Food and Agriculture Organization of the United Nations

CIHEAM IAM BARI

Heliopolis University for Sustainable Development

AgWA Partnership for agricultural water for Africa

Emerging practices from Agricultural Water Management in Africa and the Near East

Thematic Workshop

Coping with water scarcity in Egypt - the role of agriculture:

Solar-Powered Water Lifting for Irrigation in the Nile Delta

Towards a Business Model for Solar Water Pumping in Irrigation

Rasha Elkholy

30 August 2017

Theme 7:
Solar Energy

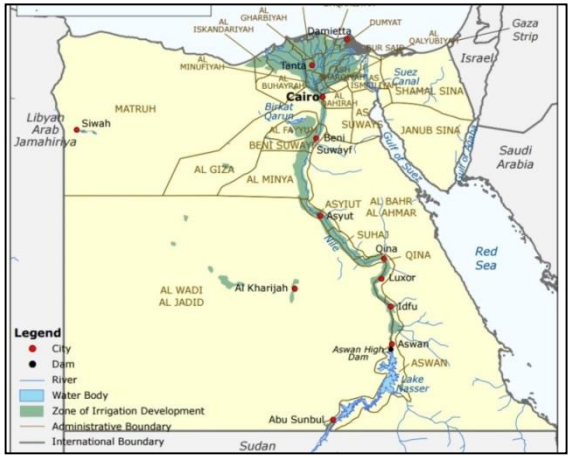
PROJECT JUSTIFICATION

- Viable alternative to the diesel and electricity currently used to power water pumps – Responding to energy crisis and fuel cost hike
- Covering irrigation canals from direct sunlight, optimally to:

  Reduce losses (surface evaporation)

  Limits the need to purchase costly land for panel installation

- Secondary benefit to farming households(other than farming)



Theme 7:
Solar Energy

IMPACT

Reduce the vulnerability of farmers in the Nile Delta to **water scarcity** and **energy supply** shocks.

OUTCOMES/OUTPUTS

- Provide a **sustainable source of energy** for the lifting of irrigation water (and potentially for other uses in non-irrigating periods), and **reduce evaporation** losses from irrigation canals as well as encouraging less use, thus increasing efficiency.
- Strengthen local capacities in the Nile Delta to adopt, operate and maintain new the techniques for the lifting of irrigation water from canals.
- Propose up-scaling and new project areas

OUTPUTS

OUTPUT 1 — Provide a sustainable source of energy for lifting of irrigation water (and potentially for other uses in non-irrigation period)

OUTPUT 2 — Strengthened local capacities in the Nile Delta to adopt, operate and maintain new techniques for the lifting of irrigation water from canals

OUTPUT 3 — Propose up-scaling and new project areas

SunEdison

Agreement

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Agreement

National Water Research Center

- Design, supply, install the PV system-.
- Strengthen local capacities in Egypt to adopt, operate and maintain new techniques for the lifting of irrigation water from canals.

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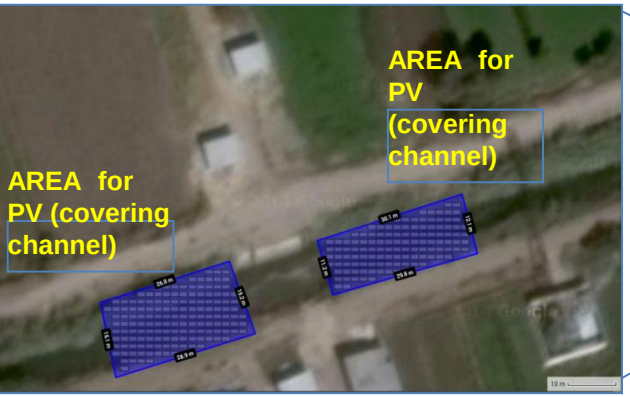
- Overseeing (site preparation, system installation, operation and testing).
- Socio-economic & environmental assessment).
- Workshops/training/technical meetings/site visits)

- Development of a Business Model is to promote sustainable use of solar energy in irrigation in the Nile Delta of Egypt

OUTPUTS

OUTPUT 1:
Provide a sustainable source of energy for lifting of irrigation water (and potentially for other uses in non-irrigation period)



Site 2

Two pilot sites located in Behaira Governerate

Site 3

Site	Name	Status	Number of pump room	Tot. number of existing pumps	Crops irrigated area	Served farmers	Proposed scenario
2	***El-Souria***	Design Phase	4	8	245	56	**Open improved canal**
3	***El-Afeer***	Operational	4	6	243	70	**Pipe improved canal**

OUTPUTS

OUTPUT 2:
Strengthened local capacities in the Nile Delta to adopt, operate and maintain new techniques for the lifting of irrigation water from canals

- Raise awareness (local farmers and WUAs) to operate and maintain the system and the benefits of the project
- Build capacity of technical staff of MWRI to maintain guidance to farmers and sustainability of intervention beyond project period & for up-scaling of the system in new locations and areas

OUTPUTS

OUTPUT 3:
Project evaluation & proposals for up-scaling and new project areas

- Perform project evaluation and document lessons learned

- Propose future actions for up-scaling and new project area

- **Development of a business model to promote sustainable use of solar energy in irrigation in the Nile Delta**

SOLAR POWERED WATER LIFTING

- Evaluation and proposal for up-scaling achieved via creation of a **Business Model** to promote sustainable use of solar energy in irrigation

Activities undertaken by: **Heliopolis University for Sustainable *Development (HUSD)***

- **Business model beyond objectives:**
  - **Cost reductions** of equipment, logistics, and replacements through large-scale sourcing & smart product design.
  - **Improved loan collection** through technical innovation, etc.
  - **Alignment of interests** along the value chain through risk and reward sharing with suppliers, distributors and financing partners.

SOLAR POWERED WATER LIFTING

- **Business Model Inception Phase:**

1. **Identification and consultation of relevant actors and partners concerned**

   Governmental, NGO, Private sector

2. **Design of data collection programme**

   Technical component

   Cost-benefit component

   Agro-economy component

SOLAR POWERED WATER LIFTING

3. Design of **Business Model** canvas with its **primary building blocks**

Main Block 1: Technical

Main Block 2: Financial

Support Block 1: Logistical

Support Block 2: Social

Support Block 3: Institutional

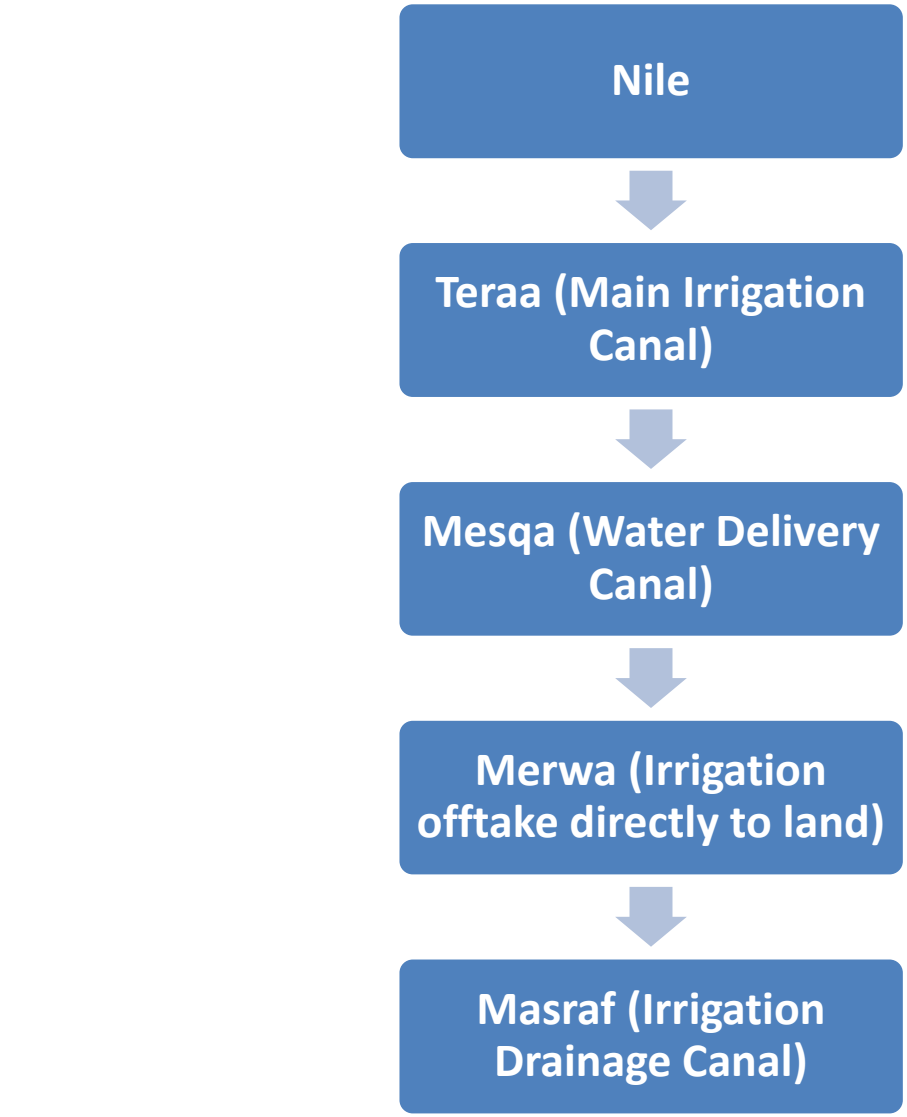
Support Block 4: Governance

SOLAR POWERED WATER LIFTING

4. Development of **Opportunities Analysis Framework**
   - Technical
   - Financial
   - Logistical
   - Social
   - Institutional & Governance

5. Organization of **Expert Consultation** to validate canvas and analysis framework

MWRI - IIIMP - Project



MWRI - IIIMP - Project

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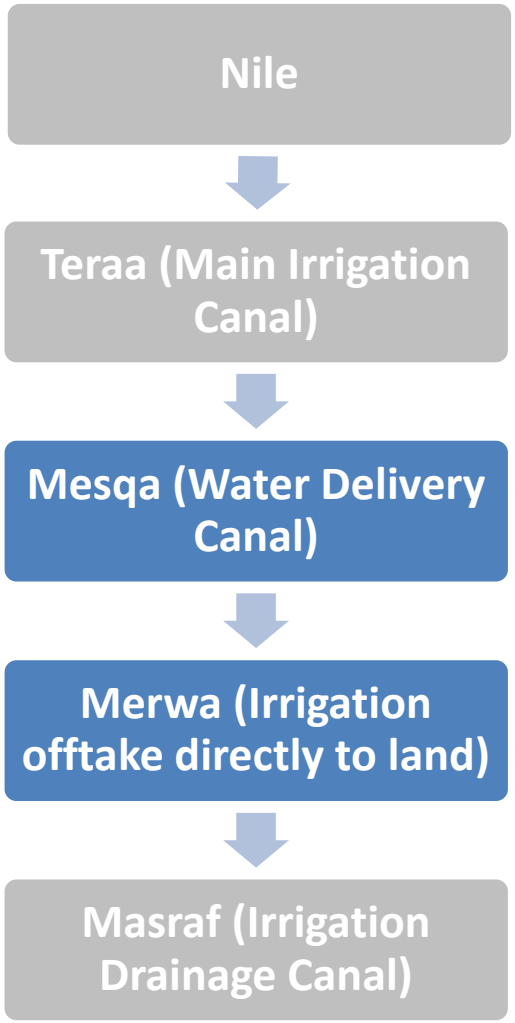
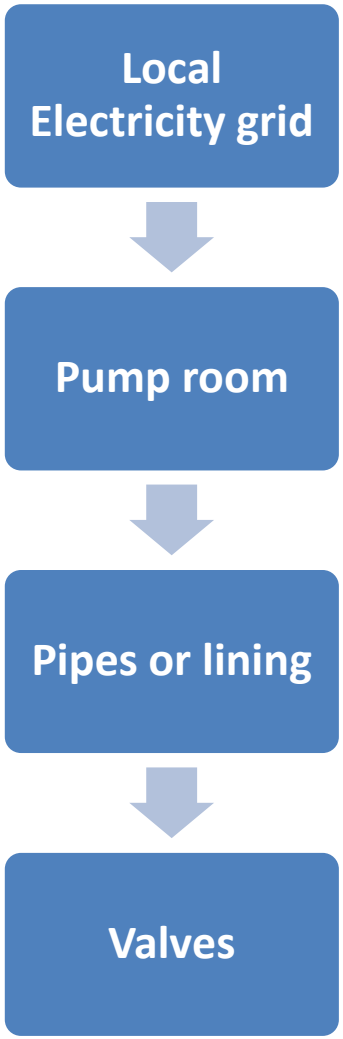
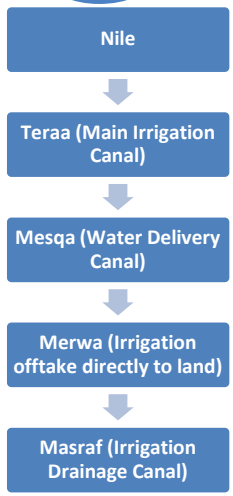




MWRI – IIIMP- Project



9,000-11,000 LE/Feddan

- Lining or covering open irrigation canals
- Installing water pumps and pump houses on mesqa
- Installing water valves on merwas
- Installing local low-voltage grid

Afir Case Study

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Main: Grid-connected pumps	Backup: Diesel pumps	Additional: PV pump
40 and 60 lit/sec	60 and 90 lit/sec	10Hp: 30 lit/sec

Afir Case Study

Pump House	PV Pump size installed per feddan (FAO pilot @ Afir)	kW PV installed per feddan (FAO Pilot@ Afir)	PV pump cost Per Feddan (L.E. @12,000L.E./kW)
1	0.13	0.27	3214
2	0.10	0.20	2368
3	0.11	0.21	2535
4	0.19	0.38	4500
Average	**0.13**	**0.26**	3154

Business Model Canvas & Opportunities Analysis Framework

Key Partners

- Ministries and Authorities
  - Electricity
  - NREA
  - Agriculture
  - Environment
  - Finance
  - Industry &Trade
  - Investment
- IFIs & IDAs
- TA organizations
- Development funds
- Private sector
- Knowledge Centers
- NGOs
- Media

Key Activities

- Site analysis
- Land quantification & allocation
- PV systems design
- Foundation
- Permitting
- Tendering
- Procurement
- Installation
- Capacity-building
- Communication
- Monitoring
- Maintenance
- Repair & support
- Replacement & Decommissioning

Key Resources

- Surveying/GIS
- Geotechnical
- Construction
- Electrical
- Full PV value chain
- Check-up & repair
- Capacity-building
- Communication
- Regulatory
- Due diligence
- Validation

Value Propositions

- Solar pumping system in addition to standard IIIDP components
- Net-metering & Feed-in tariff
- Facilitation of required permits and due-diligence
- Post-installation monitoring and optimization
- Post-installation repair and tech-support
- End-of-life replacement

Customer Relationships

- MWRI Directorates & Departments
- PV Practitioners
- NGOs
- ICT & e-Pay

Channels

- Direct communication
- Service points
- Site visits
- ICT platforms
- e-monitoring

Customer Segments

- Beneficiaries of the Integrated Irrigation Improvement & Management Project (IIIMP)
- Other Farmers and agricultural developers

Cost Structure

- Cost of Site analysis & land allocation
- Cost of PV and PV pumping systems
- Cost of foundations and support structure
- Cost of system controls
- Cost of Grid-connectivity, Feed-in tariff, & Net-metering
- Cost of PV system safety and security
- Cost of capacity building & communication
- Cost of post-installation monitoring, maintenance, tech support & repairs
- Cost of End-of-Life replacement and electronic waste management
- Cost of ICT & e-Pay systems
- Cost of permits, IFI/Donor Due Diligence & consulting fees
- Cost of Carbon finance requirements and validation

Revenue Streams

- Beneficiary payments (Cost recovery)
- Allocated National Budget
- Donors and IFIs
- Feed-in tariff (PSP)
- Advertising
- CSR
- Carbon Finance

Expert Consultation Workshop

- 30+ specialists/15 presentations
  - FAO headquarters
  - Ministry of Water Resources and Irrigation (MWRI)
  - National Water Research Centre (NWRC)
  - Ministry of Petroleum (Subsidy reform Project)
  - Ministry of Electricity (New and Renewable Energy Authority)
  - Agricultural Economy Research Institute
  - PV service providers and Private Sector
  - Academia and Technical Assistance organizations
  - Heliopolis University for Sustainable Development

Expert Consultation Workshop

- **Successful phase I**
  - FAO Delta Solar Pumping Business Model Canvas
- **Phase II**
  - Field Monitoring
  - Upgrade & Maintenance
  - Detailed Business Model

Phase II: HU Scope of Work

- Activity 1: Development of the Business Model
- Activity 2: Verification of the Business Model
- Activity 3: Commissioning and Analysis of Feed-in Tariff Scheme
- Activity 4: Monitoring PV Pumping system performance
- Activity 5: Technical optimization PV Pumping system & user capacity-building

Activity 1: Development of the Business Model

Conduct **technical & financial** analysis as the business model **baseline**
Carry out **field data collection** from relevant stakeholders
Perform a **scoped market survey** on PV panels, PV pumps, and related items
Detailing business model **cost structure** as per services provided by MWRI
Design a business model **revenue scheme** including a willingness-to-pay survey
Development of business model **risk analysis and management framework**

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Business Model Decision Support Tool

Results of the scoped market survey are to be integrated into a Microsoft Excel-based tool tailored to the project for **technical and financial analysis of scenarios** as per the model applied

Decision support tool: Models

- Support decision makers with a tool to assess and compare operation models with different techno-economic scenarios
  - Locally-available PV systems
  - Locally-available pump systems

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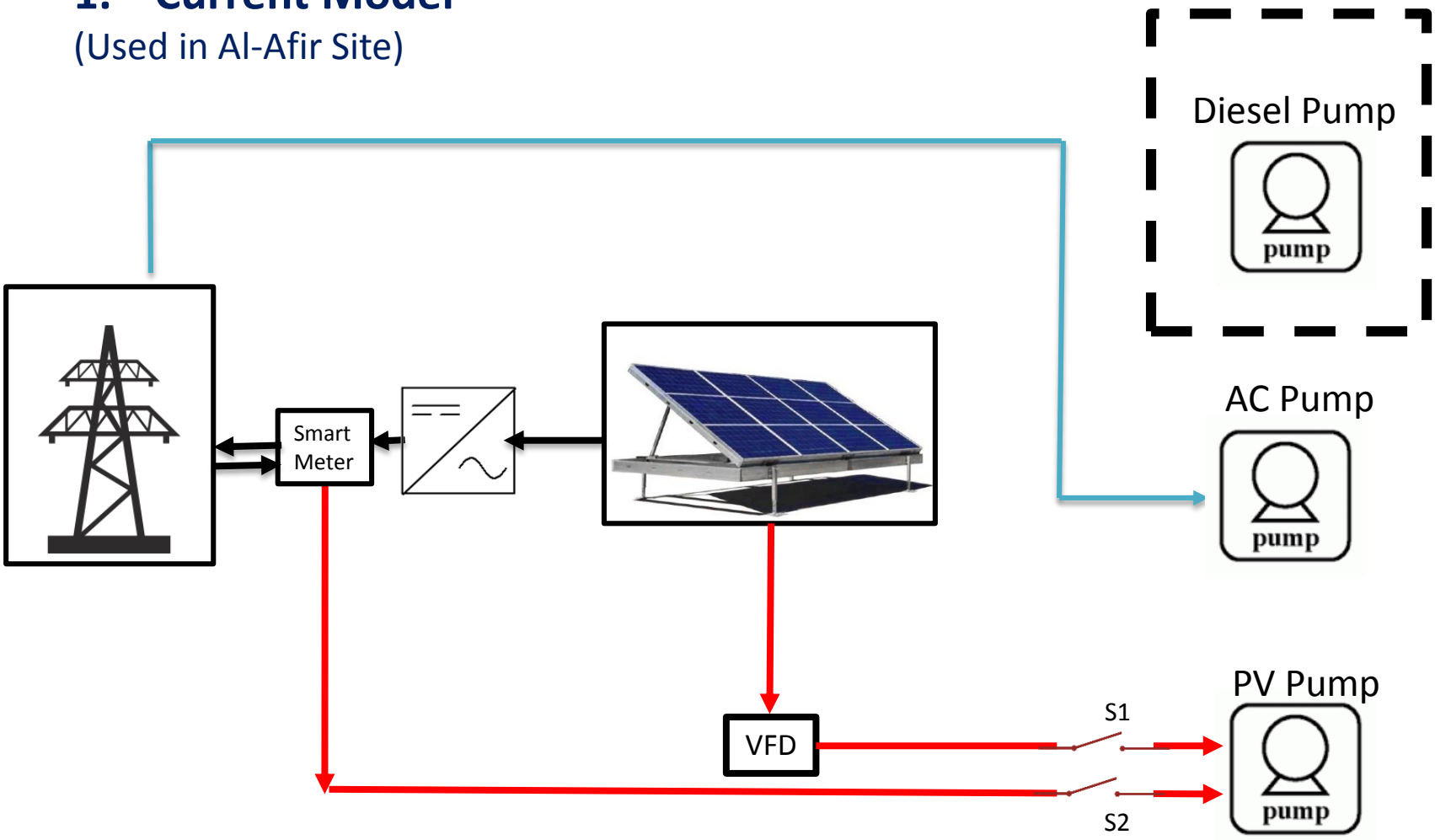
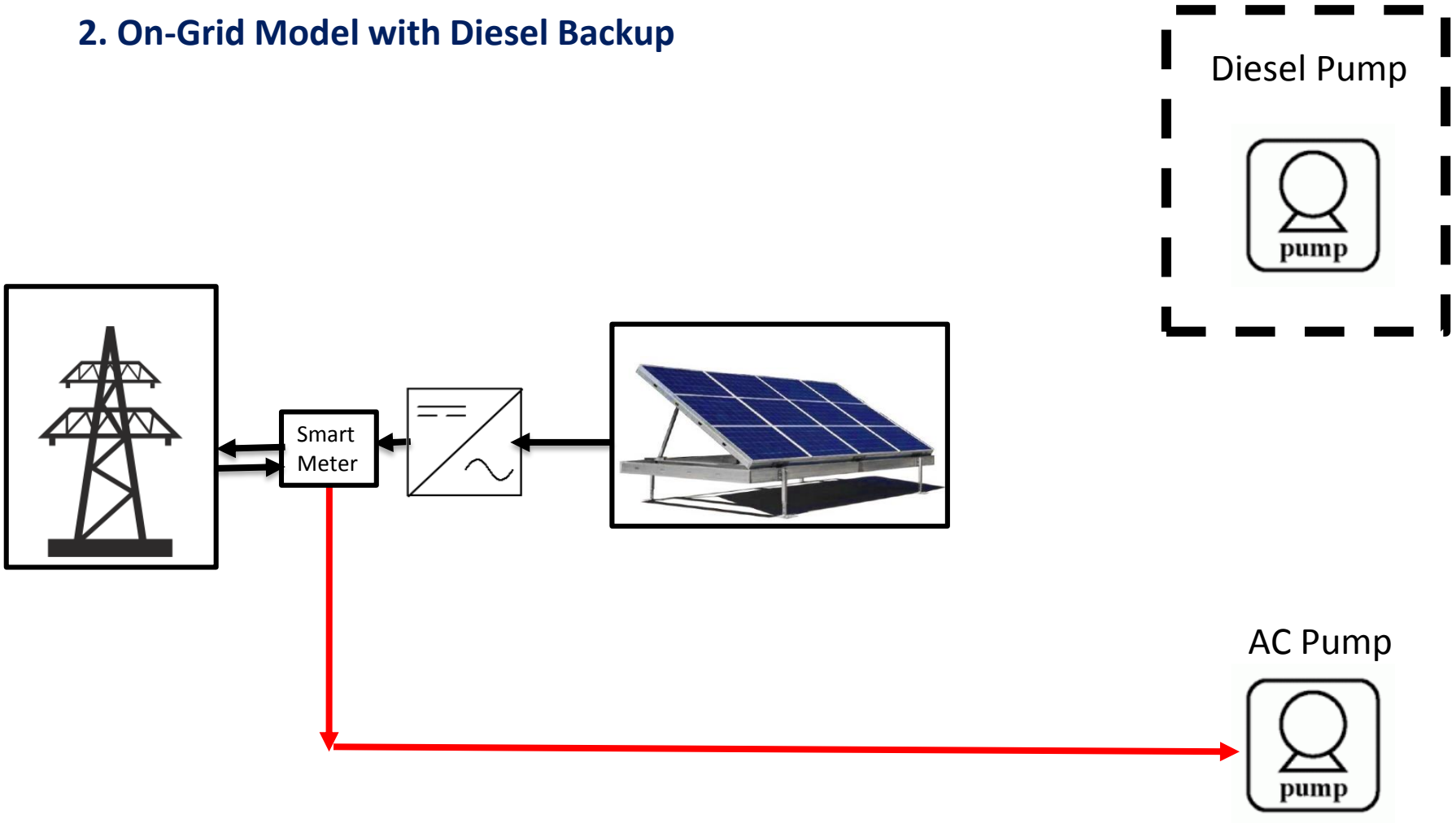
1. Current Model

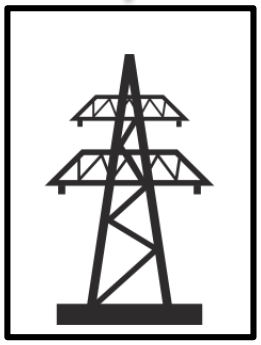
(Used in Al-Afir Site)



2. On-Grid Model with Diesel Backup



3. Off-Grid Model



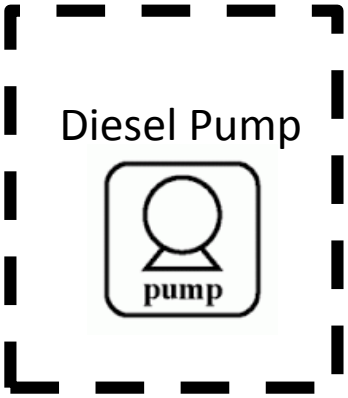
Diesel Pump

AC Pump

VFD

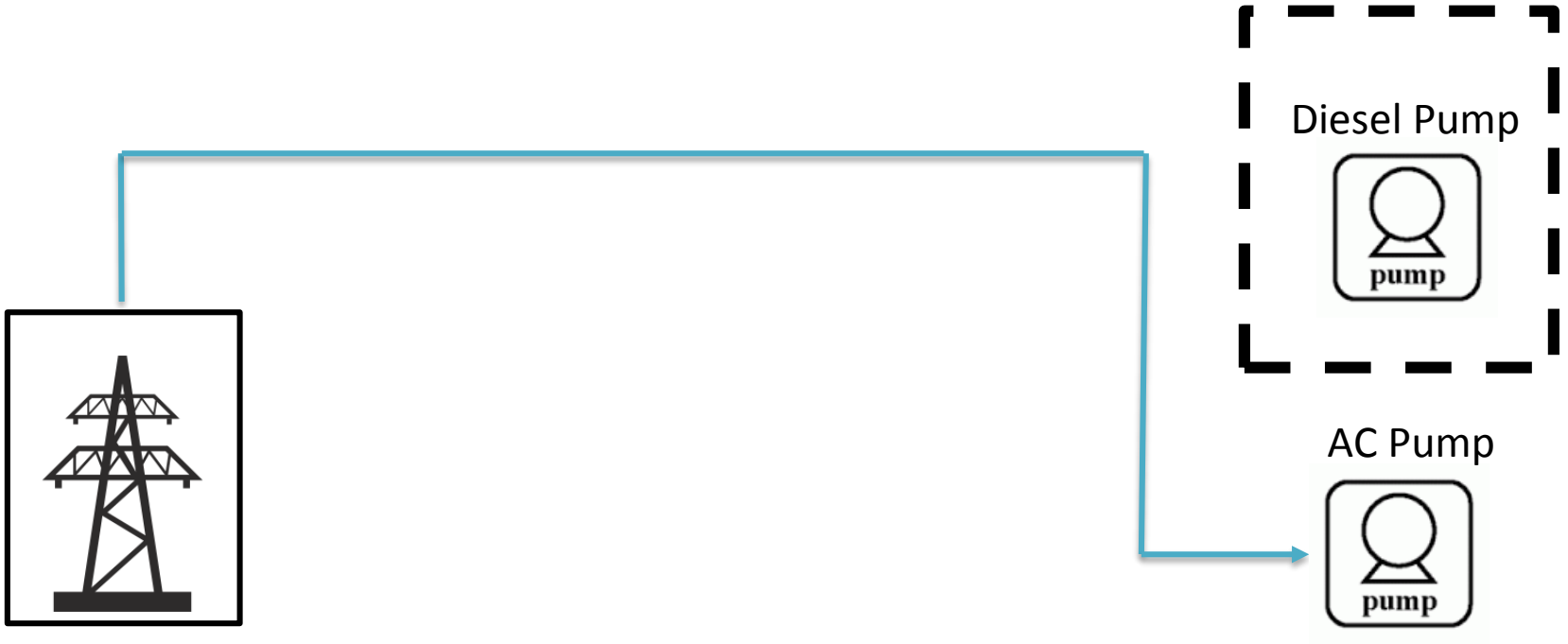
PV Pump

4. Hybrid Model



VFD

5. Conventional Model



Analysis of the Economic Tool

S	Items	Current Model	Price	On Grid Model	Price	Off Grid Model	Price	Hybrid Model	Price	Comments
	PV Components									
1	Solar Panels	Jinko Solar 310W	155584	REC TwinPeak 290TP2 BLK solar pa	177100	REC TwinPeak 290TP2 BLK solar pa	177100	REC TwinPeak 240TP2 BLK solar pa	136400	
2	Inverter	SMA Sunny tripower 15KW	95640	ABB 15KW	57750					
3	VFD	ABB 11 KW	16500			ABB 15.5KW	39200	ABB 22 KW	32500	
4	Mounting structure	Mounting Structure 2 SHANGTE	20160	Mounting Structure 2 SHANGTE	20160	Mounting Structure 2 SHANGTE	20160	Mounting Structure 2 SHANGTE	20160	
5	Installation +Combiner Box	Installation 4	43730	Installation 3	49800	Installation 3	49800	Installation 2	51730	
6	PV maintenance	Maintenance3	16800	Maintenance2	20500	Maintenance3	16800	Maintenance2	20500	
7										
8										
9										
10										
11										
12										
13										
14										
15										
	Pump Room Components									
16	PV pump	Exaliu 10 HP	13800	CCRFLEX pump system 10HP	7500	Exaliu 10 HP	13800	Exaliu 10 HP	13800	
17	AC pump	Milestone 15HP	34000	Milestone 15HP	34000	Milestone 15HP	34000			Milest
18	Diesel Pump	LUYAN Centerfugal water pump	120000			LUYAN Centerfugal water pump	120000	LUYAN Centerfugal water pump	120000	LUYAI
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
	Civil Works									
31	Fencing and security	FIXED COST		FIXED COST		FIXED COST		FIXED		
32	Room Construction	FIXED COST		FIXED COST		FIXED COST		FIXED		
33	Warning signs	FIXED COST		FIXED COST		FIXED COST		FIXED		
34	Concrete Footing	FIXED COST		FIXED COST		FIXED COST		FIXED		
35										
36										
37										
38										
39										
40										
41										
42										
43										
44										
45										
	Resources and Utilities									
46	Grid tariff	TBD		TBD		TBD		TB		
47	Fuel	TBD		TBD		TBD		TB		
48	Feed-in tariff	TBD		TBD		TBD		TB		
49										
50										
51										
52										
53										
54										
55										
	Electrical Components									
56	Smart Meter		3330		3330					
57	Feed-In Connections cost		15320		15320					
58										
59										
60										
61										
62										
63										
64										
65										
66										
67										
68										
69										
70										
	Total Cost		554864		385400			401860		

S	Item	Supplier	Model	country of manufacture	Price LE	Introst rate	lifetime per unit in years	of units per System lifetime	total price per li
1	Inverter		SMA Sunny tripower 15KW		95640	5%	5	5	826081
			SolisEdge SE15K-ER-01 15KW		30734	5%	5	5	265461
			ABB 15KW		57750	5%	5	5	498809
			ABB PVI-12.5-TL-OUTD-S 12.5 KW		49038	5%	5	5	423560
2	Solar Panels		Suntech STP 265 14.8KW		129195	5%	5	5	111599
			REC TwinPeak 290TP2 BLK solar pa		177100	5%	5	5	152968
			Jinko Solar 310W		175584	5%	5	5	151638
			Solar World Plus SW 300w mono		273600	5%	5	5	236319
3	Mounting Structure		Mounting Structure 1 IRSC		35848	5%	5	5	309631
			Mounting Structure 2 SHANGTE		20160	5%	5	5	174130
			Mounting Structure 3 UI Energy		37440	5%	5	5	323384
			Mounting Structure 4 Frontier		34560	5%	5	5	298508
4						5%	5	5	0
						5%	5	5	0
						5%	5	5	0
						5%	5		
5						5%	5		
						5%	5		
						5%	5		
6	VFD		ABB 15KW		21788	5%	5		
			ABB 18.5KW		30230	5%	5		
			ABB 22 KW		32500	5%	5		
			ABB 11 KW		16500	5%	5		
7						5%	5		
						5%	5		
						5%	5		
8						5%	5		
						5%	5		
						5%	5		
9						5%	5		
						5%	5		
						5%	5		
10	Installation + combiner Box		Installation 1		44200	5%	5		
			Installation 2		51730	5%	5		
			Installation 3		49800	5%	5		
			Installation 4		43730	5%	5		
11	PV maintenance/ year		Maintenance1		17000	5%	5		
			Maintenance2		20500	5%	5		
			Maintenance3		16800	5%	5		
			Maintenance4		19800	5%	5		
12						5%	5		
						5%	5		
						5%	5		
						5%	5		
13						5%	5		
						5%	5		
						5%	5		
14	PV Pump		Exaliu 10 HP		13800				
			CCRFLEX pump system 10HP		7500				
			IRSC Surface Pump and motor 20 HP		17325				
15	AC Pump		Milestone 15HP		34000				
16	Diesel Pump		LUYAN Centerfugal water pump		120000				

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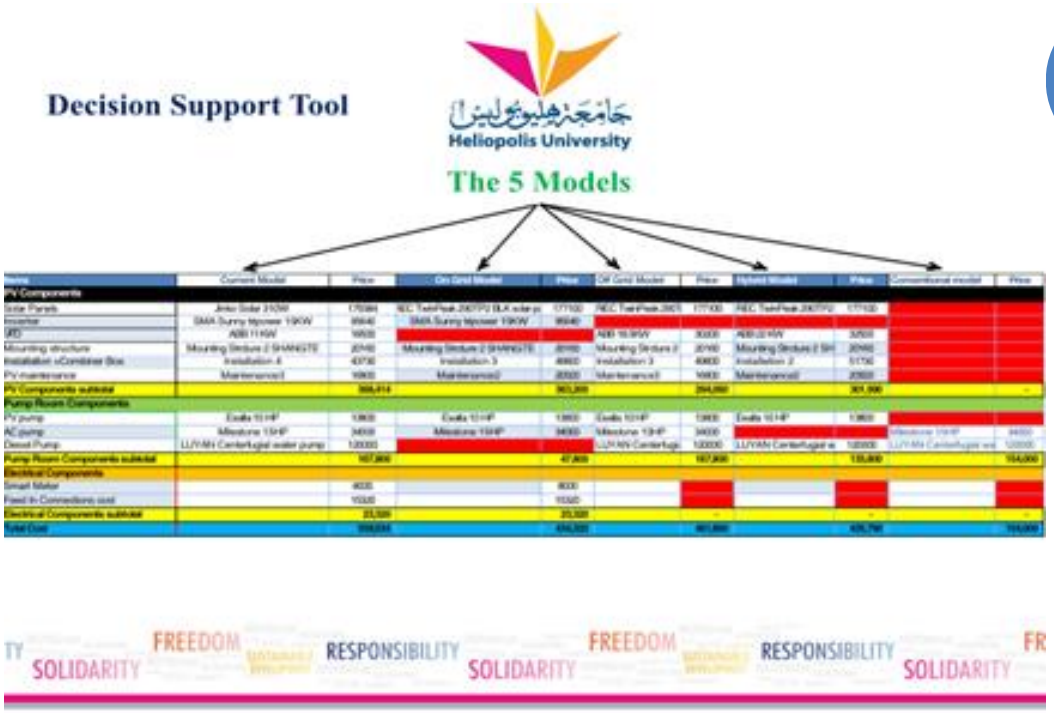
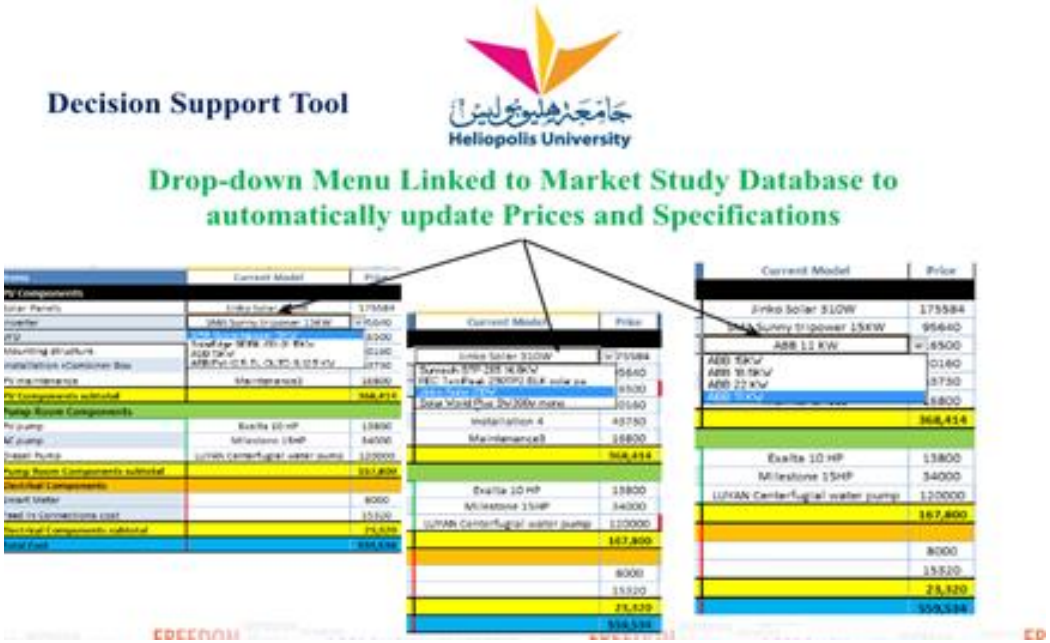
Decision Support Tool Economic potential Outputs





Current Situation

MWRI Irrigation Improvement Project IIMP	- Covered irrigation canals - Main pipelines 315/250mm - Branches 225/180mm - Valves on mesqas

Current Situation

Pump Room (Afir 4)	Serves: **40 Acres** **AC pump**: 20hp – 60 litre/s Diesel pump: 60 litre/s **22 Valves;** Farthest valve: **1000m**
Pump Room (Afir 3)	Serves: **71 Acres** **AC pump**: 20hp – 60 litre/s **AC pump**: 15hp – 40 litre/s Diesel pump: 90 litre/s **32 Valves;** Farthest valve: **1560m**
Pump Room (Afir 2)	Serves: **76 Acres** **AC pump**: 20hp – 60 litre/s **AC pump**: 15hp – 40 litre/s Diesel pump: 90 litre/s **38 Valves;** Farthest valve: **1560m**
Pump Room (Afir 1)	Serves: **56 Acres** **AC pump**: 10hp – 20 litre/s **AC pump**: 15hp – 40 litre/s Diesel pump: 60 litre/s **16 Valves;** Farthest valve: **1000+m**

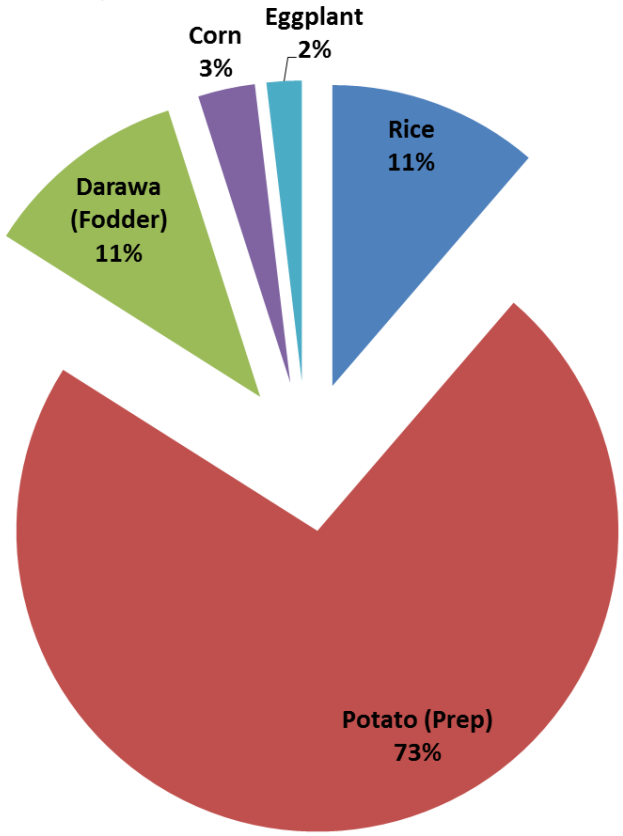
Current Situation

FAO Pilot (**additional per room**):

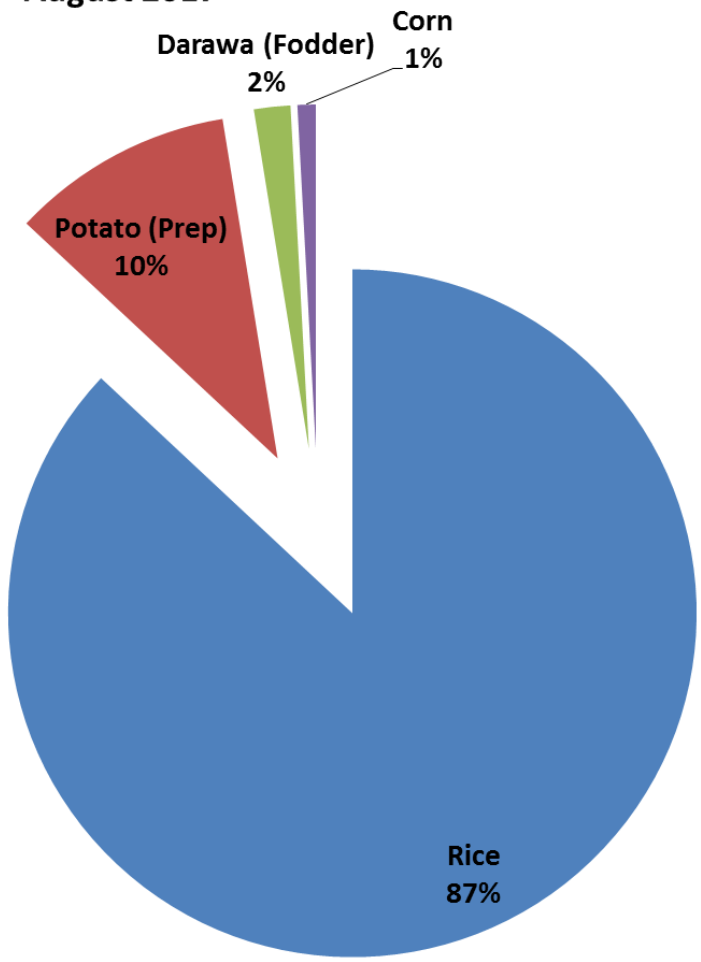
- PV Panels: 14.4 kW
- Variable Frequency Drive
- 10kW Inverter
- Net Metering with Behera Electricity Distribution Company
- Variable Frequency pump: 10hp (7.5kW)
- Pump rated discharge: 30 litre/s

Agronomy

Room 3 Crop Mix by Area - August 2017



Room 4 Crop Mix by Area - August 2017



PV Pump Discharge - PV Powered (m3)	PV Pump Discharge - Grid Powered (m3)	AC Pump Discharge - Grid Powered (m3)		
2480	2988	4374	9,842	m3
			1,094	m3/day
			370.83	m3/Acre

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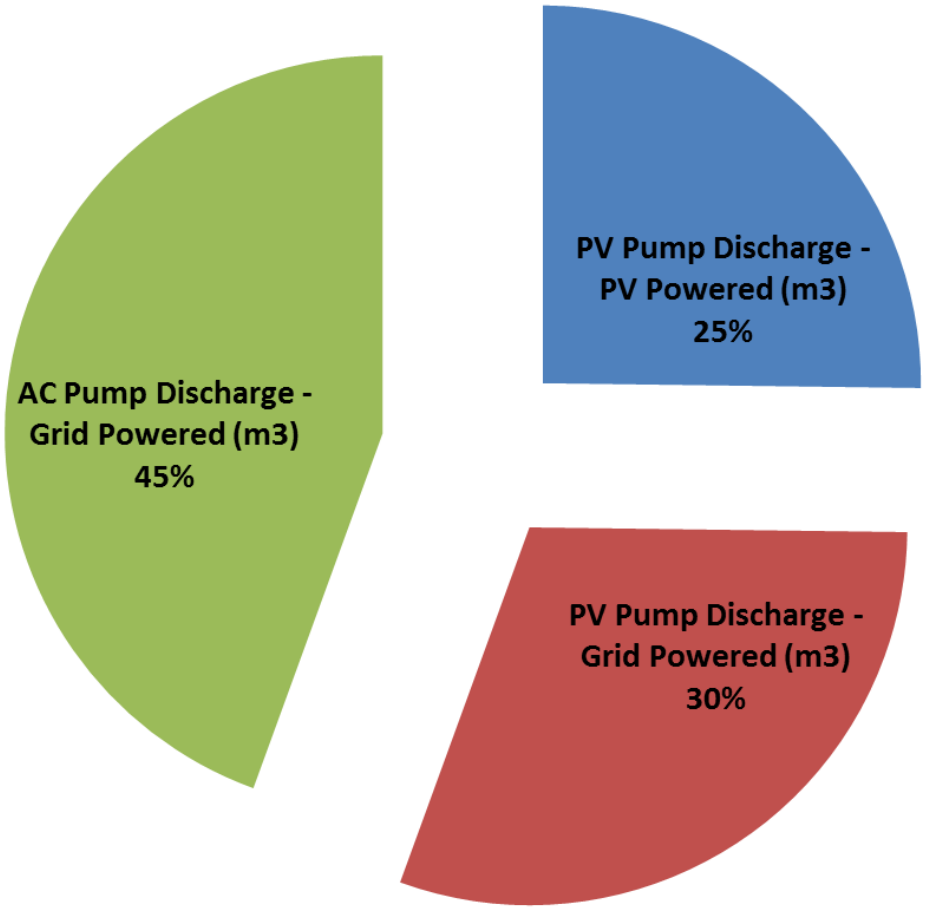
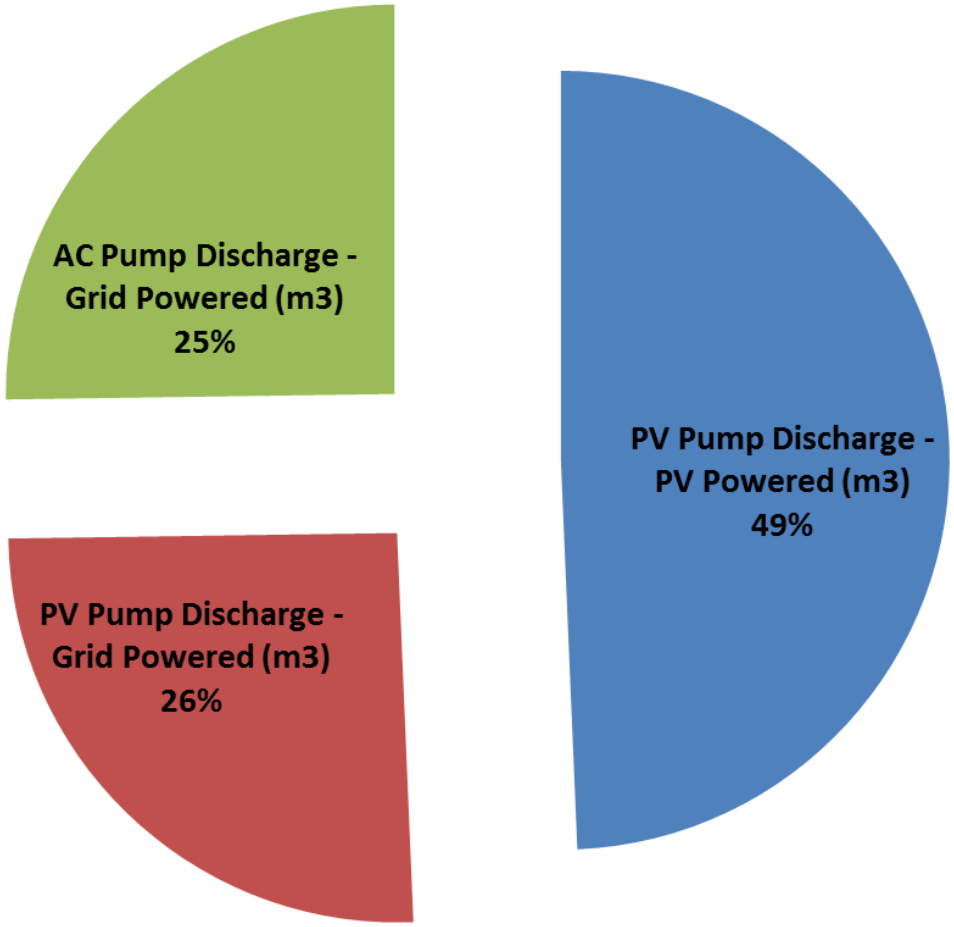
Room 3- Pump contributions- August 7-15, 2017



Inverter Feeds PV Energy to Grid

Room 4- Pump contributions- August 7-15, 2017



No Inverter

Irrigated Area & Net Metering

Room 3

	Area irrigated during monitoring		Rice	Potato (Prep)	Darawa (Fodder)	Corn	Eggplant
	637	Qirates	72	463	70.5	19.5	12
Equal to	27	Feddans (Acres)					
of total	71	Feddans (Acres) served by Room 3					

Grid Usage	Feed-In	Net Consumption (kWh)
295	192	-103

Inverter Feeds PV Energy to Grid

Room 4

	Area irrigated during monitoring		Rice	Potato (Prep)	Darawa (Fodder)	Corn
	1405	Qirates	1222	147	24	12
Equal to	59	Feddans (Acres)				
of total	40	Feddans (Acres) served by Room 4				

Grid Usage	Feed-In	Net Consumption (kWh)
610	0	-610

No Inverter

Activity 2: Verification of the Business Model

Action-plan for **post-installation** framework & **end-of-service-life** arrangements	- Post-installation Service and Maintenance - Logistical Framework - Electronic waste management
Organize and facilitate **coordination meetings**	- An Event will be organized by HU to present Project Findings to key stakeholders and to introduce the BM to potential Finance Institutions
Organize **stakeholder workshop**	

Activity 3: Commissioning/Analysis Feed-in Tariff Scheme

Supply and installation of **on/grid inverter** with accessories
Support **maintenance** of the installed system
Service package for **feed-in tariff** with electricity distribution company
Carry out regular **site visits**

Update on Project Activities: Grid Connection

- March 13 Payment of Smart meter installation fees
- April 6 Installation of Smart meters
- April 10 Grid Connection and inverter commissioning

Activity 4: Monitoring PV Pumping system performance

Identify the different **opportunities** within the project's framework	- Water availability - Energy savings - Value chain & Logistics - Monitoring - Post-installation
Discuss them with all focal points towards **consensus**	
Develop the first draft of the **economic opportunities analysis framework**	
Discuss it with all focal points towards **consensus**	

Activity 5: PV Pumping system Optimization & user capacity-building

Conduct regular PV system maintenance
Organize training session for beneficiaries on O&M

Project Activities: Maintenance Equipment

- February 27 Delivery of maintenance equipment
- Operator training on panel cleaning and equipment usage

Capacity Building Event

- A One-Day capacity building event shall be arranged at the pilot site

Capacity Building Event- Proposed Agenda

	Opening	
	Why	National & Local Project Rationale/Benefits - Energy & Water Security - Environmental Impacts - Economic Aspects
	What	Simplified Description - Afir System components - Optimal Energy-Water Operation Modes & Irrigation management - Key Safety Aspects - Other Operation Models (Off-Grid)
	Economic Sustainability	- Installation & Operation Costs - Value for Money Considerations - Willingness to pay
	What Else	Water Efficiency
	Open Dialogue & Discussion	

Final Comments

- Overwhelmingly positive feedback from stakeholders
- Wide interest from Ministers to International Finance Institutions
- Excellent technical and operational knowledge base

Final Comments

- Continuous interest from farmers and water user associations WUA to replicate experience in neighboring and regional areas

Your Comments?