)
- ◆ Water supply for 364 families, livestock and irrigation
- ◆ Significantly improved the quality of life and productivity
- ◆ No on-going energy charges, no pollutions
- ◆ Direct annual economic benefit: RMB10m

5. Lessons learned

- ◆ Being commercialized, it is still expensive for people in poverty to access to finance without external support
- ◆ Integrated water and energy systems are needed for off-grid applications to maximize the investment
- ◆ Knowledge sharing among local communities is a key for program success



6. Summary

- ❖ Solar pumps are being commercialized and proved to be a power tool for off-grid, remote area development and poverty alleviation
- ❖ Modular and distributed energy and water supply with huge economic, social and environmental benefits
- ❖ Integrated water and energy systems needed for off-grid applications to maximize the investment
- ❖ Education and knowledge sharing among local communities is a key for scale-up
- ❖ Need financial support from governments and development agencies





Dec 2011 Dongma, Xichou,
Wenshan, Yunnan



Rivers





Project Cases

The project of parallel operation of the PV pump and power grid in the small village of Xizhu Changkoi, Wuhua, Kunming
pump:18.5kW, PV:22.4kW, Net hydraulic head 90m, daily lift:200m³, supplied for 1372 persons and 230 cattle, annually saving almost RMB 70000.00.



Zezezhu, Shupi, Qiubei, Wenshan, Yunnan, 2014



Yishala, Pingdi, Renhe district, Panzhihua, Sichuan ~ the world's highest and largest photovoltaic pump systems engineering.

Pump: 117.5kW, net hydraulic head: 887m, PV: 164.64kW, Daily lift: 220m³, supply 1400 persons and 260 cattle drinking.



Dali state Longshan Administrative Center PV pump project



Pump: 60kW, PV:78.9kW, Net hydraulic head: 32m, Daily lift: 1500m³



The first big river (Mekong) PV pump system: Caibei, Jijie, Yangbi, Dali, Yunnan

- ◆ Net hydraulic head 300m, pipe length: 1800m, pump: 27.5kW, PV: 36.96kW, sunny daily lift: 100m³.



Digu, Longjie, Wuyin Township, Weishan, Dali, Yunan



Deju, Midu, Dali, Yunnan

Pump: 48.5kW, PV: 63kW



Yangcaotan, Xinmin, Wuhua, Kunming







Muge, Dongcun, Wuhua, Kunming

Gupu, Chadian, Wuding, Chuxiong, Yunnan





Stand along two pumps-Erchengba, Chuxiong, Yunnan



Papaya village, Warao town, Longyang district, Baoshan, Yunnan



Cangrong, Lujiang dam, Longyang district Baoshan, Yunnan



PV pumps in Kongtangqing, Hongta district, Yuxi, Yunnan



The first PV pump in Nujiang, Yunnan



Qizong, Tacheng, Weixi, Diqing, Yunnan~The highest total hydraulic head 1032m in 2015



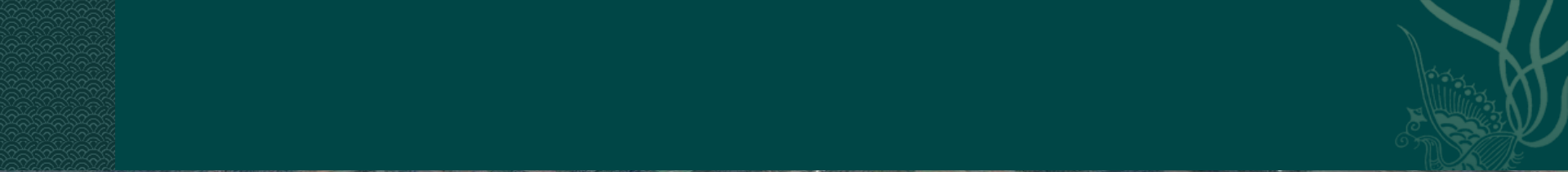
Project Case Introduction



- ◆ Households: 364
- ◆ Population: 1446
- ◆ Water resource: Pond
- ◆ Net water head: 124m
- ◆ Pipe length: 2200m
- ◆ High water container (finished): 70m³, and with about 2 small cisterns each household







老開塘

團麥地

高位水池？

豬場

水冒天光伏方阵场

Image © 2017 CNES / Airbus

Google Earth

Project Brief Introduction



- ◆ Only one water pond
- ◆ Small truck transport water only about 6 trucks each days with about 18m³ total.
- ◆ People and animal drink shortage seriously.
- ◆ Tobacco plant was serious effected.

Finance



- ◆ Provincial Science and Technology Department invested RMB350000.
- ◆ Kunming Science and Technology Bureau invested RMB150000.
- ◆ Xundian County Science and Technology Bureau invested RMB100000.
- ◆ Hekou Township invested RMB100000.
- ◆ Total: RMB600000.

System Design

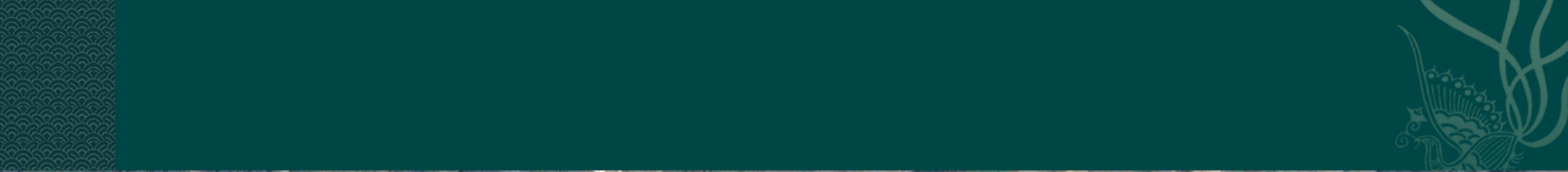


- ◆ Township finished traditional technology (grid extension) design with total investment RMB1,2000,000 included a small dam.
- ◆ Chinese standard of volume: 70L/cap.d
 - ◆ $1446 * 0.07 = 101.22 \text{m}^3/\text{d}$
 - ◆ Decided $80 \text{m}^3/\text{d}$ since about 50% people outside and investment limited.
- ◆ Use 5 hours for total load running in good sunny day

System Design



- ◆ Flux
 - ◆ $80/5 = 16 \text{ m}^3/\text{h}$
- ◆ Along the pipe resistance
 - ◆ $4.75\% * 2200 = 104.5 \text{ m}$
 - ◆ Total water head $124 + 104.5 = 228.5 \text{ m}$
- ◆ Concerning that sunshine is not maximum at most of the sunny day 10% water head will be considered
 - ◆ Total water head 253.8m.



團麥地

高位水池?

豬場

未命名地标

水冒天光伏方阵场

Image © 2017 CNES / Airbus

Google Earth

系统设计 System Design



◆ Pump selection:

- ◆ Submerge pump R150-DS-22, 18.5kW, 262m water head, 16m³/h flux.

Type	Motor Power		Three phase 380V	Q	Capacity							
				US.GPM	0	52.8	61.6	70.4	79.2	88	96.8	110
				m ³ /h	0	12	14	16	18	20	22	25
				l/min	0	200	233	267	300	333	367	417
(50Hz)	HP	kW	A	H m	Total head in meters							
R150-DS-03*	4	3	8.3		46	39	37	34	31	28	25	19
R150-DS-04*	5.5	4	10.3		61	52	49	45	42	37	32	25
R150-DS-05*	5.5	4	10.3		77	64	61	57	51	46	41	31
R150-DS-07	7.5	5.5	14		108	90	86	79	73	65	58	44
R150-DS-09	10	7.5	18.5		138	116	111	101	96	84	76	56
R150-DS-11	12.5	9.2	21		168	142	136	124	113	102	90	69
R150-DS-14	15	11	24		215	180	171	150	145	130	113	88
R150-DS-16	17.5	13	28		246	206	195	180	165	149	130	100
R150-DS-18	20	15	32		277	232	225	202	193	170	152	113
R150-DS-20	25	18.5	40		307	256	240	215	203	181	156	120
R150-DS-22	25	18.5	40		345	295	282	262	241	216	189	143
R150-DS-25	30	22	46		388	328	312	288	275	249	219	168

系统设计 System Design



- ◆ Inverter: ZYP-22, 22kW concerning high altitude.
- ◆ PV
 - ◆ 210W multi-crystalline PV module, $V_{oc}37.78V$, $V_m29.33V$, $I_m7.16A$, $I_{sc}7.63A$
 - ◆ Total 120 pieces module with total 25.2kW
 - ◆ PV array has been optimized design.
- ◆ Tubes
 - ◆ Seamless steel tube $\Phi76*3.5$ about 1000m
 - ◆ Hot dip galvanized steel pipes DN65 about 1200m.



水冒天光伏方阵场

Image © 2017 CNES / Airbus

Google Earth

Operation



Operation



- ◆ May 5, 2013 finished
 - ◆ June 14, 2014 one PV module be damaged by a drunk village person and replaced.
 - ◆ Nov 11, 2014 pump wire be cut and replaced.
 - ◆ Jan 2015 big snow damaged some tubes and repaired
- ◆ Special person takes care of the whole system.
- ◆ A certain water cost have been collected for each household for maintenance.

Experience

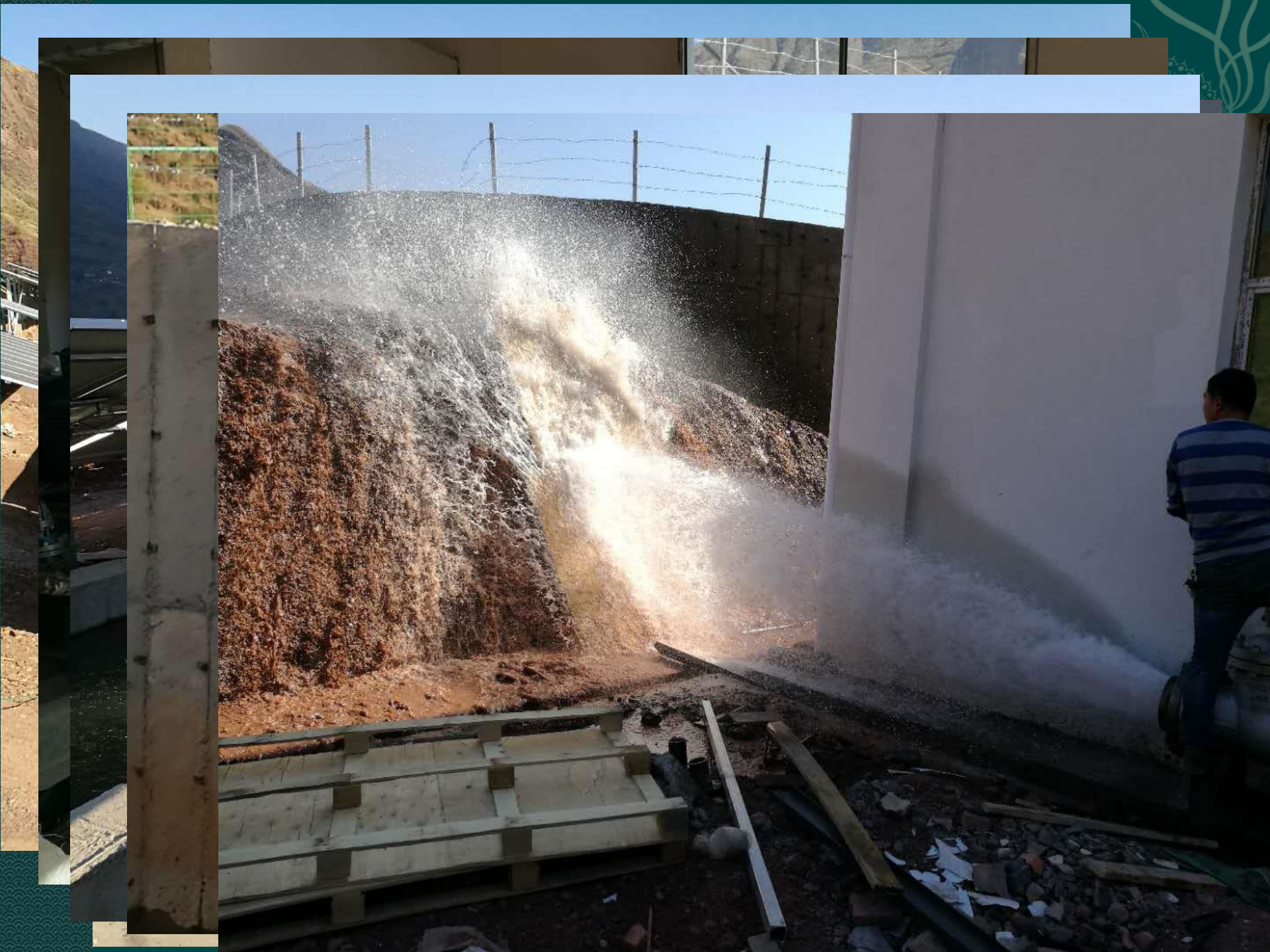


- ◆ A certain cost be collected.
- ◆ PV modules should be more.
- ◆ Anti-freeze tech not use although seldom occasion freeze.
- ◆ All works were done by the village committee
- ◆ Qualified operator shortage.
- ◆ Total village people have not involved in the project.
- ◆ Total investment from governments.

Summary



- ◆ The PV pump system has solved drink issue of human and animals.
- ◆ The PV pump system have increased RMB 10 millions income each year for tobacco plant one month earlier (total 4800mu).
- ◆ PV pump is the key to get rid of poverty for those water shortage areas.
- ◆ The system design could be improved.





4. Summary

- ◆ 1) PV pump is more and more welcomed by local people in China, especially in Yunnan Province etc. due to its economic and perfectly matching with sun shine.
- ◆ 2) PV pump technology almost matured but scale-up is still a challenge.
- ◆ 3) We can supply customization PV pump systems design, equipment manufacture and engineering building with finished hundreds of projects.



4. Summary



- ◆ 4) PV pump can promote local social and economic development greatly for similar areas like Yunnan
 - ◆ It is the cheapest pump technology without power grid.
 - ◆ The very high cost problem of using conventional pump is solved.
 - ◆ Resolve the "water in the low flow, the people no water in the mountain" dilemma.
 - ◆ It is the best way to overcome poverty and achieve prosperity by changed the history of the planting depend rain and improved the value of the land.◦



Thanks !

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