Energy Research Centre

WORKING PAPER SERIES

Working Paper 2015-012

Renewable Energy Options for 1000 Acre Agriculture Fram- A Case Study

Muhammad Ghaffar Doggar

ENERGY RESEARCH CENTRE
COMSATS INSTITUTE OF INFORMATION TECHNOLOGY,
LAHORE CAMPUS

RENEWABLE ENERGY OPTIONS FOR 1000 ACRE AGRICULTURE FARM – A CASE STUDY

Muhammad Ghaffar Doggar
ENERGY RESEARCH CENTER
COMSATS INSTITUTE OF INFORMATION TECHNOLOGY
DEFENSE ROAD LAHORE
Website: www.ciitlahore.edu.lahore
Email: drmgdoggar@ciitlahore.edu.pk

ABSTRACT

Pakistan is heavily dependent on import of oil and spends around 16 billion US$ on its import every year which takes off valuable hard currency. The indigenous energy resources are poor and cannot meet the total demand of energy. There is huge shortfall (5000-7000 MW) in power generation which has led to introduction of load shedding program @ 10-20 hours per day, hampering all the developmental activities, especially operation of agriculture tube-wells. The increased costs of commercial fuels and non availability of electricity have adversely affected the farmer's budget. Renewable energy resources having great potential can be exploited to solve the energy crises in agriculture farms. The study conducted to explore energy options for an agriculture farm comprising of 1000 acre shows substantial savings in commercial fuels especially if biogas alone is applied for Tubewells operation. The farmers can benefit of biogas and solar are applied in specific recommended areas at farm level.

1. INTRODUCTION

Pakistan is facing huge energy crisis now a days. The country is heavily dependent on import of oil and spends around 16 billion US$ on its import every year [1] which takes off 50% of the export earnings. The indigenous energy resources are poor and cannot meet the total demand of energy. The identified gas reserves would last for 10-12 years at current consumption rate of 4.05 TCF per annum, and for oil, the reserves could supply POL for only 2-3 years without import[2]. Further, there is huge shortfall (5000-6000 MW) in power generation which have led to introduction of load shedding program @ 10-20 hours per day, hampering all the development activities of industrial and agriculture sectors besides causing un employment for the people of Pakistan.

Table (1). Oil, Gas and Coal Resource Potential of Pakistan, as of June 30, 2009 [2]

Category	Oil MTOE (billion barrels)	Natural Gas MTOE (Trillion CFT)	Coal MTOE (billion ton)
Resource potential	3622/(27)	6849 /(282)	82695 / (185)
Proven recoverable reserves	113 /(0.84)	1023 /(51,532)	886 /(1.98)
Cumulative production	72 /(0.54)	410 /(18,714)	89 / (0.20)
Remaining recoverable reserve	41 /(0.31)	612 /(32,819)	797 / (1.78)
Annual production	3.2 /(66079 bpd)	28 /(1.345)	2.1 / (4.60 million ton)
Reserve to production ratio	13 years	22 years	400 years

Hydro power resource potential has been estimated to be 45000 MW but it could not be exploited due to political and financial problems which are likely to prevail as such in future. This means that the cheap hydro power resource cannot be exploited and energy costs would further escalate in view of expected price escalation in the international market. The existing (2012) costs of grid connected electricity i.e. Rs. 12 to 16 per KWh, are beyond the reach of an ordinary farmer / people of Pakistan. The agriculture sector consumes about 2% of total commercial energy. Normally diesel oil and electricity are used for on-farm mechanized operations performed using tractors, agriculture machinery and tube wells. The cost of diesel oil is also increasing, 100% escalation in HSD prices observed during the past three years, and this has seriously disturbed farmer's budget.

Table (2): Energy Consumption by Sector (2005-06 and 2010-11). [2]

Sector	Energy Consumption (MTOE)		Annual Cumulative Growth Rate (%)
	2005-06	2010-11	
Domestic	7.054	8.72	4.30
Commercial	1.247	1.521	4.00
Industrial	14.654	14.957	0.40
Agriculture	0.732	0.773	1.10
Transport	8.493	12.020	4.80
Other	0.762	0.846	2.10
Total	33.945	38.842	2.70

With this background this paper has been written on study of energy options for 1000 acre farm while focusing on use of renewable energy systems in on-farming operations. The main objectives of this study are given below:

2. OBJECTIVES

- To study the existing energy consumption pattern and cost of 1000 acres agriculture farm.
- To identify the on-farm activities for utilization of renewable energy resources while minimizing the energy cost and propose suitable energy model for 1000 acres farm.

3. IMPORTANCE OF AGRICULTURE SECTOR

Total geographical area of Pakistan is 79.61 Million hectare (Mha) of which 21.2 Mha are cultivated, 8.2 Mha are culture-able waste and 4.02 Mha under forest. The irrigated area comprises of 19.5 Mha while the remaining area is rain fed[3]. Punjab province is a major stakeholder in land utilization with 57% cultivated area and 71% area under crops.

Table (3): Land Utilization Statistics of Pakistan and Punjab [3]

Item	Pakistan	Punjab	Punjab Share (%)
Geographical area (Mha)	79.21	20.63	26
Cultivated area(M ha)	21.21	12.50	57
Area under crops (M ha)	23.80	16.96	71
Culture-able waste (M ha)	8.20	1.56	19

Agriculture sector is the largest production sector and driving force to the national economic development effort. It contributes 21% to the GDP besides offering employment opportunities to 40% labor force and major share in export earnings[3]. All types of corps are grown in the country. Major crops grown are wheat, rice, cotton, sugarcane, groundnut, potato, citrus and mango. The Punjab province contributes the highest share in agriculture production (Table 4).

Table (4): Area, Production &Yield of Major Crops (2008-09)[3]

Crop	Area (000 ha)	Production (000 ton)	Yield (kg/ha)	Share of Punjab (%)
Wheat	9046	24033	2657	77
Rice	2963	6952	2347	52
Cotton	2820	2009	714	74
Sugarcane	1029	50045	48600	65
Fodder	2370	53616	22600	80
Citrus	200	2132	10660	96
Mango	157	1754	11172	66

There is huge gap between the potential crop yields that can be achieved and the average yields achieved in Pakistan as shown in Table (5) [4]

Table (5): Actual and Potential Achievable Crops Yield (in Tons / Hectare)

Crop	Potential	National	Yield Gap
Wheat	6.4	2.66	3.75
Rice	9.0	2.35	6.65
Maize	6.9	1.50	5.40
Sugarcane	160.0	48.60	121.40

Small size of land holdings is a major hindrance in economic prosperity of farmers. Reportedly 95% of the farms are of below 10 ha and total area of these farms is 63% of the cultivated area. The owners of these farms having low income cannot purchase recommended inputs and agriculture machinery and equipment. Consequently their level of mechanization is in-adequate, selective and limited, and there is a large gap in the national and potential yield of various crops.

Table (6): SIZE OF LAND HOLDING AND ARE OF FARMERS[3]

Size (Hectare)	% of Total Farms	% of Cultivated Area
< 5.0	86.00	44.00
5 – 10	9.00	19.00
10 – 20	4.00	16.00
>20	1.00	21.00

Main source of irrigation water is the four rivers i.e. Sind, Chenab, Jhelum and Kabul. The rivers supply about 136 MAF per annum and103 MAF is diverted to canals. Total water available at farm gate is 78.06 MAF excluding the water conveyance and evaporation losses. This is supplemented with 50.32 MAF of ground water pumped from one million tube wells installed in the country. In Punjab, out of 56 MAF diverted from rivers to canals 16 MAF are lost due to evapo transpiration and seepage and only 40 MAF is available at farm gat. The Tube wells supply 33 MAF and total available water at farms fate is 73 MAF.

Majority of the tube wells are diesel operated (88%) and only 12% have electric motors. Most of the tube wells (78%) are of 0.5 to 1.00 cusec capacity with 20-25 hp engine per motor. Punjab province has got the highest share in tube wells installation (90%) while Sind (8%), Baluchistan (%) and KPK (1%)[4]. The population of tractors is 0.41 million with indigenous production of 60561 tractors per annum[3]. Most of the tractors are of 35 to 65 hp and few are of 75-85 hp. With increased number of tractors, the use of tractor operated agriculture implements is increasing steadily. The available farm power is 0.50 hp per acre which is almost half of the recommended level of 1.00 hp per acre by FAO. The existing level of mechanization in Pakistan is in-adequate and all the on-farm activities are not mechanized. Local manufacturing of agricultural machinery such as thresher, reaper, cultivator, rotavator, MB plow, bar & disc harrows seed drills, planters and sprayers etc. are being done by 500 manufactures, most of which are small industrial units and are located in selected nine towns, cities of the country.

4. ENERGY CONSUMPTION PATTERN

In order to evaluate the energy consumption pattern of a 1000 acres agriculture farm and exploit renewable energy resources i.e. solar, bio-gas and biomass, following assumptions have been made:

4.1. ASSUMPTIONS

The assumptions made for calculating the energy consumption in agriculture farm operations are as under;

- Farm size is 1000 acres which is leveled and agriculture crops are grown @ 130% cropping intensity.
- The farm is located in Southern Punjab (Vehari district).
- Major crops grown are wheat (66% of farm area), cotton (50 % of farm area), fodder (10% of farm area) sugarcane (4% of farm area) and maize (5% of farm area).
- Agricultural machinery selected for farming operations are tractors, implements, planting machinery, combine harvesters and wheat straw chopper blower etc. (**Annexure-A**).
- 14 tractors, 10 No. (each of 50 HP), 4 Nos. (each of 85 HP) and 10 Nos. tube wells (one cusec each) are required for 1000 acres farm (**Annexure-A**).
- Canal water is available but not sufficient to maintain 130% cropping intensity. The tube well water is supplemented to cover the shortfall. It is assumed that 50% of the water demand is met through 10 tube wells(one cusec each).
- Agriculture experts, field assistants, operators and baildars are employed on full time basis at the farm (**Annexure-B**).
- The labor resides at the farm and meets their domestic energy needs i.e. cooking, lighting and heating from kerosene and agriculture waste.
- Renewable energy i.e. biogas and solar, shall be utilized at the farm with the objective to reduce consumption of electricity and diesel to minimize input energy costs.

4.2. ENERGY CONSUMPTION - EXISTING SCENARIO

4.2.1. MACHINERY OPERATION

Energy is required to perform the following on-farm operations using agricultural machinery:

- Tillage Operation
- Seed Bed Preparation
- Crop Planting and Inter-culture
- Chemical Spraying
- Harvesting and Threshing, and Material Handling /Transportation

From the available population of tractors at 1000 acres, net available farm power becomes 0.84 which is quite rational and close to the limit recommended by FAO for developing countries.

4.2.2. MACHINE USE HOURS

The operational hours and energy consumption for wheat, cotton, sugarcane, maize and fodder were calculated based on field capacity of agricultural machinery and actual consumption of fuel (**Annexure C / I-V)**. The machine use hours for different crops are given in the **Table 7**.

Table (7): Machine Use Hours For Different Crops

Item	Wheat	Cotton	Sugarcane	Maize	Fodder
Area under crop (acres)	*660*	*500*	*40*	*50*	*100*
Land preparation (Hours)	792	600	48	60	120
Seed bed preparation and sowing (Hours)	1650	1250	120	100	150
Inter culture (Hours)	330	250	20	300	0
Tube-well Irrigation (Hours)	3960	9000	1200	300	600
Pesticide / Spraying / Fertilizer application (Hours)	462	1100	20	50	0
Harvesting &Threshing(Hours)	548	500	0	50	100
Total use hours	8402	13200	1448	910	1070
Average per acre	13	26	36	18	11

Note: Area under crops: wheat (66%), cotton (50%), fodder (10%), sugarcane (4%) & maize (5%)

4.2.3. ENERGY CONSUMPTION PATTERN AND COSTS

The energy costs have been calculated based on the actual consumption of diesel oil for operating agriculture machinery with tractor and of tubewells **(Annexure C / I-V)** at prevailing market rate of diesel. It has been observed that more energy is required for cotton, wheat, sugarcane and less for other crops. Main factors for increased energy cost for cotton are high number of irrigations with diesel tube wells and large area under crop. Comparing the energy consumption per unit area, sugarcane ranks on top, cotton 2nd and maize 3rd. The percentage shares of energy cost of wheat, cotton, sugarcane, maize & fodder are 37, 55, 5, 1 & 3 respectively.

Table (8). Energy Consumption Pattern and Costs of Different Crops For 1000 Acre Farm

	Description	Wheat	Cotton	Sugarcane	Maize	Fodder
A.	Area under crop (acre)	660	500	40	50	100
B.	**Farming Operations (Excluding Tube-wells)**					
i.	Diesel consumption(liter)	425700	628500	53440	11950	30100
ii.	Cost (M. Rs.)	45.55	67.25	5.72	1.28	3.22
C.	**Tube-wells Operation**					
i.	Diesel Oil (Liters)	13860	31500	4200	1050	2100
ii.	Electric (KWh)	102960	234000	31200	7800	15600
D.	**Cost of Tube-wells Operation**					
i.	Diesel (M. Rs.)	1.48	3.37	0.45	0.11	0.22
ii.	Electric (M. Rs.)	1.34	3.04	0.41	0.10	0.20
E.	**Total Energy Cost**					
i.	Diesel (M.Rs.) (Bii + Di)	47.03	70.62	6.17	1.39	3.45
ii.	Electric (M.Rs.) (Bii + Dii)	46.89	70.29	6.12	1.38	3.42
F.	**Energy Consumption GJ**					
	Total GJ	20440	30690	2680	605	1497
	GJ per acre	31	61	**67**	12	15

5. RENEWABLE ENERGY OPTIONS

5.1. BIO GAS ENERGY

Animal dung is the source of biogas and is available in abundant quantities in Pakistan. It has been estimated that more than 11000 million m^3 biogas can be generated using the available animal dung which is sufficient to meet energy demand of millions of rural people in addition to supply of fertilizer rich in nutrients to enhance the soil fertility.

Bio gas manure (Bg M) commonly known as slurry or bio fertilizer, is rich in Nitrogen (1.5% to 2.5%), Phosphorus (1.2% to 1.5%) and Potash (0.80% to 1.2%). It enhances soil water holding capacity and aeration, accelerates the root growth, inhibits the weed growth and increases crop yield @ 10% to 20%. The biogas manure can supplement chemical fertilizers with 35% net savings in the use of chemical fertilizers.

Table (9): Composition of Nutrients in Bio-Gas Manure and Farm Yard Manure [5]

Manure	N_2 (%)	P_2O_5 (%)	K_2O (%)
Fresh cattle dung	0.3-0.4	01.-0.2	1.0-0.3
Farmyard manure	0.4-1.5	0.3-0.9	0.3-1.9
Poultry manure	1.0-1.8	1.4-1.8	0.8-0.9
Cattle Urine	0.9-1.2	Trace	0.5-1.0
Paddy straw	0.3-0.4	0.8-1.0	0.7-0.9
Wheat straw	0.5-0.6	0.1-0.2	1.1-1.3
BgM	**1.5-2.5**	**1.2-1.5**	**0.8-1.2**

Biogas can also be used for operation of diesel tube wells hence irrigation of crops. The technology has been tested and found viable for operation of one cusec diesel tube well which can be operated for 10-12

hours per day @ 80:20 (Biogas: Diesel). Biogas can also be used for cooking of food, lighting and generation of electricity for running of small agricultural machinery e.g. fodder chopper, dairy & milling equipment at farm. A biogas plant with feeding rate of 2 tons per day can produce 85 m^3 of biogas [6] that is sufficient to operate one cusec tube-well (20 HP) for upto 12 hours per day (**Annexure-D**). The owner of tube well however, will require 100-125 animals to supply animal dung i.e, feeding material, for the operation biogas plant. The estimated cost of one biogas plant producing 85 m^3 gas per day is around Rs. 1.00 million. Thus an investment of Rs. 10.00 million is required to install 10 biogas plants to run ten diesel tube wells at 1000 acres farm. The operation of biogas powered diesel tube wells would be beneficial as it reduces energy cost @ Rs. 4.512 million per annum (Table 10). This shows that the cost of investment for ten biogas plants shall be recovered in two years. If additional benefits of reduced use of mineral fertilizers due to biogas manure applied in field are also taken into account, the net savings in energy consumption becomes Rs. 9.50 million per annum. Increased crop yields @ 10-20% shall be additional benefits.

Table (10): Benefits of Bio-Gas Energy For Tube Wells Operation

Sr. No.	Description	Wheat	Cotton	Sugar-cane	Maize	Fodder	Total
1	Area under Crop (Acre)	660	500	40	50	100	1350
2	Cost of Diesel use for diesel Tubewells (M.Rs.)	1.483	3.371	0.449	0.112	0.225	5.640
3	Cost of Diesel to operate biogas tubewells (M.Rs.)	0.297	0.674	0.090	0.022	0.045	1.128
4	Savings in T/Wells Operation (M. Rs.)	1.186	2.696	0.360	0.090	0.180	4.512
5	Savings in Use of Mineral Fertilizers (M. Rs.)	2.45	1.83	0.148	0.185	0.371	4.984

Note: The benefits to be accrued from livestock (1250 animals) in the form of meat and milk production have not been accounted here.

5.2. SOLAR ENERGY

Pakistan lies in sunny belt countries and receives 5 KWh per m^2 of solar energy daily. The country enjoys bright sunshine spell throughout the year (over 3000 hours) and solar systems can be used all the year round. Two types of solar systems are normally used; Solar PV (dc power) and Solar thermal (air / water heating). Solar PV systems are costly but have long life (25 years +). Solar PV power can be used for on farm lighting, water pumping and for running very small DC operated machinery. Solar thermal systems are cheaper and can be applied for drying of food grains and storage. Solar PV water pumping technology is feasible for shallow water depths especially when water conservation measures are adopted. It is also favorable for drinking water needs. High quality solar PV water pumps have been developed by renowned companies of developed countries (Lorenz, Grundfos & Mono-pumps etc.) and a large number are in operation in different parts of the world. Under local climatic conditions of southern Punjab, a 10 KW solar PV water pump (excluding batteries) can supply 432-575 cubic meter [7] of water daily from 60 feet depth (**Annexure-E/I-II**). The pumped water will be stored in a tank and applied to field under gravity action thus the systems do not need batteries for night operation.

Another 15 KW solar PV water pump can supply same amount of water from 100 ft depth[7]. The cost of solar water pumps is given below:

- 10 KW solar pump (20 liter /sec, 60 ft depth) Rs. 3.40 million
- 15 KW solar pump (20 liter /sec, 100 ft depth) Rs. 4.725 million

The use of solar water pumps shall eliminate the need for diesel or electric tube-wells. The solar PV systems do not require maintenance as the life of solar PV panel is more than 50 years. And normally 10-25 years warranty is offered by good manufacturer in Europe. Therefore, the O&M cost will be negligible. The 10 KW solar PV systems can also be used for running stationary agricultural machinery and dairy equipment during idle hours of tube-wells. It may, therefore, be concluded that solar PV water pumps would reduce energy costs of 1000 acres farm, besides meeting the domestic energy needs of households for lighting, ventilation etc., but its initial investments are high.

5.3. BIOMASS POWER

Biomass power can be generated using cotton stalks, corn straw, wood chips, and other agriculture wastes. The calorific value of cotton stalk is 17.4 GJ/ton and of wheat straw 14.4 GJ/ton which are quite suitable for power generation.

It has been estimated that 500 ton cotton stalk and 660 ton of wheat straw shall be produced from the 1000 acres farm annually. This amount is too short to run a biomass power plants available in the market. The Chinese Models of biomass power plant are in the range of 11-30 MW. The feeding rate of cotton stalk to run 11 MW power plant is 9 ton/hour which means growing cotton on 66000 acres. Hence feasibility of bio mass power plant while planning for 1000 acres may not be appropriate. However, efficient use of cotton stalks may be made in the form of briquettes i.e. after shredding the stalks and compacting the same in the form of briquettes (small compacted blocks which may be used as fuel in lieu of wood etc.).

6. CONCLUSIONS /RECOMMENDATIONS

The commercial energy, diesel fuel and electricity play vital role in mechanized farming operations under existing energy consumption pattern but are becoming unavailable and costly. Main reasons for not using alternate energy resources are lack of awareness and non-availability of alternate energy technologies / equipment accessible to the farmers.

A farm of 1000 acres employing modern agricultural machinery and tubewells and growing cotton, wheat, fodder, maize and sugarcane @130%-140% cropping intensity would consume 37 GJ of energy per acre per annum. More energy is required for cotton and sugarcane than for wheat, maize and fodder due to predominantly more irrigation requirements from tubewells.

- By running biogas powered diesel tube well, followings monetary benefits would be accrued:

- *Savings in the cost of diesel @ 80% =Rs. 4.51 million per annum*
- *Savings in the use of mineral fertilizers @ 30% = Rs.4.984 Million per annum*
- *Enhanced crop yields =10-20% per acre*
- *The investment for installation of 10 bio-gas plants would be recovered in 1-2 years only.*

With the installation of solar water pumps, capital and operational cost of diesel and electric tube wells shall be reduced. Following savings shall be made:

- *Savings in capital cost of 10 diesel or electric tube wells*
- *Annual O&M cost of 10 diesel or electric tube wells i.e Rs.3 to 4 million per annum.*
- *Solar energy can also be applied for lighting, dehydration of food products.*
- *Small agro machinery requires less power can be run on the same PV system.*

It is more feasible that biogas powered tube wells and equipment may be installed at farms to minimize the commercial energy consumption and costs. In view of the above the above findings, following energy model is proposed for 1000 acre farm in Southern Punjab at Vehari District.

<table>
<tr><th>Farming Operation</th><th colspan="2">Viable Mode of Energy</th><th>Remarks</th></tr>
<tr><td>Tillage, Planting /Seeding, Spraying, Inter-culture, Harvesting, Transport of produce etc.</td><td colspan="2">Diesel operated tractor and agriculture machinery</td><td>Consumption of diesel fuel is inevitable as per existing practices</td></tr>
<tr><td>Irrigation through Tube wells</td><td>Biogas powered diesel tube well</td><td>-</td><td rowspan="8">• Savings of energy @ 8.38 GJ per acre per annum for tube wells operation with biogas operation
• Energy consumption to be reduced by 23% (from 37 GJ to 28.62 GJ per acre) with biogas
• In terms of monetary benefit, biogas induction will save Rs. 9.50 million per annum;
o Rs 4.51 million (80% diesel for tube wells)
o Rs. 4.984 million (30%-35% mineral fertilizer).</td></tr>
<tr><td>Farm Shed Lighting</td><td>Biogas lamp</td><td>Solar PV</td></tr>
<tr><td>Path Ways Lighting</td><td>-</td><td>Solar PV</td></tr>
<tr><td>Cooking of Food</td><td>Biogas</td><td>-</td></tr>
<tr><td>Water Heating</td><td>Biogas</td><td>Solar water heater</td></tr>
<tr><td>Dehydration of Food Grains / Fruits etc.</td><td>-</td><td>Forced convective solar PV dryers</td></tr>
<tr><td>Fodder Chopper (With Electric Generator)</td><td>Biogas</td><td>-</td></tr>
<tr><td>Dairy Equipment (With Electric Generator)</td><td>Biogas</td><td>-</td></tr>
</table>

Note: The costs of solar PV pumps have declined due to drop in the prices of solar cells and increased efficiency since 2011-12. So solar PV will become more attractive as on current market prices.

REFERENCES

1. Vision 2030 (Energy Chapter), Planning Commission of Pakistan, Government of Pakistan Islamabad.

2. Energy Year Book, Hydrocarbon Development Institute of Pakistan (HDIP), Government of Pakistan (GoP), Islamabad (2011)**.**

3. Agriculture Statistics of Pakistan, MINFAL (Ex), Government of Pakistan (GoP), Islamabad (2008-09).

4. Internal Reports and Briefs on Agriculture and Water Resources, Directorate General Agriculture (Field and Water Management Wings), Agriculture Department, Government of the Punjab, Lahore.

5. Presentations on Construction of Bio-gas Plant, Operation and Maintenance" (Jan to March 2012) Field Wing of Agriculture Department, Government of the Punjab, Lahore.

6. Bio-gas Operated Diesel Tubewells (Project Proposal), Field Wing of Agriculture Department, Government of the Punjab, Lahore (June 2012)

7. Design Calculations Made by Author on System Sizes of Solar Water Pumps and Data Collected From Private Firms: German Pumps Supplier (Grundfos and Lowrenz) (2012).

ACKNOWLEDGEMENT

The author conducted this study while he was working as Project Coordinator for Biogas Tube wells Project in Agriculture Department (2012) and is grateful to all officials and engineers especially to German solar pumps suppliers in Pakistan and biogas contractors firms who provided data for conducting the study.

Annexure-A

AGRICULTURE MACHINERY REQUIRED FOR 1000 ACRE FARM

Sr. No.	Description	Type	Unit Price	Required Number		Total Price	
				For 100 Acre	For 1000 Acre	For 100 Acre	For 1000 Acre
1	Tractor	85 HP	825000	1	4	825000	3300000
2	Tractor	50 HP	625000	1	10	625000	6250000
3	Trolley	-	300000	1	10	300000	3000000
4	Chisel Plow		40000	1	3	40000	120000
5	Rotavator		100000	1	5	100000	500000
6	Disc Harrow		120000	1	5	120000	600000
7	Cultivator		45000	1	10	45000	450000
8	Wheat Seed Drill		40000	1	5	40000	200000
9	Cotton Planter		80000	1	5	80000	400000
10	Sugarcane Planter		120000	1	2	120000	240000
11	Ridger		40000	1	5	40000	200000
12	Fodder Cutter		156000	1	4	156000	624000
13	Tractor Mounted Sprayer		135000	1	2	135000	270000
14	Rotary Slasher		102000	1	2	102000	204000
15	Fertilizer Spreader		43000	1	3	43000	129000
16	Cotton Ridger with Fertilizer attachment		110000	1	3	110000	330000
17	Ditcher		28000	1	1	28000	28000
18	Boder Disk		36000	1	1	36000	36000
19	Laser leveller		525000	1	1	525000	525000
20	Fodder Chopper		40000	1	10	40000	400000
21	Wheat Straw Chopper		425000	1	2	425000	850000
22	Tractor Mounted Combine		1600000	1	1	1600000	1600000
23	Self Propelled Combine		2000000		1	0	2000000
24	Misc. Tools		28000	1	10	28000	280000
25	Tubewell 1 Cusec		525000	1	10	525000	5250000
	Grand Total					**6088000**	**27786000**
	Million Rs.						**27.786**

Annexure-B

REQUIREMENT OF LABOUR / WORKER FOR 1000 ACRE FARM

Sr. No.	Designation	Staff Requirement		Sallary (Rs.)	
		For 100 Acres	For 1000 Acres	Per Month (Rs.)	Per Annum
1	Agriculture Scientist / Farm Manager		1	40000	480000
2	Field Assistant	1	10	18000	2160000
3	Tractor / Tubwell Operators	1	10	12000	1440000
4	Beldars / Labourers	4	40	10000	4800000
		6	**61**		**8880000**

Annexure-C / I

ENERGY CONSUMPTION PATTERN FOR WHEAT CROP IN SOUTHERN PUNJAB (DISTRICT VEHARI)

Sr. No.	Description/ Operation	Unit	Energy Consumption Pattern for Wheat Crop								
			No. of passes / runs per acre	Operational Hours per Acre	POL Consumption (liter/hr)	Total Energy Consumption (Liters)	Rate (Rs./liter)	Energy Cost Per Acre (Rs.)	Other Inputs Cost per acre (Rs.)	Total Cost Per acre (Rs.)	Total Cost for 100 acre (Rs.)
1	**Land Preparation**										
a.	Rotavator/Disc Harrow	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
b.	Precision land leveling	Hours	1	0.6	5.5	3.3	107	353.10	0.00	353.10	35310
c.	Deep plowing (Chisel Plow)	Hours	1	0.1	5.5	0.55	107	58.85	0.00	58.85	5885
2	**Seed Bed Preparation**										
a.	Cultivator and Planking	Hours	4	2	5.5	11	107	1177.00	0.00	1177.00	117700
3	**Sowing**										
a.	Seed	Kg							2200	2200	220000
b.	v	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
4	**Fertilizer**										
a.	Farm Yard Manure	One Trolley							2000	2000	200000
b.	Urea	2 bags							3600	3600	360000
c.	DAP	1 bags							4500	4500	450000
d.	Potash	1 bag							2500	2500	250000
e.	Transportation	Rs.							150	150	15000
f.	Fertilizer Spreader	Hours	1	0.4	5.5	2.2	107	235.40	0.00	235.40	23540
5	**Hoeing (Tractor Operated Bar Harrow)**	Rs.	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425

Annexure-C / I

6	**Irrigation**										
a.	Canal Water	Rs.	2	6					95.72	95.72	9572
b.	Tubewell Water (Diesel) OR	Hours	2	6	3.5	21	107	2247.00	0.00	2247.00	224700
c.	Tubewell Water (Electric)	kWh	2	6	26	156	13	2028.00	0.00	2028.00	202800
7	**Pesticide application**										
a.	Cost of Pesticide + Weedicide	Rs.							1500.00	1500.00	150000
b.	Tractror Operated Sprayer	Hours	1	0.3	5.5	1.65	107	176.55	0.00	176.55	17655
8	**Harvesting/ Threshing**										
a.	Tractor Op.Combine	Hours	1	0.33	5.5	1.815	107	194.21	0.00	194.21	19420.5
b.	Tractor Operated Wheat Straw Chopper	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
9	**Transportation of Produce**										
a.	Tractor trolley	Rs.							200.00	200.00	20000
	Grand Total excluding Irrigation with Tubewell	**Rs.**	**15**	**12**	**55**	**645**	**107**	**69031**	**16746**	**20118**	**2011783**
	Grand Total Including Irrigation with Diesel Tubewell (Exld. Electric)	**Rs.**	**17**	**18**	**59**	**1037**	**107**	**110981**	**16746**	**22365**	**2236483**
	Grand Total Including Irrigation with Electric Tubewell (Exld. Diesel)	**Rs.**	**17**	**18**	**81**	**1436**	**13**	**18670**	**16746**	**22146**	**2214583**

Note: Machine use hours for Precision land levelling and deep plowing taken as 1 time pass per annum and evenly destributed among 5 crops.

Annexure-C / II

ENERGY CONSUMPTION PATTERN FOR COTTON CROP IN SOUTHERN PUNJAB (DISTRICT VEHARI)

Sr. No.	Description/ Operation	Unit	Energy Consumption Pattern for Cotton Crop								
			No. of passes / runs per acre	Operational Hours per Acre	POL Consumption (liter/hr)	Total Energy Consumption (Liters)	Rate (Rs./liter)	Energy Cost Per Acre (Rs.)	Other Inputs Cost per acre (Rs.)	Total Cost Per acre (Rs.)	Total Cost for 100 acre (Rs.)
1	**Land Preparation**										
a.	Deep plowing (Chisel Plow)	Hours	1	0.1	5.5	0.55	107	58.85	0.00	58.85	5885
b.	Rotavator/Disc Harrow	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
c.	Precision land leveling	Hours	1	0.6	5.5	3.3	107	353.10	0.00	353.10	35310
2	**Seed Bed Preparation**										
a.	Cultivator with Planking	Hours	4	2	5.5	11	107	1177.00	0.00	1177.00	117700
3	**Sowing**										
a.	Cotton Seed	Kg							2500	2500	250000
b.	v	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
4	**Fertilizer**										
a.	Farm Yard Manure	One Trolley							2000	2000	200000
b.	Urea	2 bags							3600	3600	360000
c.	DAP	1 bags							4500	4500	450000
d.	Potash	1 bag							2500	2500	250000
e.	Transportation	Rs.							150	150	15000
5	**Ridger cum Fertilizer Spreader**	Hours	1	1	5.5	5.5	107	588.50	0.00	588.50	58850

Annexure-C / II

6	**Interculture**										
a.	Hoeing & Earthing up (Ridger / Rotry Cultivator)	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
7	**Irrigation**										
a.	Canal Water	Rs.	6	18					95.72	95.72	9572
b.	Tubewell Water (Diesel) OR	Hours	6	18	3.5	63	107	6741.00	0.00	6741.00	674100
c.	Tubewell Water (Electric)	KwH	6	18	26	468	13	6084.00	0.00	6084.00	608400
8	**Pesticide application**										
a.	Cost of Pesticide	Rs.							6000.00	6000.00	600000
b.	Tractor Operated Sprayer	Hours	4	1.2	5.5	6.6	107	706.20	0.00	706.20	70620
9	**Picking (Manual)**	**Rs.**							10000	10000	1000000
10	**Stalks Shredding through Rotary Slasher**	Hours	1	1	5.5	5.5	107	588.50	0.00	588.50	58850
10	**Transportation of Produce**										
a	Tractor trolley	Rs.							600.00	600.00	60000
	Grand Total excluding Irrigation with Tubewell	**Rs.**	**21**	**25**	**50**	**1257**	**107**	**134531**	**31946**	**36301**	**3630062**
	Grand Total Including Irrigation with Diesel Tubewell (Exld. Electric)	**Rs.**	**27**	**43**	**53**	**2300**	**107**	**246121**	**31946**	**43042**	**4304162**
	Grand Total Including Irrigation with Electric Tubewell (Exld. Diesel)	**Rs.**	**27**	**43**	**76**	**3277**	**13**	**42597**	**31946**	**42385**	**4238462**

Note: Machine use hours for Precision land levelling and deep plowing taken as 1 time pass per annum and Evenly distributed among 5 crops.

Annexure-C / III

ENERGY CONSUMPTION PATTERN FOR SUGARCANE IN SOUTHERN PUNJAB (DISTRICT VEHARI)

Sr. No.	Description/ Operation	Unit	Energy Consumption Pattern for Sugarcane Crop								
			No. of passes / runs per acre	Operational Hours per Acre	POL Consumption (liter/hr)	Total Energy Consumption (Liters)	Rate (Rs./liter)	Energy Cost Per Acre (Rs.)	Other Inputs Cost per acre (Rs.)	Total Cost Per acre (Rs.)	Total Cost for 100 acre (Rs.)
1	**Land Preparation**										
a.	Deep plowing (Chisel Plow)	Hours	1	0.1	5.5	0.55	107	58.85	0.00	58.85	5885
b.	Rotavator/Disc Harrow	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
c.	Precision land leveling	Hours	1	0.6	5.5	3.3	107	353.10	0.00	353.10	35310
2	**Seed Bed Preparation**										
a.	Cultivator with Planking	Hours	4	2	5.5	11	107	1177.00	0.00	1177.00	117700
b.	Ridger	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
3	**Sowing**										
a.	v	Kg							9000	9000	900000
b.	Tractor Operated Sugarcane Planter	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
4	**Fertilizer**										
a.	Farm Yard Manure	Kg							2000	2000	200000
b.	Urea	2 bags							3600	3600	360000
c.	DAP	1 bags							4500	4500	450000
d.	Potash	1 bag							2500	2500	250000
e.	Transportation	Rs.							150	150	15000
5	**Interculture**										
a.	High clearance ridger	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425

Annexure-C / III

6	**Irrigation**										
a.	Canal Water	Rs.	10	30					135	135	13500
b.	Tubewell Water (Diesel) OR	Hours	10	30	3.5	105	107	11235.00	0.00	11235.00	1123500
c.	Tubewell Water (Electric)	KwH	10	30	26	780	13	10140.00	0.00	10140.00	1014000
7	**Pesticide application**										
a.	Cost of Pesticide & its application	Rs.							1200	1200.00	120000
8	**Harvesting and Trash removal (Manual)**	**Rs.**							5500	5500.00	550000
9	**Transportation of Produce**										
a.	Tractor trolley	Rs.							700.00	700.00	70000
	Grand Total excluding Irrigation with Tubewell	Rs.	**20**	**35**	**39**	**1336**	**107**	**142947**	**29285**	**32051**	**3205095**
	Grand Total Including Irrigation with Diesel Tubewell (Exld. Electric)	**Rs.**	**30**	**65**	**42**	**2717**	**107**	**290762**	**29285**	**43286**	**4328595**
	Grand Total Including Irrigation with Electric Tubewell (Exld. Diesel)	**Rs.**	**30**	**65**	**65**	**4173**	**13**	**54251**	**29285**	**42191**	**4219095**

Note: Machine use hours for Precision land levelling and deep plowing taken as 1 time pass per annum and Evenly distributed among 5 crops.

Annexure-C / IV

ENERGY CONSUMPTION PATTERN FOR MAIZE IN SOUTHERN PUNJAB (DISTRICT VEHARI)

Sr. No.	Description/ Operation	Unit	Energy Consumption Pattern for Maize Crop								
			No. of passes / runs per acre	Operational Hours per Acre	POL Consumption (liter/hr)	Total Energy Consumption (Liters)	Rate (Rs./liter)	Energy Cost Per Acre (Rs.)	Other Inputs Cost per acre (Rs.)	Total Cost Per acre (Rs.)	Total Cost for 100 acre (Rs.)
1	**Land Preparation**										
a.	Rotavator/Disc Harrow	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
b.	Precision land leveling	Hours	1	0.6	5.5	3.3	107	353.10	0.00	353.10	35310
c.	Deep plowing (Chisel Plow)	Hours	1	0.1	5.5	0.55	107	58.85	0.00	58.85	5885
2	**Seed Bed Preparation**										
a.	Cultivator and Planking	Hours	4	1.5	5.5	8.25	107	882.75	0.00	882.75	88275
3	**Sowing**										
a.	Seed	Kg							5000	5000	500000
b.	Planting with Fertilizer Application	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
4	**Fertilizer Application**										
a.	Farm Yard Manure	One Trolley							2000	2000	200000
b.	Urea	2 bags							3600	3600	360000
c.	DAP	1 bags							4500	4500	450000
d.	Potash	1 bag							2500	2500	250000
e.	Transportation	Rs.							150	150	15000
5	**Weeding**	Rs.							1000	1000	100000

6	**Hoeing (Manual)**	Rs.							1500	2000	200000
7	**Irrigation**										
a.	Canal Water	Rs.							95.72	95.72	9572
b.	Tubewell Water (Diesel) OR	Hours	2	6	3.5	21	107	2247.00	0.00	2247.00	224700
c.	Tubewell Water (Electric)	KwH	2	6	26	156	13	2028.00	0.00	2028.00	202800
8	**Pesticide application**										
a.	Cost of Pesticide & Spraying	Rs.	1	1	5.5	5.5	107	588.50	1000.00	1588.50	158850
9	**Harvesting/ Threshing**	Rs.	1	2	5.5	11	107	1177.00	1000.00	2177.00	217700
10	**Transportation of Produce**										
a.	Tractor trolley	Rs.							200.00	200.00	20000
	Grand Total excluding Irrigation with Tubewell	Rs.	**10**	**6**	**39**	**239**	**107**	**25541**	**22546**	**26694**	**2669442**
	Grand Total Including Irrigation with Diesel Tubewell (Exld. Electric)	**Rs.**	**12**	**12**	**42**	**512**	**107**	**54827**	**22546**	**28941**	**2894142**
	Grand Total Including Irrigation with Electric Tubewell (Exld. Diesel)	**Rs.**	**12**	**12**	**65**	**787**	**13**	**10230**	**22546**	**28722**	**2872242**

Note: Machine use hours for Precision land levelling and deep plowing taken as 1 time pass per annum and Evenly distributed among 5 crops.

Annexure-C / V

ENERGY CONSUMPTION PATTERN FOR FODDER IN SOUTHERN PUNJAB (DISTRICT VEHARI)

Sr. No.	Description/ Operation	Unit	Energy Consumption Pattern for Fodder								
			No. of passes / runs per acre	Operational Hours per Acre	POL Consumption (liter/hr)	Total Energy Consumption (Liters)	Rate (Rs./liter)	Energy Cost Per Acre (Rs.)	Other Inputs Cost per acre (Rs.)	Total Cost Per acre (Rs.)	Total Cost for 100 acre (Rs.)
1	**Land Preparation**										
a.	Rotavator/Disc Harrow	Hours	1	0.5	5.5	2.75	107	294.25	0.00	294.25	29425
b.	Precision land leveling	Hours	1	0.6	5.5	3.3	107	353.10	0.00	353.10	35310
c.	Deep plowing (Chisel Plow)	Hours	1	0.1	5.5	0.55	107	58.85	0.00	58.85	5885
2	**Seed Bed Preparation**										
a.	Cultivator with Planking	Hours	3	1.5	5.5	8.25	107	882.75	0.00	882.75	88275
3	**Sowing**										
a.	Seed along with sowing (Manually)	Kg							10000	10000	1000000
4	**Fertilizer**										
a.	Farm Yard Manure	Kg							2000	2000	200000
b.	Urea	2 bags							3600	3600	360000
c.	DAP	1 bags							4500	4500	450000
e.	Transportation	Rs.							150	150	15000

Annexure-C / V

5	**Irrigation**										
a.	Canal Water	Rs.							135	135	13500
b.	Tubewell Water (Diesel) OR	Hours	2	6	3.5	21	107	2247.00	0.00	2247.00	224700
c.	Tubewell Water (Electric)	KwH	2	6	26	156	13	2028.00	0.00	2028.00	202800
6	**Harvesting with Fodder Cutter**	Hours	1	1	5.5	5.5	107	588.50	0.00	588.50	58850
8	**Transportation of Produce**										
a.	Tractor trolley	Rs.							600.00	600.00	60000
	Grand Total excluding Irrigation with Tubewell	Rs.	**7**	**4**	**28**	**102**	**107**	**10887**	**20985**	**23162**	**2316245**
	Grand Total Including Irrigation with Diesel Tubewell (Exld. Electric)	**Rs.**	**9**	**10**	**31**	**301**	**107**	**32175**	**20985**	**25409**	**2540945**
	Grand Total Including Irrigation with Electric Tubewell (Exld. Diesel)	**Rs.**	**9**	**10**	**54**	**519**	**13**	**6746**	**20985**	**25190**	**2519045**

Note: Machine use hours for Precision land levelling and deep plowing taken as 1 time pass per annum and Evenly distributed among 5 crops.

Annexure-D/1

ESTIMATED COST OF BIOGAS PLANT FOR ONE CUSEC DIESEL TUBEWELL (DUAL FUEL SYSTEM, 80:20)

Assumptions

Tube well Discharge	1 cusec
Engine for tubewell	20 hP (Peter engine)
Depth of water/irrigation	3 inch
One tubewell command area	50 acre
Tubewell operation	Dual Fuel System
Total Area	50 Acre
Nos of Irrigations	30 per acre per year
Biogas Plant Well Dia	16 feet (5 m^3)
Biogas Plant Well Depth	18 feet (5.5 m^3)

Output / Calculations

Volume of water required to irrigate one acres	43560 × 3/12 = 10890 ft^3
Tubewell discharge	1 cusec
Operation of tubewell per irrigation per acre	3 Hrs
Operational time (hours per year per acre)	90 Hrs
Operational time for 50 acres (hours per year)	4500 Hrs
Operational time per tubewell per day	12 Hrs
Biogas consumption rate for 20 HP diesel dual fuel engine (per HP per hour)	0.25- 0.35 m^3
Biogas required for operation of tubewell for one hour	6 m^3
Total Gas required per day for 20 HP tubewell operation	72-84 m^3
Gas production from 2 ton of gober	85 m^3
Animal dung required for one biogas plant per day	2 ton
Feeding rate for one plant per day (including water)	**4 ton**
Animal yield "gober" (kg per head per day)	15-20 kg
Nos. of animals required to produce 2 ton gober per day (sufficient for one cusec tubewell)	100-125 Nos
Cost of one plant	Rs. 1.00 million (Annex D II)

Annexure D/II

ROUGH COST ESTIMATE OF MATERIAL OF BIOGAS PLANT WITH STIRRING HEAT EXCHANGER (4 ton feeding rate i.e. 2 ton goober + 2 tone water per day)

Sr. No	Material Description	Qty	Amount (Rs)
1	Excavation Rs. 15/ cft	7500 cft	112500.00
2	Bricks Rs. 6000/1000	14000 Nos	84000.00
3	Cement Rs. 440/bag	80 Nos	35200.00
4	Sand Rs. 20/ ft^3	450 ft^3	9000.00
5	Gravel Rs. 50/cft	150 cft	7500.00
6	M.S. round ½ inch dia Rs. 73/kg	200 kg	14600.00
7	Labor charges for construction of well & feeding tank	Lump sum	50000.00
A	**Sub-Total**		**312800.00**
8	Stirring system Complete		100000.00
9	Heat exchanger (S.S.PIPE) 2”		100000.00
B	**Sub-Total**		**200000.00**
10	Gas holder (fiber)		350000.00
11	Accessories Transportation charges		15000.00
12	Gas storage, compressor ,Accessories		100000.00
C	**Sub-Total**		**465000.00**
Grand Total (A+B+C)		**Rs. 977800.00 i.e. One Million Rupees**	

Note: The costs were taken during year 2012

Annexure-E / I

ESTIMATED COST OF SOLAR PV WATER PUMPING SYSTEM (DC) FOR 50 ACRES FARM (5" DIA OF DELIVERY PIPE, 20 LITER PER SECOND, 60 FT DEPTH OF WATER TABLE); - GERMAN ORIGIN SOLAR PUMPS

Description	Unit	Technical Specifications	Cost (Rs.)
Assumptions			
Depth of water table	Meter	18 (60 ft.)	-
Location		Southern Punjab (Vehari)	-
Available solar radiation (Avg)	KWh per day	5 - 5.5	-
Ambient temperature	C^o	30 - 40	-
Amount of water required	Liter per second	20	-
Amount of water required	m^3 per day	432 - 576	-
System Size			
PV Panel (single crystel Si Cells) 96 Volt system @ Rs. 250/- per W	KW	10	2200000.00
Lorenz (German) DC Pump (Submercible with DC motor) 96 Volt system	KW	10	1100000.00
Power control panel, including charge controller for PV panel	Lorenz	1 Set	
Piping and accessories, steel wire rope, flexible hanging wire & water level sensor etc.	Lorenz	1 Set	100000.00
Total			**3400000.00**

Note: The costs indicated are for the year 2012 and taken from German solar pumps supplier (Lorenz, Grundfos)

Annexure-E / II

ESTIMATED COST OF SOLAR PV WATER PUMPING SYSTEM (DC) FOR 50 ACRES FARM (5" DIA OF DELIVERY PIPE, 20 LITER PER SECOND, 100 FT DEPTH OF WATER TABLE); - GERMAN ORIGIN SOLAR PUMPS

Description	Unit	Technical Specifications	Cost (Rs.)
Assumptions			
Depth of water table	Meter	30 (100 ft.)	-
Location		Southern Punjab (Vehari)	-
Available solar radiation (Avg)	KWh per day	5 - 5.5	-
Ambient temperature	C^o	30 - 40	-
Amount of water required	Liter per second	20	-
Amount of water required	m^3 per day	432 - 576	-
System Size			
PV Panel (single crystel Si Cells) 96 Volt system @ Rs. 250/- per W	KW	15	3300000.00
Lorenz (German) DC Pump (Submercible with DC motor) 96 Volt system	KW	15	1300000.00
Power control panel, including charge controller for PV panel	Lorenz	1 Set	
Piping and accessories, steel wire rope, flexible hanging wire & water level sensor etc.	Lorenz	1 Set	125000.00
Total			**4725000.00**

Note: The costs indicated are for the year 2012 and taken from German solar pumps supplier (Lorenz, Grundfos)