SOLAR ELECTRIC PRESSURE COOKER REPORT

This report will explain the sizing and designing process of choosing all components within the whole solar system. Solar design starts backward from the load to the panels and batteries.

1. LOAD

The electrical load is a DC pressure cooker. At procurement process we decided to name it “Solar Electrical Pressure cooker-SEPC)”. This is because of the importation duty that is not levied on solar products and if the cookers come in written DC as opposed to Solar, the importation duty might apply.

So, the name of the load is **SEPC.**

We started the process by contacting the only manufacturer of SEPC in China and they provided a list of all their stock of solar cookers.

We eliminated cookers based on power consumption, we had previously been testing a DC Cooker given to us by Jon Leary, the project advisor and it cooked slowly, we were looking for a Cooker that might increase the cooking time by increasing power rating of the cooker. We eliminated cookers that were rated less than 300W.

We also choose to try both 12V and compare them with the 24V cooker. In addition, we decided to test AC/DC cookers because most of the rural areas now have grid connection and as Kenya grows, the government is dedicated to increase grid-connectivity.

We also tried to work with pot capacity of 5L since the average household in the rural areas of Kenya have an average of 5 members. So, we eliminated most of 3L Pots.

Finally we settled on 4 SEPCs and we choose to fly them here as opposed to shipping via ship due to time constrains. They only took a week to get here.

POWER RATING	POT CAPACITY	QTY
12V, 300W,DC	5L	1
24V,400W,DC	5L	1
24V/220V,AC/DC	5L	1
12V/220V,AC/DC	2.8L	1

Observations and Recommendations

1. **We** noted that the 12V cookers had a problem with the appliance cable size, it is too small for the 17Amps that it was drawing from the battery. It was hot throughout and at some point it actually melted. The manufacturer cable is size is 2.00mm2 flexible. We would recommend a cable size of 4.mm2 or above to lower the resistance of the cable. With the recommended size, the cable can comfortably withstand currents of 17Amps.We have since learnt that the poor quality cable extends to the inside of the cooker hence we decided to rule out the 12V cooker from being deployed to customers. If the design itself is faulty then the cases of melting of cables will be a constant headache in the field. We eliminated the two 12V cookers and remained with the two 24V cookers.
2. **The po**wer rating was exaggerated. The actual power drawn by the cookers from the battery were as shown:

POWER RATING	POT CAPACITY	ACTUAL POT CAPACITY	QTY	ACTUAL POWER DRAWN
12V, 300W,DC	5L	4L	1	200W
24V,400W,DC	5L	4L	1	240W

24V/220V,AC/DC	5L	4L	1	240W
12V/220V,AC/DC	2.8L	2.5L	1	200W

The power drawn by the cooker has a direct impact on the size of the battery and the panel array. Fortunately, it favored the less bulky system. However, it was taking more time to cook compared with the pure AC cooker which is rated at 1100W. For Example, the pure AC cooker takes 50Minutes to cook 0.5Kg of Githeri (Maize and beans) but the solar electric cookers take around 2 hours to cook the same amount. Recommendation, since the solar system will be more affordable to more people if the solar cooker cooks with the above stated power, it is wise to continue with the cooker as it is. Increasing the size of the DC coil in order to reduce cooking time will result in a bulky and more expensive system.

3. The 'WARM' function on the SEPC does not function as well as the one in the AC pressure cookers since it is not tied to a timer. Recommendation is to integrate a timer into the Solar Electric Pressure cooker.
4. All the cookers took almost the same amount of time to cook the meals. There was no significant variation in cooking time between the 4 cookers.
5. Since the Kenyan government is committed to ensuring grid connectivity in rural areas, the recommendation would be to have an AC/DC cooker so that both options are available to the end-user. Hence the recommendation is for the project to adopt the 24V/220V, AC/DC cooker for the pilot phase of the project.

2. BATTERY BANK

The original project document had proposed a 1kwh storage.

The 24V/220V, AC/DC SEPC is rated 400W but that is on the AC side, the DC side only draws around 290W, for the sake of our calculations we are going to estimate it at 300W.

LOAD/APPLIANCE =300W

THE DAILY ENERGY CONSUMPTION TABLE

APPLIANCE	QTY	USAGE-HOURS	WHRS	KWH
240W	**1**	**6**	**1440**	**1.44**

LEAD ACID BATTERY

Assumptions

1. 50% depth of discharge(DOD)

1440WHRS=50%
? =100%
Carry-out cross-multiplication.
100% = 2880WHRS
2880WHRS = 2880VAHRS
2880VAHRS/24V = **120AHRS=120AH**

Recommendation:

A lead Acid battery of 120AH will give you 6 hours of cooking with our appliance without any solar arrays, especially at night and during cloudy weather.
A **100AH** battery was recommended because it is what is a readily available in the market at the 120AH range.

Lithium-ion Batteries

APPLIANCE	QTY	USAGE-HOURS	WHRS	KWH
240W	**1**	**6**	**1440**	**1.44**

Assumption:
1. DOD =80%

80%=1440WHRS

100%=?

Cross multiply the above.

1800WHRS=1800VAHRS

1800VAHRS/24V=75 AHRS= **75AH**

Recommendations

The lithium-ion battery is more compact and longer lasting however the price was too high especially the local price. We also had difficulty finding a lithium-oin battery in the Kenyan market. Importing was an option but it was still more expensive to import lithium ion from China than to buy the lead acid batteries locally. Also, the china market is flooded with poor quality items, we had limited resources and time in order to source for and test for the best quality in the china market.

S/N	Battery Brand	Battery Description	starting voltage	End Voltage	Discharge time	Discharge current	Charge Time	Charge current
Battery 1	Ritar	24V, 100AH, GEL, MAINTENANCE FREE,	12.86V	11.30V	**5Hours**	10Amps	5hrs	10Amps
Battery 2	Oushang	24V, 100AH, GEL, MAINTENANCE FREE,	13.20V	10.77V	**5 Hours**	10Amps	5hrs	10Amps

The above values gives us an estimate of how long it takes to charge and discharge a 100AH,24V lead acid battery bank. The recommendation is to connect two 100Ah batteries in series to get the recommended 24V, 100AH battery bank.

2. PANEL ARRAY

The panel array is easy to size when you have your load and charging current.

APPLIANCE	QTY	USAGE-HOURS	WHRS	KWH
240W	**1**	**6**	**1440**	**1.44**

Daily Energy use = 1440WHRS

Assumption

1. 20% losses in efficiency for the panel
2. Assume 6 sun Hours In Nakuru (Mogotio and Mbaruk)

80%=1440WHRS

100% =?

100%=1800WHRS

Sun hours = 6hours

1800WHRS/6HRS= 300Watts panels

Recommendation

Any panel above 300Watts will comfortably power the load, the 300W panels have a current of about 10 Amps hence it is above the minimum charging current of 5Amps.

Solinc is the only local solar manufacturer in Kenya. We choose their panels due to assured quality and easy access to warranty in case of issues, they also had a competitive price. We went for polycrystalline panels due to their price, also, the efficiency difference between them and the mono crystalline is minimal.

CHARGE CONTROLLER

The system needed a charge controller to prevent over-discharge of batteries.

APPLIANCE	QTY	USAGE-HOURS	WHRS	KWH
240W	**1**	**6**	**1440**	**1.44**

The Appliance power Draw= 240W

240W=240VA

240AV/24V=10AMPS

Assumption

1. 20% power losses in the system

=10*1.2=12Amps

Recommendations

A charge controller of 24V rated above 12Amps will do for the system.

Also look at the maximum current of the panel which is 10Amps.

Add 10Amps allowance in case of additional loads that the customer might want to add in the future.

A charge controller of above 20Amps is recommended.

TABLE SHOWING THE RECOMMENDED SOLAR ITEMS AND THEIR SUPPLIERS				
S/N	**ITEM**	**DESCRIPTION**	**QTY**	**SUPPLIERS**
1.	SOLAR PANELS	320Wp, 24V, POLYCRYSTALLINE	45	SOLINC
2.	SOLAR BATTERIES	GEL,MAINTENANCE FREE,100AH,12V,RITAR	90	CHLORIDE EXIDE & POWERPOINT,
3.	POWER METERS	Voltmeter and Ammeter and Watt-meter	45	JUMIA ONLINE SHOP
4.	CHARGE CONTROLLERS	40Amps,24/12V,PWM	45	CHLORIDE EXIDE
5.	DC ELECTRIC PRESSURE COOKER	24V/220V,400W,5L	44 Pcs	TESIGA
9.	CIRCUIT BREAKERS		45 pcs	

DESIGN OF THE WIRING DIAGRAM FOR THE SOLAR SYSTEM