Trip Report:
Community-level Energy, Irrigation, Refrigeration and Cereal Mills
Potou (Senegal) MVP Cluster
March, 26th-April, 27th, 2009
José Barnuevo

1. Objectives.

The main objective of the trip was to conduct surveys on the use of energy in different sectors in the MVP cluster of Potou (Senegal). The subjects are energy use in public and private buildings, small irrigation systems, refrigeration systems for fish conservation and cereal mills. The surveys aimed at identifying the different energy systems employed in business establishments, public institutions, as well as other activities like agriculture and fishing. Once those systems were identified, the surveys were also designed to learn about the maintenance service, the energy costs, and the plans related to energy use projected by the owners. The purpose of conducting those surveys was to establish what was in place before the MVP project begun, what plans were made and which of those plans have been achieved, paying attention to the maintenance and conservancy of these systems.

2. Schedule.

26-27 March: Meeting with MVP staff in Louga (Senegal).
30 March-21 April: Fielding of Community, business, irrigation systems, refrigeration systems and cereal mills surveys.
Surveys conducted:

22 Public and private institutions
14 shops and businesses
18 irrigation systems
3 grinding mills
1 fish conservation system
2 market surveys

Table 1: Surveys conducted

A more detailed schedule with daily activities is presented in APPENDIX I. The GPS position of these sites is specified in APPENDIX II.

3. Data Gathered.

- Local Development Plan for the Rural Community of Leona.
- Energy Action Plan Proposition for the Rural Community of Leona.
- 5 years Energy Action Plan for the Rural Community of Leona.
- Solar systems specifications and locations.
- Specifications of the Motor Pumps provided by the MVP project.
- Specifications of the Grinding mills provided by the MVP project.

4. Energy systems.

The importance of energy supply and energy access to achieve the objectives of the Millennium Development Goals (MDG) led the Millennium Villages Project (MVP) to include an "energy component" in every project launched. One of the main objectives of the MVP is to electrify, as soon as possible, the community buildings in the Potou MVP site cluster. The priority is to electrify schools, health centers, two multimedia centers and the fishing post in Niayam using a PV solar system. In the mid-term, it is projected to ask for the extension of the medium voltage power lines that have already arrived to Leona, Potou and Thiowor. This grid belongs to ASER (Agence Sénégalaise d'Electrification Rurale).

4.1. Energy systems in public buildings.

The surveys were conducted at many public buildings of the cluster with one energy system. Those buildings are schools, health centers, the Rural Council, the fishing post and a Community house. Some of those systems were installed by the MVP project, others by the AFDS (Agence Française de Développement du Sénégal), and others by the SENELEC (Société Nationale d'Electricité du Sénégal).

Location	Building	Energy system	Provider	Electrified since
Leona	Rural Council	Grid	SENELEC	December 2006
Leona	School	Grid	SENELEC	January 2009
Leona	Health Center	Grid	SENELEC	2007
Leona	Stock-farmers house	Flashlights	-	-
Potou	School	Grid	SENELEC	October 2008
Potou	Health Center	Grid	SENELEC	February 2009
Potou	Family house	Grid	SENELEC	2006-2007
Batlamine	School	PV solar system	MVP	2009
Batlamine	Health center	PV solar system	MVP	2008
Gabar	School	PV solar system	MVP	November 2008
Gabar	Health center	PV solar system	AFDS	March 2004
Thiowor	School	PV solar system	MVP	2009
Sague Sathiel	School	PV solar system	MVP	2009
Sague Sathiel	Health center	PV solar system	MVP	2008
Syer Peulh	Health center	PV solar system	MVP	June 2008
Ndialakhar Samb	Health center	PV solar system	MVP	2008
Ndemba	Health center	PV solar system	MVP	2008
Ouassoum Assal	Health center	PV solar system	MVP	November 2008
Maka Tare	Health center	PV solar system	AFDS	2006
Santhiou Diatji	Health center	PV solar system	AFDS	August 2005
Keur Koura Dieri	Health center	PV solar system	AFDS	2003
Niayam	Fishing Post	PV solar system	MVP	September 2008

Table 2: Type of public building, location and type of energy system

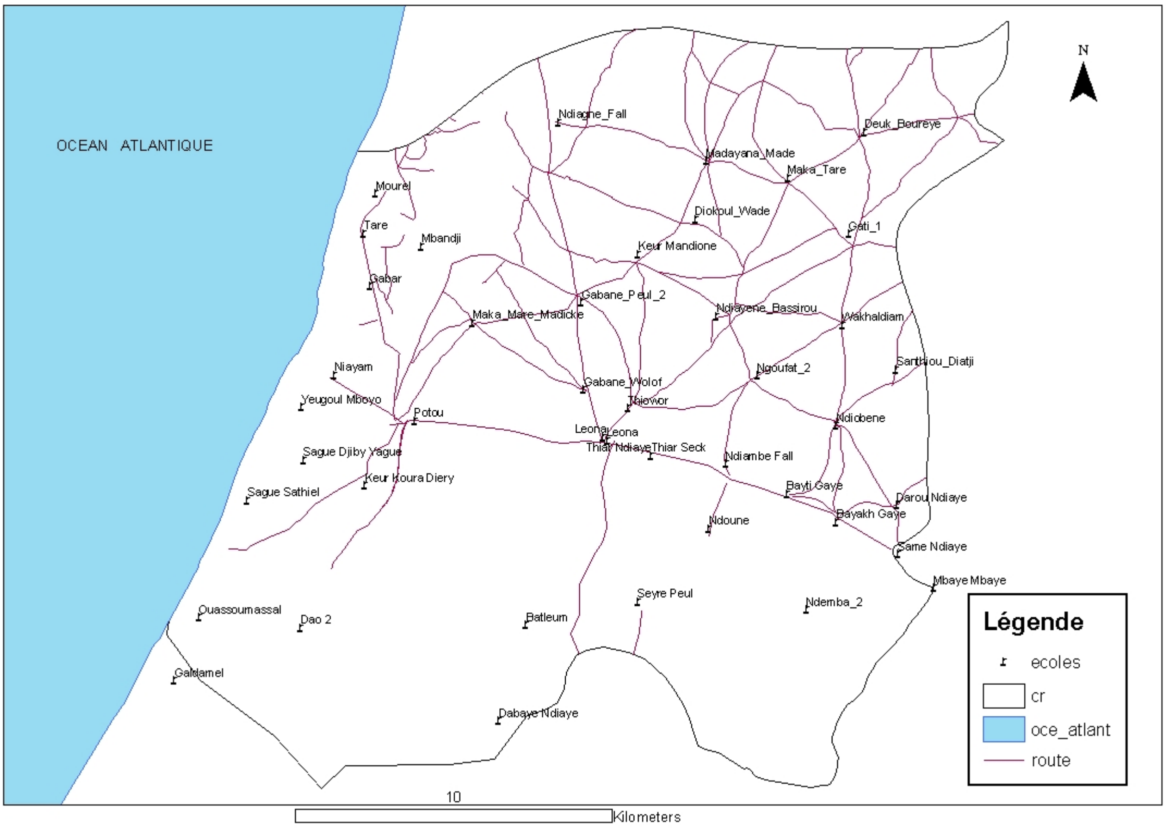
4.1.1. Schools.

Schools at the Rural Community are of different kind and size. They are composed of one or many buildings, with a metallic roof: There are many classes and an office for the director. In some villages there will also be one or two provisional classes in wooden made shelters. In those schools, no autonomous energy system has been used. In many cases, one of the classes of the school is the lodging of a teacher or the director.

Picture 1: School at Gabar.

In 2006, at the beginning of the Project, there were 42 schools in the cluster, and none of them was electrified. The main reason is the long distance between these buildings and the existent Grid, which makes the costs unaffordable for the community. No autonomous energy system was employed. Basically, these buildings only need electricity for lighting, especially during the night. Occasionally, there will be electricity needs for multimedia and audiovisual systems (computers, TVs, DVDs, etc.). Teachers used LPG lamps, flashlights with 1.5V batteries or candles to light up the classes. In some cases no energy source was used, so no work could be done after dark.

Picture 2: School interior.



Picture 3: Scholar map in the Rural Community of Leona

In 2007, the MVP plans were to electrify 4 schools with a non-conventional and renewable energy source. Two options were considered: PV solar systems and generators. The objective was to provide energy to at least two classes. The energy system chosen was the PV solar system. Lighting can be provided by efficient bulbs that don't consume too much energy.

The schools were selected by the education coordinator. These schools were in Batlamine, Gabar, Thiowor and Sague Sathiel. At present, there are six electrified schools in the cluster. Two of them are connected to the grid, and four of them use a PV solar system.

Location	Energy system	Electrified Classes/Total classes	Maximum Power subscribed (kW)
Leona	Grid	1/8	0.957
Potou	Grid	1/7	Unknown*
Batlamine	PV solar system	3/3	75 Wc
Gabar	PV solar system	2/6	75 Wc
Thiowor	PV solar system	2/6	75 Wc
Sague Sathiel	PV solar system	2/4	75 Wc

Table 3: Electrified schools

* The director hasn't received the first electricity bill yet

4.1.1.1. PV Solar systems.

The specifications of the PV solar systems installed in these four schools are as follows:

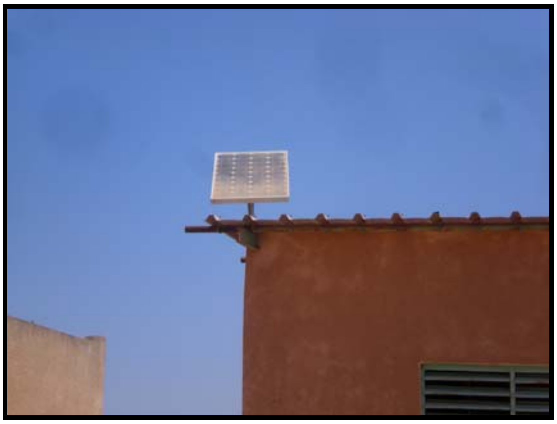
- 1 PV module, 75Wc Isofoton.
- 1 module support.
- 1 charge controller 10A -12V / 24V Phocos.
- 1 solar battery, 100Ah / 12V Tudor Enersol.
- Bulbs 7W / 12V Phocos.
- Wires and accessories.
- Accessories, including 2 power points, 1 grounding post, 1 box for the battery, 2 fuses and 2 switches.

There are no class activities at the school during the night. The light provided by the PV solar systems is used by the teachers or directors that live in the school to correct exams or to prepare the classes.

Picture 4: Charge Controller

Picture 5: Battery

The charge controller protects the battery from being overcharged by the solar array and from being deep discharged by the loads. The battery is a lead acid battery with liquid electrolyte.



Picture 6: PV Solar module, 75Wc

Picture 7: Bulb, 7W

The bulbs used to illuminate the classes are 7W energy efficient bulbs.

Picture 8: Battery and charge controller

The PV solar systems installed in the four schools electrified by the MVP have the same specifications.

The PV solar systems were put in place a few months ago. The first one, in Gabar, started to run in November 2008. There are no operation or transport costs, as the energy is provided by the sun. Only the acquisition costs were relevant, but they were paid by the MVP. At present the systems are under warranty, so there are no maintenance costs yet. Once the warranty expires, the MVP will consider two options. The first one is to create an annual or a three year-term maintenance contract with the provider of the solar systems. This option guarantees the correct maintenance of the system, because the provider knows the components and how they function. Also, the provider has an easy access to spare components. The second option is to sign a contract with a technician who lives in the cluster and specializes in solar energy. This solution is generally less expensive than the first one, but it has the inconveniences of a difficulty in obtaining spare components, as well as the possible lack of technical skills of local electricians. This is why the energy coordinator would like to train some electricians around the cluster so that they would be able to perform the maintenance of all the solar systems installed in the region. This training would include a one week course in Dakar and the acquisition of a tool box with all the elements necessary to make all the reparations. At present, no repairs have been needed for the solar systems installed in the schools. Nevertheless, the energy coordinator has made a couple of visits with a technician to check the conservation of the system and its functioning.

The teachers and directors are very satisfied with the functioning of the PV solar systems provided by the MVP. They don't have any complaints on the operation of the system and they are satisfied with the maintenance service provided so far. Thus far, they have not had energy blackouts or brownouts with the PV systems. These energy cuts might happen during the winter season, when the rain falls. The winter season goes from July to October. The systems are in place since November, which means that the probability of suffering energy cuts since they were put in place was low. The schools don't have an emergency system in case the solar system stops working. If this happens, teachers and directors have flashlights to get some light in the room. They use flashlights most often while walking to the toilets, which are outside the building. Those toilets are not electrified, and neither is the court. The consumption depends on the school, and goes from the 2 batteries/month in Thiowor to the 16 batteries/month in Sague Sathyel, which represents 400F CFA-3,200F CFA (≈0.8-6.4$).

The grid has already arrived to Thiowor. The director of the school has already asked SENELEC to get connected up to the grid. As soon as this connection is done, the solar system will be taken to another school.

4.1.1.2. <u>Schools connected to the grid.</u>

There are only two schools that are connected to the grid, as can be seen in table 2. These schools are in Leona and in Potou. These villages are the main villages in the cluster and have been electrified since 2007, although their schools were not electrified until January 2009.

Picture 9: School at Potou

The maximum power subscribed is 0.957kW in the Leona school (possibly the same power subscribed in Potou). There is a big difference in energy uses between these two schools. In Leona, only one class and the lodging need energy for lighting, but in Potou there are five computers and one room (the director's office) that need energy. The computers are only used during school hours. In both cases most of the classes aren't electrified, which is the main complaint of the directors because they can't use bulbs to light the rooms or use other equipment as audiovisuals. None of the schools have adademic activities during the night. In Leona only one bill has been paid. The consumption was very low (1kWh/2 months, ≈1,000F

CFA). Only one small bulb was being used during the night. No bill has been paid in Potou yet, but because of the utilization of computers, it is expected to be much higher than the one of Leona.

Picture 10: 36W neon tube, in Potou

Picture 11: 7W bulb in Potou

Picture 12: Small bulb in Leona

The light is provided by 7W efficient bulbs, 36W neon tubes and other small bulbs.

Picture 13: Computers in Potou

There are 5 computers in Potou. They are made up of a monitor (100-240V; 1.5A; 50/60Hz), a CPU (100-240V; 3.6A; 50/60 Hz) and an inverter.

Picture 14: Connection in Potou

Picture 15: Connection in Leona

The connection to the grid was performed by ASER who paid all costs involved.

The teachers and directors are very satisfied with the electricity provided by the grid. They don't have any complaints on the operation of the system and they are satisfied with the maintenance service provided so far. This maintenance is performed by an electrician from the cluster, although a SENELEC technician can be called to make some repairs. For the first repair, there will be a cost involved, but the second service call will be free of charge. Only in Leona, the teacher interviewed mentioned that they suffer energy cuts. These energy cuts are not frequent (about 2 blackouts in three months) and last for about 45 minutes. If this happens, teachers in Leona have flashlights to get some light in the room. There aren't any emergency systems in Potou. So far, minimal problems have occurred with the systems, so the consumption of batteries is very low.

4.1.1.3. Conclusions

In 2007, the MVP plans were to electrify four schools with a non conventional and renewable energy source. The energy system chosen was the PV solar system. When the villages where these PV solar systems were installed eventually gained access to the grid, the solar systems would be taken to other schools. Plans were made to bring those solar systems to four other schools in 2009. In April 2009, the four schools pointed by the education coordinator were electrified with a PV solar system. In one of them (Thiowor) the grid will be soon available, so the solar system will be taken to another school.

The benefits obtained with the utilization of an energy system at these schools are evident. The light provided by bulbs and neon tubes is much brighter than the light provided by candles and LPG lamps. This improves the visual health of pupils, teachers and directors. In some of the schools the teachers and directors use one classroom as lodging. Electricity provided by the grid or a PV solar system allows them to work during the night, correcting exercises and preparing new classes. Energy access also allows the use of computers, as in Potou. Another consequence of these autonomous energy systems is that the consumption of other energy sources, like batteries or LPG canisters, has dropped.

The education employees are satisfied with the energy provided by both systems. They are also satisfied with their maintenance service, although thus far they have not needed much. It is still not easy to find skilled electricians in the cluster, so it would be a good idea to train some local workers to maintain the PV systems. This maintenance service is assured in those schools connected to the grid by the technicians of SENELEC.

Directors and teachers from schools where a PV solar system has been installed would like to have access to the electricity provided by the grid. The reason is that they would like to be able to use other equipment such as computers or audiovisuals to improve the quality of the classes. The problem remains that the grid hasn't arrived to most of these villages. Only in Thiowor the grid is available, and although the school has not been connected yet, connection is imminent. In Potou, the director would like to have an emergency system, such as a generator, just in case there is an energy cut. Another request of the education agents is the electrification of every class in the school and of the toilets. In two cases, they would be interested in building lodging for the teachers or directors. These buildings should also be electrified. It would be like the lodging of the medical staff in the health centers of the community.

Some questions can be formulated:

- Do the teachers/directors live in the schools because they have electricity?
- Is it necessary to electrify all the classes?
- Is it necessary to electrify the toilets?
- Is it helpful to build a lodgment and electrify it for the teachers/directors?
- The grid has not arrived to many of the villages of the cluster, even though plans have already been made. In the mean time, is it worth it to get more PV solar systems for more schools?
- If the project finishes, who will bring the solar systems to other schools if the grid has not already arrived there?
- Should agents be trained in basic solar system maintenance?
- If the grid has not arrived to all the villages when the project will be over, who will pay for the continued maintenance of the solar systems?
- Is it necessary to train one/some electricians of the cluster in solar systems maintenance?

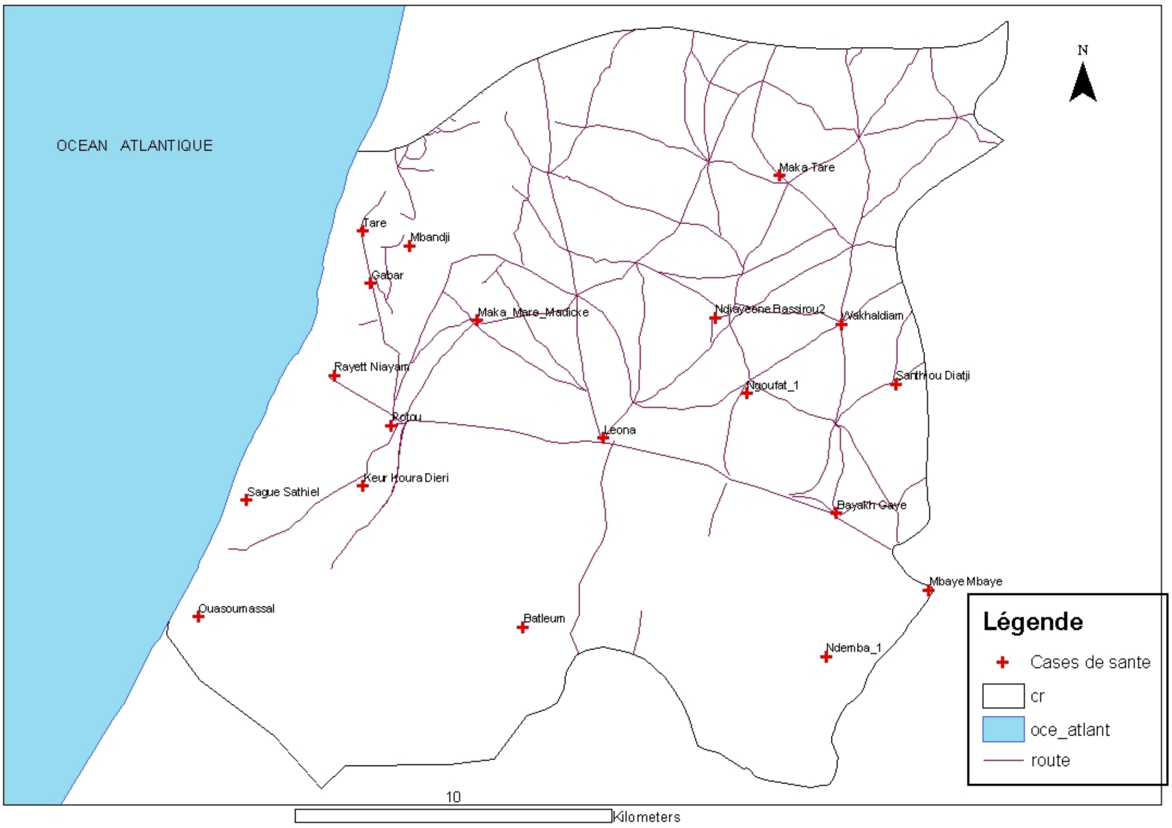
4.1.2. Health centers.

Health Centers at the Rural Community are of different kinds and sizes. They are composed of one or many buildings, with a metallic roof, and there are many rooms. There are two types of health centers: “Posts” and “Cases”. The Posts are in the main villages and provide more services than the Cases. For instance, there are several buildings (one of them is lodging for the nurse in charge of the Post), and medical equipment like refrigerators or sterilizers can be found there. There is a water filter in each Post, installed by GM, that also needs energy, even though they cannot be used right now because of a technical problem not allowing them to work properly. Some of the Posts have a maternity ward. One or many health agents live in the Post, and there are beds to provide continuous care to those who are seriously ill. The Cases are smaller, and their main function is to help women to deliver and to provide basic assistance (basic diagnoses, first aid services, etc.). In these Cases, lighting is the only service that requires energy. Two health agents are present at any time. They both live in the same village as the Case but not inside it. Activities in these buildings can be planned for any time of the day or night, depending on the needs of the population.

Picture 16: Post at Leona.

Picture 17: Case at Ouassoum Assal

In 2006, at the beginning of the Project, there were 19 health centers (1 Post and 18 Cases) in the cluster, and only five of them (Post at Leona and Cases at Gabar, Maka Tare, Santhiou Diatji and Keur Koura Dieri) were electrified with a PV solar system. All but Leona had a PV solar system installed by AFDS. The main reason is the long distance between these buildings and the existing grid, which makes the costs unaffordable for the community. No autonomous energy system was employed in the rest of the health centers. Services requiring lighting, especially during the night, include use of medical equipment such as refrigerators to conserve vaccines and sterilizers and operating other devices such as fans and computers. Before the installation of these autonomous energy systems, lighting was the only service that could be provided in the health centers. The energy was provided by a solar system in five Cases, and by LPG lamps, flashlights with 1.5V batteries and candles to light the rooms. In some cases no energy source was used, so no work could be done after dark.



Picture 18: Health centers map in the Rural Community of Leona

In 2007, the MVP plans were to electrify 3 Posts and 4 Cases with a non conventional and renewable energy source. The cases would be electrified with a PV solar system, while the Posts would be electrified with a hybrid system composed by a PV solar system and a generator. The objective is to provide energy for lighting, use of medical equipment, audiovisuals and fans in the Posts and Cases. At the present time, only PV solar systems have been provided to the health centers. There are no generators. Lighting can be provided by efficient bulbs that do not consume too much energy.

Every Post built by the MVP is divided in two buildings, the Post (where health care is given) and the lodging for the nurse. Each Post will have three independent PV solar systems:

- One for the Post (lighting, medical equipment, fans, etc.)
- One for the refrigerator (vaccine conservation)
- One for the lodging (lighting and audiovisuals)

The health centers were selected by the health coordinator. These clinics were in Sague Sathiel, Syer Peulh, Ndialakhar Samb, Batlamine, Ndemba, Thiolome Fall and Ouassam Assal.

At present, there are twelve electrified health centers in the cluster. Two of them are connected to the grid, and ten of them use a PV solar system.

Location	Energy system	Type	Maximum Power subscribed
Leona	Grid	Post	5.742kW
Potou	Grid	Post	5.742kW + 0.957kW
Sague Sathiel	MVP solar system	Post	225Wc + 300Wc + 300Wc
Syer Peulh	MVP solar system	Post	225Wc + 300Wc + 300Wc
Ndialakhar Samb	MVP solar system	Post	225Wc + 300Wc + 300Wc
Batlamine	MVP solar system	Case	225Wc
Ndemba	MVP solar system	Case	225Wc
Ouassam Assal	MVP solar system	Case	225Wc
Gabar	AFDS solar system	Case	300Wc
Keur Koura Dieri	AFDS solar system	Case	300Wc
Maka Tare	AFDS solar system	Case	300Wc
Santhiou Diatji	AFDS solar system	Case	300Wc

Table 4: Electrified health centers

In Potou there are two different bills, one for the Post and another one for the lodgingt. Four Cases were already electrified by AFDS. These PV solar systems were installed at the same time that the building was built. The MVP also built the buildings of the three Posts electrified with a PV solar system.

4.1.2.1. PV Solar systems.

The specifications of the PV solar systems installed by the MVP in the Posts are as follows:

Post:

- 3 PV module, 75Wc Isofoton.
- 1 module support.
- 1 charge controller 30A -12V / 24V Phocos.
- 1 Inverter sinus 350W-12V/240V Victron energy.
- 3 solar batteries, 100Ah / 12V Tudor Enersol.
- Bulbs 7-11W / 12-220V Phocos.
- Wires and accessories.
- Accessories, including 3 power points, 1 grounding post, 3 boxes for the batteries, 9 fuses and 9 switches.

Picture 19: Post at Syer Peulh.

Picture 20: Inverter.

Picture 21: Bulb

The bulbs used to provide light are 7-11W energy efficient bulbs.

Picture 22: Water filter in Sague Sathiel

Refrigerator:

- 4 PV module, 75Wc Isofoton.
- 1 module support.
- 1 charge controller 30A -12V / 24V Phocos.
- 3 solar batteries, 100Ah / 12V Tudor Enersol.
- Wires and accessories.
- Refrigerator TWC 3000 DC, 163 liters, 12V/24V.

Picture 23: Refrigerator

Lodgment:

- 4 PV module, 75Wc Isofoton.
- 1 module support.
- 1 charge controller 30A -12V / 24V Phocos.
- 1 Inverter sinus 350W-12V/240V Victron energy.
- 4 solar batteries, 100Ah / 12V Tudor Enersol.
- Bulbs 7-11W / 12-220V Phocos.
- Wires and accessories.
- Accessories, including 2 power points, 1 grounding post, 4 boxes for the batteries, 8 fuses and 8 switches.

Picture 24: Lodgment in Sague Sathyel

Picture 25: Batteries

Picture 26: Inverter and controller

The specifications of the PV solar systems installed by the MVP in the Cases are as follows:

- 3 PV module, 75Wc Isofoton.
- 1 module support.
- 1 charge controller 30A -12V / 24V Phocos.
- 1 Inverter sinus 350W-12V/240V Victron energy.
- 2 solar batteries, 100Ah / 12V Tudor Enersol.
- Bulbs 7-11W / 12V Phocos.
- Wires and accessories.
- Accessories, including 2 power points, 1 grounding post, 2 boxes for the batteries, 5-7 fuses and 5-7 switches.

Picture 27: 7W Bulb in cases

Picture 28: Solar modules in Ouassam Assal Case

Picture 29: Batteries, Inverter and Controller

The MVP PV solar systems were put in place in 2008. There are no operation or transport costs, as the energy is provided by the sun. Only the acquisition costs were relevant, but they were paid by the MVP. Like the solar systems described in the previous section (schools), the systems are under warranty, so there are no maintenance costs yet. At present, no repairs have been needed in the solar systems installed in the health centers. Nevertheless, the energy coordinator has made a couple of visits with a technician to check the conservation of the systems and their functioning.

The health agents are very satisfied with the functioning of the PV solar systems provided by the MVP. They don't have any complaints about the operation of the system, and they are satisfied with the maintenance service provided so far. Only three of the Posts have suffered from energy cuts. These energy cuts might happen more during the winter season, when the rains come, from July to October. These energy cuts are generally caused by a lack of sunlight, and in one case because of an excess in the use of energy in the lodging. Most of the clinics have an emergency system in case the solar system stops working, but it will only provide light, so the medical equipment cannot be used. The different emergency systems are LPG lamps and flashlights with 1.5V batteries. The consumption depends on the demand of the patients, and is between 2-4 batteries/month 400F CFA-1,200F CFA (≈0.8-2.4$).

The specifications of the PV solar systems installed by the AFDS in the Cases are as follows:

- 1 PV module, 300Wc.
- 1 module support.
- 1 charge indicator 300W/30A Oscar.
- 1-3 solar batteries, 100Ah / 12V.
- Bulbs and neon tubes.
- Wires and accessories.
- Accessories, including power points, grounding post, fuses and switches.

Picture 30: Charge indicator

Picture 31: Battery

Picture 32: Batteries and controller

Picture 33: PV solar module

Picture 34: Bulb

These PV solar systems were installed a few years ago, at the same time that the Case was built. The oldest one is from 2003. There are no operation or transport costs, as the energy is provided by the sun. Only the acquisition costs were relevant, but they were paid by the AFDS. At present, none of the systems work correctly. Either the batteries get discharged after a couple of hours working, or they make strange noises. Besides, they do not provide enough energy to light more than one bulb at the same time. In one Case, in Keur Koura Dieri, the system does not work at all. When the AFDS finished the installation of the systems, they left some money that would be used for paying the maintenance of these systems. There was one electrician from Louga who was in charge of this service. But the money left by the AFDS has already been spent, and since then no maintenance service has been done. This might be the reason why the systems don't work correctly. As a matter of fact, the health agents are not even doing any basic maintenance service, because in two cases bird excrement could be seen all over the batteries and the charge indicator.

The health agents are not satisfied at all with the functioning of the systems provided by the AFDS. As stated before, they simply do not work properly, suffering from a lot of energy cuts. These energy cuts might happen more during the winter season, when the rain falls, but they regularly suffer from energy cuts because of the malfunctioning of the systems. These Cases have many emergency systems in case the solar system stops working. If this happens, they have LPG lamps, petrol lamps, flashlights with 1.5V batteries and candles to get some light in the room. The consumption depends on the clinic, but is much higher than in health centers with a solar system provided by the MVP or with a connection to the grid. The costs are in between 1.500F CFA/month and 6,000F CFA/month (3-12$), depending on the energy source used.

4.1.2.2. Health centers connected to the grid.

There are only two Posts that are connected to the Grid, as can be seen in table 3. These Posts are in Leona and in Potou. These villages are the main villages in the Cluster, and are electrified since 2007. The Post in Leona was electrified in 2007, while the Post in Potou was electrified in 2008, when the building was built.

Picture 35: Post at Potou

The maximum power subscribed is 5.742kW in both Posts, and in Potou there is another meter for the lodging. The maximum power subscribed in that case is 0.957kW. The consumption every two months in these two centers is in between 525-600kWh, which represents more than 90,000F CFA every two months (≈180$). Leona's clinic is the bigger health center in the Community, and has more medical equipment than any other clinic. No transportation fees are paid to get the electricity.

The connection to the grid was performed by ASER. The costs were paid by different NGO's and Community Associations in both cases.

The health agents are satisfied with the electricity provided by the grid. They don't have any complaints about the operation of the system and they are satisfied with the maintenance service provided so far. This maintenance will be done by an electrician from the cluster, even though it is possible for a SENELEC technician to be called to make some repairs. In any case, there will be any cost involved for the clinic, because all the services will be paid by different NGO's or Community Associations. The only problems with the energy system so far are caused by the energy cuts. Leona's nurse would like to have a better emergency system than flashlights or candles to work while those blackouts occur. He is very concerned about the possibility of suffering an energy cut in the middle of a serious intervention. This could result in serious problems for the patient. These energy cuts are quite frequent (about once a week in Leona, twice a month in Potou) and last for about 45 minutes. When an energy cut happens, the only service that can be used is lighting with flashlights. He would like to complement the electricity from the grid with a solar system or a generator. As a matter of fact, there is a generator in the clinic, but he does not know if he can use it because it belongs to those who built the structure to put the water filter in place. There is no emergency system in Potou. No medical equipment can be used while a blackout happens. The consumption of batteries in Leona is 4 batteries every month, which represents 700F CFA/month (≈1.4$).

4.1.2.3. Conclusions.

In 2007, the MVP plans were to electrify three Posts and four Cases with a non conventional and renewable energy source. The energy system chosen was the PV solar system. Once the villages where these PV solar systems were installed had access to the grid, the solar systems would be taken to other schools. In April 2009, the three Posts and three of the Cases pointed by the health coordinator were electrified with a PV solar system. One of the Cases (Thiolome Fall) was being built at the moment of the visit, so the objectives have almost been accomplished.

The benefits obtained with the use of an energy system at these health centers are evident. The light provided by bulbs and neon tubes is much brighter than the light provided by candles and LPG lamps. This improves the work of health agents, especially when there is an emergency during the night. Electricity provided by the grid or a PV solar system allows them to work during the night. The use of medical equipment like refrigerators to conserve the vaccines and sterilizers is another evident benefit of the use of electricity. This avoids people having to go to Leona or Potou to get basic health care. Another consequence of these autonomous energy systems is that the consumption of other energy sources, like batteries or LPG canisters, has dramatically decreased. The costs of emergency systems, such as batteries or LPG in the Cases where the solar systems have been installed by the AFDS, are much higher than the costs of emergency systems in the rest of Health centers that are electrified (400-1,200F CFA to 1,500-6,000F CFA every month).

Most of the health agents are satisfied with the energy provided by both systems, and are also satisfied with their maintenance service. The only systems with problems are the ones installed by the AFDS. In those cases, the health agents are not satisfied at all with nor the conservation nor the maintenance of the systems. They suffer of frequent energy cuts that avoid them from working during the night. As said before in the schools section, it is not easy to find skilled electricians in the cluster, so it would be a good idea to train some of them to perform the maintenance service for those health centers with a PV solar system. This maintenance service is assured in those Posts connected to the grid by the technicians of SENELEC.

Health agents from clinics where a PV solar system has been installed would like to have access to the electricity provided by the grid. Again, the reason is that they would like to be able to use other equipment such as refrigerators and sterilizers. Audiovisuals and fans are also desired by the health agents. The problem is that grid access has not arrived in most of these villages. Only in Leona and Potou the grid is available. In Leona, the nurse would like to have an emergency system, like a generator or a solar system, just in case there is an energy cut. Another reason would be to reduce the electricity bill, because he thinks that electricity is very expensive. Some of the Posts would also like to have an emergency system, because they are very concerned about the possibility of suffering an energy cut during an emergency situation.

Questions can be formulated:

- Access to the grid has not arrived in many of the villages of the cluster, even though plans have already been made. In the mean time, is it worth it to get more PV solar systems for more schools?
- Is it really necessary to replace the solar systems installed by the AFDS?
- Can these Cases wait until the grid arrives to these villages (or to other villages which Cases/Posts have a solar system provided by the MVP)?
- Should agents be trained in basic solar system maintenance?
- If the grid has not arrived to all the villages when the project will be over, who will pay for the maintenance of the remaining solar systems?
- If the project finishes, who will bring the solar systems to other clinics if the grid has not already arrived there?
- Is it necessary to train one/some electricians of the Cluster in solar systems maintenance?

4.1.3. Other public buildings.

There are other public buildings in the Cluster. A few of them are electrified but most of them are not. The electrified ones exist only in Leona and Potou, where the grid has already arrived. A major reason to electrify these buildings in villages is their importance as Community Centers.

The surveys were conducted in the Rural Council in Leona, the stock-farmers house in Leona, the Familial house in Potou and the Fishing Post in Niayam. In most of these buildings, the main energy needs are for lighting and using audiovisuals and computers. Lighting is only needed during the night, while the computers and audiovisuals are needed during the whole day. Before these buildings could use electricity as energy source, the workers used petrol lamps and candles to put some light in the rooms.

The MVP plans in 2007 related to public buildings (besides schools and clinics) were to provide a PV solar system and a generator to the Fishing Post in Niayam for the use of micro-computers, light points and fans. The generator would provide energy to the micro-computers while the solar system would provide energy to the rest of the equipment. As can be seen in table 4, only a PV solar system has been provided to the Fishing Post. No micro-computers are being used in the Fishing Post. Also, it was planned to build two Multimedia Centers (CMC) in Leona and Potou. The one in Leona has already been built, but it is not working because the computers haven’t arrived yet. The building is behind the Rural Council building and it will be connected to the grid once the computers are available. The electric installation has already been made. The CMC in Potou has not been built yet.

Building	Location	Energy system	Maximum Power subscribed
Rural Council	Leona	Grid	0.957kW
Stock-farmers house	Leona	-	-
Familial house	Potou	Grid	0.957kW
Fishing Post	Niayam	MVP solar system	150Wc
CMC	Leona	Will be grid	-
CMC	Potou	Not built yet	-

Table 5: Public buildings considered

Picture 36: Stock-farmers house in Leona

Picture 37: Rural Council in Leona

The Rural Council and the Familial house are connected to the grid. The Fishing Post is electrified with a PV solar system provided by the MVP. The Stock-farmers House is not electrified at all and uses flashlights with 1.5V batteries and candles to light the room. The CMC's are not working yet.

The specifications of the PV solar system installed by the MVP in the Fishing Post are as follows:

- 2 PV module, 75Wc Isofoton.
- 1 module support.
- 1 charge controller 20A -12V / 24V Phocos.
- 1 Inverter sinus 350W-12V/240V Victron energy.
- 2 solar batteries, 100Ah / 12V Tudor Enersol.
- Bulbs 7-11W / 12V Phocos.
- Wires and accessories.
- Accessories, including 2 power points, 1 grounding post, 2 boxes for the batteries, 9 fuses and 9 switches.

Picture 38: Batteries in the Fishing Post

Picture 39: PV solar modules in the Fishing Post

Picture 40: Batteries, inverter and controller in the Fishing Post

The energy consumption in these buildings depends on the energy system used.

Building	System	Consumption	Costs /2months	Provider	Year
Rural council	Grid	≈70kWh	8-10,000F CFA	SENELEC	2006
Stock-farmers house	1.5V Batteries Candles	4 batteries/month 8 candles/month	1,600F CFA 4,000F CFA	Shops	-
Family house	Grid	≈200kWh	23-25,000F CFA	SENELEC	2006
Fisehermen's house	PV solar system	-	-	MVP	2008

Table 6: Energy consumption in public buildings

The maximum power subscribed in both Rural Council and Family house is 0.957kW. The consumption every two months in these two centers is very different. While the consumption at the Rural Council is around 70kWh every two months, at the Family house it is around 200kWh every two months. These two consumptions represent 9,000F CFA and 24,000F CFA every two months respectively. Consumption at the Family house is higher because there are more activities than at the Rural Council. Family house activities occur during the whole day, while at the Rural Council there are activities only during eight hours each weekday. As a matter of fact, the manager of the Family house got rid of a refrigerator because the electricity bill was very elevated. No transportation fees are paid to get the electricity.

The MVP PV solar system was put in place in September 2008. There are no operation or transport costs, as the energy is provided by the sun. Only the acquisition costs were relevant, but they were paid by the MVP. Like the solar systems described in the previous section (schools), the systems are under warranty, so there are no maintenance costs yet. At present no repairs have been needed for the solar system installed in the Fishing Post. Nevertheless, the energy coordinator has made a couple of visits with a technician to check the conservation of the systems and its functioning. The Fishing post representative would like to get access to the grid, because he wants to be able to use more equipment to improve the work conditions at the building. If they had electricity from the grid, they would be able to use warning lights, UHF radios, computers and printers. This would be helpful since currently, if he needs to print a document, he must go to Louga and use the equipment of the MVP office. This makes him lose time (1-hour trip) and money (fuel for the motorbike).

The representatives at the Rural Council and the Family House are satisfied with the electricity provided by the grid. They don't have any complaints about the operation of the system and they are satisfied with the maintenance service provided so far. This maintenance is done by an electrician from the cluster, even though sometimes a SENELEC technician is called to make some repairs. In that case, there will be no cost. The electrician costs depend on the problem, but they go from 2,500F CFA to 15,000F CFA. In both cases the representatives mentioned that it is not easy to find skilled electricians in the Cluster. They must call an electrician from Louga, meaning that they usually have to wait at least a couple of days, sometimes even more. Nevertheless, they are satisfied with the maintenance service. The only problems with the energy system are caused by the energy cuts. These energy cuts are more frequent and last longer in Leona than in Potou. When there is a blackout, no work can be done in the Rural Council, while in the Family House it is only a problem if it happens during the night. In that case, the only service that can be used is lighting with flashlights. The consumption of batteries in this building is 4 batteries every month, which represents 600F CFA/month (≈1.2$).

4.1.3.1. Conclusions.

In 2007, the MVP plans were to electrify the Fishing Post and two Multimedia Centers. The energy system chosen was the PV solar system in the Fishing Post, and the grid in the CMC's. Once the village where this PV solar system was installed had access to the grid, the solar system would be employed to provide energy to a warning light that would be very useful to the fishermen. In April 2009, the Fishing Post was electrified with a PV solar system. The CMC's are not working yet. The one in Leona has already been built and the electric installation has already been made, but it is not working yet because there are no computers. The CMC in Potou hasn't been built yet.

The benefits obtained with the utilization of an energy system at these buildings are evident. The light provided by bulbs and neon tubes is much brighter than the light provided by candles and LPG lamps. Electricity provided by the grid or a PV solar system allows them to work during the night. The use of computers and printers is another benefit of using electricity. Only in the Family House in Potou there are flashlights as an emergency system in case of energy cuts.

All the representatives interviewed are satisfied with the energy provided by both systems, and are also satisfied with their maintenance service. Only the representative of the Stock-farmers house is not satisfied with what they have. The frequency of energy cuts in the buildings where the energy is provided by the grid is between once and twice every month. As said before in the schools point, it's not easy to find skilled electricians in the Cluster, so it would be a good idea to train some of them, so that they could do the maintenance service.

Representatives from the Fishing Post and the Stock-farmers house would like to have access to the electricity provided by the grid to be able to use other equipments, like computers, bulbs and radios. In Niayam, where the fishing Post has been established, the grid has not arrived yet. The Stock-farmers council is debating if it is really necessary to get connected to the grid. If they decide to get connected, they will not have problems since the grid is already available in Leona and the buildings that surround them are already branched.

4.2. Energy systems in Shops.

4.2.1. Use of energy in shops.

There are two main economic centers in the Cluster: Leona and Potou. The weekly market in these villages (Mondays in Leona, Tuesdays in Potou) is a main attraction for all the residents of the Cluster. The most important is the one in Potou. The dynamism of the trade in these villages has made possible the presence of many shops and stores. In these main villages many kinds of shops can be found (clothes shop, convenience shop, agricultural products, metallic workshops, etc.). In the rest of the cluster, the villages have a very small number of shops, if any, and they are always convenience stores where different products are sold (edibles, cleaning products for the house, batteries, etc.).

The surveys were conducted at 14 shops in different villages of the cluster. Most of them are in Potou and Leona, and are convenience stores. Most of the shops in these two villages use electricity from the grid, while the rest of the shops, in villages where the grid has not arrived yet, use LPG as the main energy source for lighting the room. There are several services that require energy in these shops. Lighting, refrigerators, audiovisuals, fans and work equipment are the most important. Bulbs, neon tubes and LPG lamps are turned on during the night. Refrigerators work only when there are drinks available. In Thiowor, the refrigerators run on LPG. Work equipment like battery chargers or polishers only run when needed, and audiovisuals are turned on all day. Fans are turned on only during the warmer hours.

Picture 41: Convenience store in Leona

Picture 42: LPG lamp

Village	Type of shop	Energy source
Gabar	Convenience store 1	LPG

Gabar	Convenience store 2	LPG
Leona	Convenience store 1	Electricity from the grid
Leona	Sewing workshop	Electricity from the grid
Leona	Repair workshop	Electricity from the grid
Leona	Pharmacy	Electricity from the grid, PV solar system and generator
Potou	Convenience store 1	Electricity from the grid
Potou	Fertilizers and seeds	Electricity from the grid
Potou	Convenience store 3	Electricity from the grid
Potou	Mechanic workshop	Electricity from the grid
Tare	Convenience store 1	LPG
Tare	Convenience store 2	LPG
Thiowor	Convenience store 1	LPG
Thiowor	Convenience store 2	Electricity from the grid

Table 7: Shops and stores where the surveys were conducted.

The grid has only arrived in Leona, Thiowor and Potou. In Thiowor, shops do not have access to the grid yet, because the priority for the SENELEC is to connect all the households first. Once they finish connecting the households, they will start connecting the shops, school and mosque. The second convenience store in Thiowor can use electricity from the grid because it is using the connection from the house where it belongs. All the shops in Leona and Potou, where the surveys were conducted, are connected to the grid, and most of them have their own electricity meter. In two cases, the shop gets the electricity from a connection out of the shop (usually their neighbor). But the owners have an agreement with the "provider" and share the energy costs. In both cases, the owners have requested the SENELEC to get their own electricity meter.

Location	**Type**	**Energy system**	**Maximum Power subscribed**	**Consumption (bimester)**	**Costs F CFA (Bimester)**

Gabar	Convenience store 1	LPG canister (6kg)	-	6 bottles	21,000F (3,500/bottle)
Gabar	Convenience store 2	LPG canister (6kg)	-	4 bottles	11,200F (2,800/bottle)
Leona	Convenience store 1	Electricity from the grid	0.957 kW	≈20kWh	≈4,500F
Leona	Sewing workshop	Electricity from the grid	Unknown(1)	Unknown(1)	≈8-10,000F
Leona	Repair workshop	Electricity from the grid	2.871 kW	≥ 105kWh	≈20-40,000F
Leona	Pharmacy(2)	Electricity from the grid, PV solar system and generator	Grid: unknown Solar system: unknown Generator: 2.8kW	≈240 l unleaded fuel	≈120,000F
Potou	Convenience store 1	Electricity from the grid	0.957 kW	≥ 145kWh	≈35,000F
Potou	Fertilizers and seeds	Electricity from the grid	Unknown(1)	Unknown(1)	≈5,000F
Potou	Convenience store 3	Electricity from the grid	0.957 kW	≈330kWh	≈57,000
Potou	Mechanic workshop	Electricity from the grid	0.957 kW	≈133kWh	≈26,000
Tare	Convenience store 1	LPG canister (6kg)	-	4 bottles	12,000F (3,000/bottle)
Tare	Convenience store 2	LPG canister (6kg)	-	Unknown(3)	Unknown
Thiowor	Convenience store 1	LPG canister (3 and 6kg)	-	4 bottles (6kg) 2 bottles (3kg)	11,200F (2,800/bottle 6kg) 2,800F (1,400/bottle 3kg)
Thiowor	Convenience store 2	Electricity from the grid and LPG (6kg)	Unknown(1)	Unknown(1) 2 bottles (6kg)	Unknown(1) 5,800F (2,800F/bottle)

Table 8: Energy sources consumption and costs.

(1)These are the shops that don't have an electricity meter, so they do not get an electricity bill every 2 months. Even though they do not get a bill, they pay for the electricity spent. They have an agreement with the legal owner of the electricity meter, who is the one that actually receives the bill.
(2)The owner of the pharmacy does not know the power of the solar system or the maximum power subscribed from the grid.
(3)The owner of this shop does not know the exact consumption of LPG or the price he pays.

The shops that are connected to the grid do not have to pay transport fees to get the energy. Only the shops in Gabar and the pharmacy in Leona have transportation fees. These fees are in between 500F CFA and 1,000F CFA every 10-15 days. The shops in Thiowor and Tare sell

LPG canisters, so whenever they need a bottle, they just take one. They do not pay any transportation fees to get the LPG canisters.


Picture 43: Electric Installation inside a shop


Picture 44: Electricity meter


Picture 45: Bulb in a shop in Thiowor


Picture 46: Refrigerator that runs on LPG

The energy systems used before the arrival of the grid to the villages were LPG canisters, flashlights and candles. In one case, there was a solar system, and in another case a generator. In the mechanic workshop coal was used to heat the metal. In the rest of the villages, the energy source hasn't changed at all. They have always used LPG canisters as the main energy source.

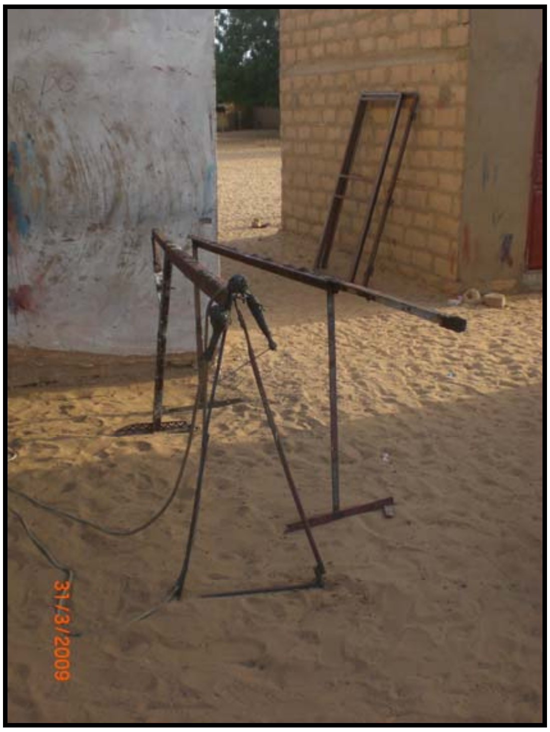
The benefits obtained with the utilization of an energy system at these buildings are evident. The light provided by bulbs and neon tubes is much brighter than the light provided by candles and LPG lamps. The electricity allows the easier utilization of refrigerators, freezers and other work devices like polishers, electric sewing machines and battery chargers which couldn't be used before. In villages where the grid hasn't arrived yet, there are refrigerators that run on LPG, but their maintenance is more complicated than for the refrigerators that run on electricity. Electricity from the grid is more useful, easier and safer than the old energy sources used.

Picture 47: Battery chargers in Potou

Picture 48: Electric sewing machine

To get connected to the grid, the shop owners had to make a demand to the SENELEC. Then, they had to pay a caution of 20,000F CFA for the electricity meter.

All the representatives interviewed are satisfied with the energy provided by the grid. A couple of them think that electricity is very expensive, but they are the ones who use high consuming devices as battery chargers or freezers. Owners of shops located where the grid has not arrived yet are satisfied with the LPG lamps, but they would like to be able to use the electricity from the grid or another system, like a PV solar system. The major problem is that either the grid has not arrived in the village and they do not have financial means to acquire another energy system. Most of the shop owners would like to use the electricity from the grid to expand their businesses and provide a higher number of services, like keeping cold drinks, or battery and mobile phone chargers. It would allow them to use bulbs or neon tubes to light the rooms and to use fans and audiovisuals.



Picture 49: Welding group

The owners of the shops have different emergency lighting systems in order to keep on working if an energy cut happens. In villages where the grid already exists, the different emergency systems are rechargeable lamps, flashlights (with 1.5V batteries) and candles. Lighting the room is the only service that can be covered by alternate methods when there is a blackout. These energy cuts are frequent (about a couple of times every month) and can last for at least a half an hour. In villages where the grid has not arrived yet, the emergency systems are flashlights (with 1.5V batteries) and candles. Sometimes there is a shortage of LPG in the region of Louga. These energy cuts can last for a week.

In shops that use electricity from the grid, the maintenance of the system is done by an electrician. There are electricians in Leona, Potou and Louga. The larger problem is that it is very difficult to find skilled electricians in the cluster. Whenever there is a problem, the owners call the electricians, so the service is done punctually. Nevertheless, most of the owners have not had any problem with the system yet, so they haven't required the services of an electrician yet. There is no maintenance service in the shops where LPG canisters are the main energy source. Whenever the lamp gets empty, they replace it with another one. When a lamp gets broken, they replace it with another. The lifespan of these lamps is about five years, and each lamp costs 6,000F CFA (≈12$).

4.2.2. Market survey.

All the convenience stores sell different energy sources, especially batteries and candles. The bigger ones also sell LPG canisters and a couple of them recharge batteries and sell fuel. The sales during the weekly markets in Leona and Potou are much higher than the sales during the rest of the week. During these days, a lot of temporary sale posts fill the streets of Leona and Potou. Most of them sell fish and farming products, but many sell small energy sources like candles and different kinds of batteries.

Source	Unit	Average/Unit	Range	Cheaper	Expensive
LPG	6kg bottle	2,860F CFA	2,750-3,000F	Shop Tare	Shop Tare
	3kg bottle	1.500F CFA	1,300-1,800F	Shop Leona	Shop Leona
Batteries	Hellessens RV20, 1.5V	210F CFA	200-250F	Market Potou	Shop Leona
	Hellessens R6, 1.5V	140F CFA	100-200F	Shop Tare	Shop Leona
	Royal AA, 1.5V	100F CFA	100F	Market potou	Shop Tare
	Royal AAA, 1.5V	105F CFA	50-200F	Shop Tare	Shop Leona
	Royal R20D	160F CFA	100-200F	Market Potou	Shop Thiowor
Candles	20 cm.	45F CFA	25-50F	Market Potou	Shop Gabar
	30 cm	130F CFA	100-150F	Shop Potou	Shop Leona
Battery charge	24h	1,000F CFA	1,000F	Shop Potou	Shop Potou
Fuel	Liter	640F CFA	580-800F	Shop Potou	Shop Potou
Diesel	Liter	491F CFA	491F	Shop Potou	
Mix	Liter	650F CFA	650F	Shop Potou	
Coal	Kg	250F CFA	250F	Particular Leona	
Wood	Char	7,500	7,000-8,000F	Particular Leona	

Table 9: Prices of the energy sources

The whole market survey can be seen in the APPENDIX III.

Picture 50: LPG canisters outside a shop in Potou

Picture 51: 6kg LPG canister

3 kg LPG canisters can only be found in Leona and Potou. The most common LPG canister is the 6 kg one, and can be found in many villages. The provider of the LPG canister is from Louga. Once a week, a truck with filled LPG canisters goes to the shops in the cluster and

exchanges them for empty bottles. The owner of the shop pays depending on the quantity of bottles exchanged.

Picture 52: Can used to measure coal

Picture 53: Coal wood

Picture 54: Wood

Picture 55: Char used to measure the wood

Energy sources like coal and wood were difficult to find. Only one particular store in Leona and one person in a temporary post sold them. I saw young girls in the fields collecting wood each day, but this is probably for domestic consumption, not for sale.

Picture 56: Temporary post in Potou

Picture 57: Battery for recharge

There were many temporary posts in Leona and Potou that sold batteries and candles. A few shops in these villages had a battery charger.

4.3. Importance of the grid in the cluster.

Electricity from the grid arrived to Leona and Potou in 2007. Since then:

- 92 households signed in to SENELEC in Leona
- 251 households signed in to SENELEC in Potou

This data is from august 2009.

Picture 58: Grid all over Potou

In Potou, almost every shop is connected to the grid and uses electricity to light their shops at night. Even very small shops (similar to temporary posts, but made of wood) use electricity from the grid. There are a couple of clothes shops that use two small neon tubes to provide light. They connect these neon tubes to a house nearby. An estimation of almost 95% of the shops that were open at night use electricity from the grid.

Picture 59: Electricity in a Potou shop

Picture 60: Electricity in a Potou shop

Picture 61: Neon tubes in a Potou shop

Picture 62: Luminous panel in Potou

There is not much light in the street. The only light comes from the shops. It is not easy to walk at night under these conditions. That is why a lot of people walk with flashlights (reason for high sales volume?). There are a few shops that still use LPG lamps to light the rooms, but they are a minority.

Picture 63: Obscurity in the streets of Potou

In Leona, only three shops were open at night. All of them used electricity from the grid as their energy source. The light in the street is bright enough to walk around without much problems of visibility.

The grid arrived to Thiowor in January 2009. Since then, 198 households asked the SENELEC to be connected. 97 have already been connected to the grid. Most of the households have asked for a connection, and those who are not connected yet have already done the installation. Therefore, the rest of the households will be connected very soon. The priority will be to connect every household. Once they are all connected, SENELEC will start to connect the shops, the school and the mosque.

Picture 64: Wire derivation in Thiowor

Picture 65: Pole installed for the connection to the grid

Picture 66: Grid in Thiowor

Picture 67: Grid in Thiowor

One of the consequences of the arrival of the grid to Thiowor is that the sales of batteries for flashlights and candles have dramatically decreased.

Picture 68: Household connection to the grid

In Thiowor there are some lights in the streets, which allow walking through them without visibility problems. A few people in Thiowor believe that there should be more information about the use of electricity. They think that it is a very good energy source, but also that it could be dangerous if people don't know how to manage the wires. As could be seen in the point before, people think that there are not skilled electricians in the cluster.

Picture 69: Lights in the streets of Thiowor

Picture 70: Lights in the streets of Thiowor

Currently, there are plans to bring the grid to Bayti Guèye, Sinthiou Diadji, Syer, Ndialakhar, Ndade, Keur Koura Déry, Sague Sathiel, Dao, Galdamel, Boundouwala, Niayam, Gabar, Ndiélègne, Taré, Mourel, Sam Ndiaye, N'Dieumb Fall and Ndiayène (Peulh, Wolof, Bassirou).

Questions can be formulated:

- Is it necessary to train one/some electricians of the cluster for the maintenance of the households?
- There is not much light in the streets of Potou. Perhaps it is caused by bad maintenance of the street lamps. Besides the expansion of the grid, should there be some investment in the maintenance of the existing street lamps?

4.4. Irrigation systems.

Agriculture is the most important economic sector in the cluster, even though in the last years, the rainfall has decreased, and the salinity of the soils have grown, which means that the soils have lost fertility. Agriculture requires a big quantity of water. Two different areas can be found in the cluster: the Dieri, where agriculture is rain fed, and the Niayes, where the shallow water table is employed. In the Dieri, the main crops are peanuts (Arachis hipogea), millet (Pennisetum glaucum) and cowpeas (Vigna unguiculata). In the Niayes, the main crops are onions (Allium cepa), tomatoes (Solanum lycopersicum), carrots (Daucus carrota), cabbages (Brassica oleracea) and eggplants (Solannum melongena). Onion is the chief crop of the area.


Picture 71: Onion field


Picture 72: Cabbage field

The surface of the fields in the Niayes is not bigger than 2ha, and most of them are smaller than 1ha.

One of the objectives of the trip was to study the different methods used to elevate the water table in the Niayes area. In this area two systems are used to elevate the water: manually and with a small sized motor pump (2-3kW). The water table in the Niayes can be found between 1.5 and 10 meters underground. Once the water is elevated, there are different distribution systems. There are drip irrigation systems, hose systems, and even manual systems with buckets (the water is elevated to some basins where one or many farmers can collect it and then irrigate the field manually, or is elevated directly from the well).

Picture 73: Hose

Picture 74: Drip irrigation

Picture 75: Basins

In the Dieri area the water table is deeper (≈25m). The systems used to elevate the water in this region are more powerful motor pumps and wind energy pumps. The MVP is considering the use of other energy sources, like PV solar systems, to elevate water in this area. One PV solar system has already been put in place in Gabane, but it is not functional yet.

Only the systems used in the Niayes area will be considered in this report.

In 2007, the MVP plans were to provide 35 surface motor pumps to the farmers in the area of Niayes. The motor pumps would be given to the farmers association in Potou, and then they would distribute them to the farmers with financial means. There are farmers in the cluster that are also using other motor pumps, even though they have not been provided by the MVP.

4.4.1. Motor pumps provided by the MVP.

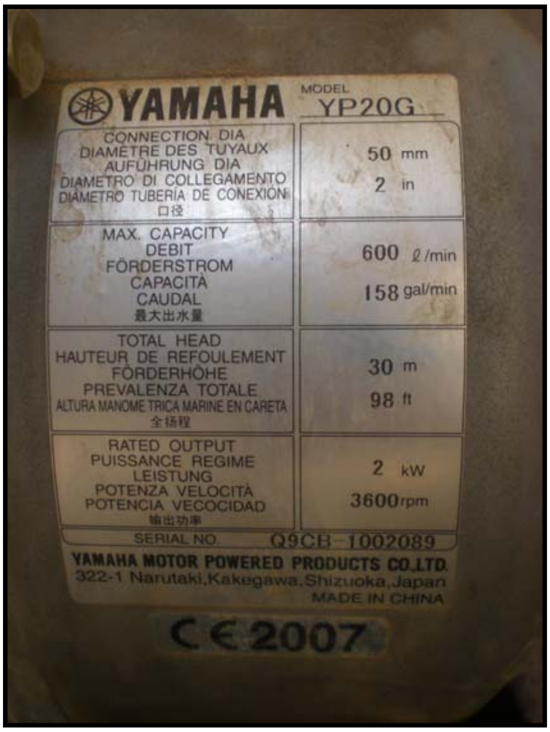
A small sized surface motor pump is used to elevate the water and distribute it in the field. The size of the motor pump would be determined after studying the surface, the depth of the water table (total static head) and an estimated flux rate.

The motor pump selected is the YAMAHA YP20G, and the provider would be CFAO from St. Louis. The engine runs on unleaded fuel.

Model	Power	Speed	Max flux rate	Static head	Aspiration head	Carburant
YAMAHA YP20G	2kW	3,600r/min	600l/min	30m	7m	Unleaded fuel

Table 10: Technical specifications of the motor pump provided by the MVP

The whole technical specifications can be seen in APPENDIX IV.



Picture 76: YAMAHA YP20G label with technical

A drip irrigation system would be distributed with the motor pump at the same time, but there has been a problem with the provider and these kits are not available for the farmers yet. The farmers that are already using a drip irrigation system bought it by their own means.

When the surveys were conducted, only eight farmers were using the motor pumps provided by the MVP. The rest of the farmers had collected them, but were not using them because they were waiting for the drip irrigation kits. In the APPENDIX IV there is a list of farmers that will get a motor pump and the actual situation of the motor pump.

Nº	Farmer	Village
5	Babacar BOYE	MOUREL
7	Sidy DIOP	NGOUFATTE
12	Ndiaye BA	NIAYAM
13	El Hadji Magatte BOYE	MOUREL
18	Salif BA	MOUREL
26	Abdou Toute BOYE	MOUREL
27	El Hadji NIANG	MOUREL
32	El Hadji Mbaye DIOP	GABAR

Table 11: Farmers with motor pump provided by the MVP (2kW) already working

Even though there are many wells in each field, only one is used to elevate the water. The depth of these wells is between 2 and 8 meters. The red circle in the pictures below indicates the location of the well.


Picture 77: Motor pump


Picture 78: Motor pump


Picture 79: Motor pump

Picture 80: Motor pump

MVP pump	Area ha	Power	Hours/ day	Fuel Consumption (l/day)	Fuel Ratio (l/hour)	Water consumption	mm/year	Irrigation system
5	0.4(*)	2kW	5	5	1	57,600l/day	2,700	Basins
7	0.2(*)	2kW	6	4	0.67	19,200l/day	1,800	Basins
12	0.85	2kW	4	4	1	72,000l/day	1,058	Drip
13	0.5	2kW	4	5	1.25	72,000l/day	1,800	Hose
18	0.4	2kW	8	2.5	0.3	144,000l/day	4,500	Hose
26	1.25	2kW	8	6.6	0.8	144,000l/day	2,768	Drip Hose
27	0.7	2kW	6	5	0.8	108,000l/day	1,928	Hose
32	0.3	2kW	2	1	0.4	36,000l/day	1,500	Drip

Table 12: Performance of the MVP motor pumps (2kW)

(*)It takes two days to irrigate the whole area. So the area irrigated is twice that value. The workers irrigate eight hours every day, even though the motor pump only works for five and six hours respectively.

The motor pumps are working at half speed. The curves of the motor pumps were asked to the provider (CFAO in St. Louis), but not all were not given. Anyway, given the equation $\frac{Q_1}{Q_2} = \frac{V_1}{V_2}$, where Q_1 is 600l/min (maximum flux rate), V_1 is 3,600r/min (maximum speed) and V_2 is the working speed of the engine (in this case 1,800r/min), then Q_2 is 300l/s. So the estimated flux rate is 300l/min.

Water consumption: $W = Q * t$

- W= water consumption (l/day)
- Q= Flux rate (l/hour)
- t= Hours/day

We can calculate the water consumption per square meter and day: $Wm = \frac{W}{ha} * \frac{1}{10.000}$

The area taken up by the crop is estimated as 80% of the total area.

Except in one case that seems far off from the rest (MVP18), the average water consumption is **16.94** $\frac{mm}{day}$. If MVP18 is considered, the average is 20.06 $\frac{mm}{day}$. The whole field is irrigated once a day.

The average consumption of fuel is **1.14**l/h, if MVP13 is not considered. If it is considered, the average fuel consumption is 1.31l/h.

Farmers buy the fuel at the gas stations of Louga or St. Louis, and all of them have transportation fees, even though no one specified them. The price of the unleaded fuel liter is 580F CFA (≈1.16$).

By using calculus, we can obtain how many hectares are irrigated every hour ($\frac{ha}{hr}$).

$$r = \frac{\sum ha}{\sum hr} = \mathbf{0.11}\frac{ha}{hr}$$

In this calculation MVP18 is not included. If it is included, the number of hectares that are irrigated every hour would be 0.09 $\frac{ha}{hr}$

Before having these motor pumps, most of the farmers already had one or many motor pumps. They bought it by their own financial means. The reason for changing is either their old motor pumps were broken, either they preferred to have a new one. Those who did not have a motor pump before, use to employ agricultural workers to irrigate the fields.

The motor pumps are on warranty for six months, so no maintenance fee is being charged right now. The provider of the maintenance service is a technician of CFAO, the provider of the motor pumps. This service is given once a week. The technician visits the farmers who own a MVP motor pump, so the service is given on site. While checking the performance of the motor pump, the technician gives advices to the farmers about how to keep the engine in good shape. In many cases, he found anomalies in the performance of the motor pumps. In one case the oil used was not convenient for the engine. In another case, the motor pump wasn´t in the right position. The smoke escape valve wasn't facing the open air. But most of the motor pumps were working pretty well. Generally, the service is given on site, but if the problem is too serious, the technician will take the motor pump to St. Louis and try to repair it there. This happened with only one of the motor pumps (number 27). This motor pump had a problem with the ignition system. The CFAO technician gives also a small maintenance guide with basics advices, written in Wolof (local language), to teach owners and users how to do the basic maintenance of the motor pump. Once the warranty expires, after six months, the farmers will decide who does this service. CFAO has already made an offer to these farmers. If they keep doing this maintenance service they will charge lower prices than for the rest of the owners and farmers. For the present, all the farmers are very satisfied with the maintenance service given and with the performance of the motor pumps as well.

Farmers do not suffer from energy cuts. When they run out of fuel, they go to the gas station to get more. If they did have energy cuts, they would not be able to elevate the water to irrigate and could not use their drip irrigation systems or hoses. The problem would last until they get to the gas station. In case the motor pump stops working, only one of the farmers has another motor pump that could be used to keep on irrigating.

Only two farmers say that their energy needs are not covered. They would like to have more motor pumps to irrigate the whole field. The first one has a big surface (1.25ha) to irrigate and the second one has another field far away from the field where the motor pump has been put on place. The rest of the farmers have their energy needs covered. They are able to irrigate the whole field with the motor pump provided by the MVP.

4.4.2. Private motor pumps.

Some farmers in the cluster already have one or many motor pumps to irrigate their fields. The different motor pumps used are YAMAHA YP30G (3.3kW), YAMAHA YP20G (2kW), KAMA and ROC. The farmers bought them in St. Louis (CFAO for the Yamahas) and in Mboro (the rest of the motor pumps).

Nº	Model	Village
1	ROC	MOUREL
2	YAMAHA YP30G	GABAR
3(*)	KAMA and ROC	GABAR
4	YAMAHA YP30G	GABAR
5	YAMAHA YP30G	GABAR
6	YAMAHA YP30G and YAMAHA YP20G	POTOU

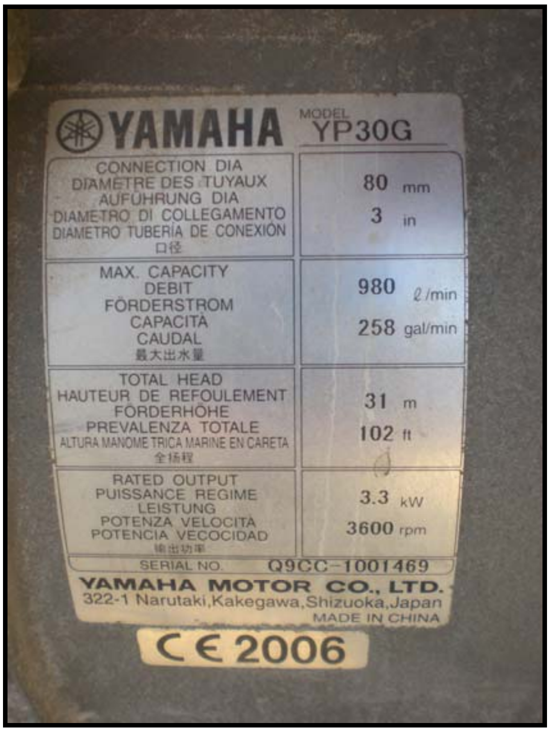
Table 13: Private motor pumps

(*) This farmer owns four motor pumps. One has been provided by the MVP but has not been put in place yet. Another one is broken.

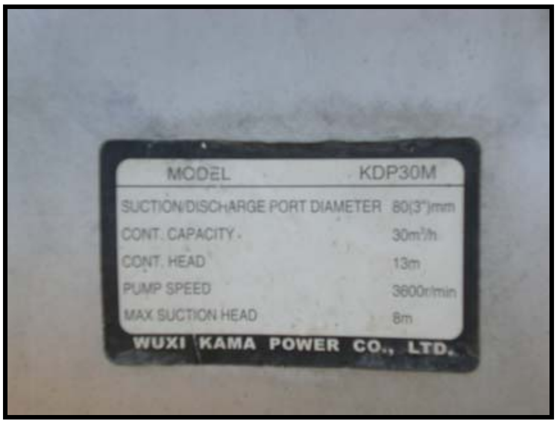
Model	*Power*	*Speed*	*Max flux rate*	*Static head*	*Aspiration head*	*Carburant*
YAMAHA YP20G	2kW	3,600r/min	600l/min	30m	7m	Unleaded fuel
YAMAHA YP30G	3.3kW	3,600r/min	980l/min	31m	7m	Unleaded fuel
KAMA KD30	-	3,600r/min	500l/min	-	8m	Gasoil
ROC	-	-	-	-	-	Gasoil

Table 14: Technical specifications of the private motor pumps

The whole technical specifications for the YAMAHA motor pumps can be seen in APPENDIX IV.



Picture 81: YAMAHA YP30G label with technical specifications



Picture 82: KAMA KD30 label with technical specifications

Picture 83: YAMAHA YP30G Motor pump

Picture 84: KAMA KD30 Motor pump

Picture 85: ROC Motor pump

Even though there are many wells in each field, only one is used to elevate the water. The depth of these wells is between 4 and 10 meters. The red circle in the pictures above indicates the location of the well.

Private Pump	Area Ha (**)	Power	Hours/ day	Fuel Consumption (l/day)	Fuel Ratio (liter/hour)	Irrigation system	Water consumption	mm/year	Cost of motor pump
Mourel1	0.9	-	6	5	0.8	Hose	Unknown	-	Unknown
Gabar2	0.3	3.3kW	1	2	2	Drip Manual	29,400l/day	1,200	325,000F
Gabar3(*)	2	3kW, -	4+4	3+3	0.75+0.75	Drip	252,000l/day	1,500	400,000F 500,000F
Gabar4	0.25	3.3kW	2	1	0.5	Drip Manual	58,800l/day	2,880	325,000F
Gabar5	0.5	3.3kW	1	1	1	Drip	29,400l/day	720	375,000F
Potou6	0.3	3.3kW 2kW	0.6+0.6	0.8+0.8	1.2	Drip	33,000l/day	1,170	300,000F (30G) 350,000F (20G)

Table 15: Performance of the private motor pumps (2-3.3kW)

(*) Only two motor pumps are considered. The KAMA KD30 has a legible label which says that the maximum flux rate is $30m^3$/hour, or 500l/min at a 3,600r/min speed.

(*) Only the area irrigated with the motor pump is considered.

The farmers do not know the working speed of the motor pumps, so the flux rate cannot be calculated. Supposing that they also work at half speed, the estimated flux rates would be the following: for the YAMAHA YP30G, given the equation $\frac{Q_1}{Q_2} = \frac{V_1}{V_2}$, where Q_1 is 980l/min (maximum flux rate), V_1 is 3,600r/min (maximum speed) and V_2 is the working speed of the engine (in this case 1,800r/min), then Q_2 is 490l/s. So the estimated flux rate for the YAMAHA YP30G is 490l/min. Using the same equation for the KAMA KDP30, we find that the estimated flux rate is 250l/min. For the other motor pumps, the labels are illegible that the flux rate cannot be estimated.

Farmers irrigate the fields for almost 4-5 months, around 120-150 days.

Water consumption: $W = Q * t$

- W= water consumption (l/day)
- Q= Flux rate (l/hour)
- t= Hours/day

We can calculate the water consumption per square meter and day: $Wm = \frac{W}{ha} * \frac{1}{10.000}$

Except one case that seems too far from the rest (Gabar4), the average water consumption is **11.47** $\frac{mm}{day}$. If Gabar4 is considered, the average is 14.94 $\frac{mm}{day}$. The whole field is irrigated once a day.

The average consumption of fuel is **1.69**l/h, if Gabar2 is not considered. If it is considered, the average fuel consumption is 2.52l/h.

Farmers buy the fuel at the gas stations of Louga or St. Louis, and all of them have transportation fees. These transportation fees are estimated in between 2,000 and 5,000F CFA/two weeks. The price of the unleaded fuel liter is 580F CFA (≈1.16$) and the one for the diesel liter is 500F CFA (≈1$).

By using calculus, we can obtain how many hectares are irrigated every hour ($\frac{ha}{hr}$).

$$r = \frac{\sum ha}{\sum hr} = \mathbf{0.23} \frac{ha}{hr}$$

In this calculation Gabar4 is not included. If it is included, the number of hectares that are irrigated every hour would be $0.22 \frac{ha}{hr}$

Before having these motor pumps, all the farmers were employing agricultural workers to irrigate the fields.

The provider of the maintenance service is a technician of CFAO, the provider of the motor pumps. Two of the motor pumps are still on warranty, and get this service for free once a week, as do the farmers that have a motor pump provided by the MVP. In the other cases, the maintenance service is also done by a technician of CFAO. This service would be provided when the motor pump breaks. The farmers could not specify the costs of this service. There is only one case in which the maintenance is done by an agricultural worker. All the farmers are satisfied with the maintenance service provided and the performance of the motor pumps.

Farmers do not suffer frequently from energy cuts. When they run out of fuel, they go to the gas station to get more. If it happened, they would not be able to elevate the water to irrigate and couldn't use their drip irrigation systems or hoses. The problem would last until they get to the gas station. If the motor pump stops working, none of the farmers have another motor pump that could be used to keep on irrigating.

4.4.3. <u>Manual irrigation.</u>

One or many workers elevate the water from a well with two buckets. The volume of the buckets is between 5 and 12 liters. The fields are irrigated by agricultural workers, who are generally not the owners of the fields. There are many wells distributed through the field to make the work easier.

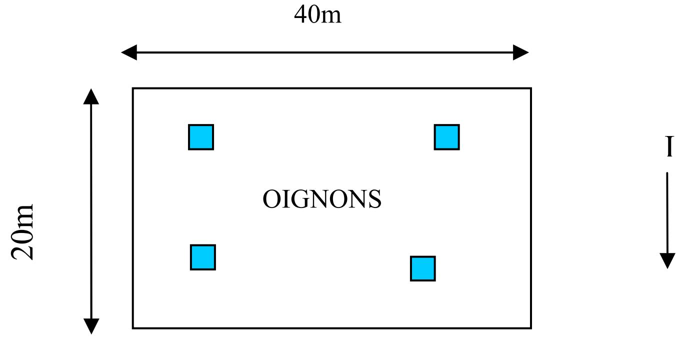


Figure 1: Wells distribution

The surface of the fields is between 0.08 and 0.1ha. The crops are cultivated in soil trays to make the better use of the water. Each of these soil trays has a surface of $0.2m^2$ (50x40cm).

Picture 86: Soil trays

The agricultural worker spends around 1-1.5 minutes to elevate two buckets with water and irrigate a soil tray. This is an estimated time since the work is not continuous. The worker stops irrigating once in a while to talk to other people or to take a rest. This is why the flux rate has been calculated estimating 1.5 minutes per trip. The whole field is irrigated once a day.

Field	**Village**	**Area Ha**	**Workers**	**Hours/ day**	**Volume buckets**	**Flux rate**	**Consumption (l/day)**	**Time /trip (min)**	**mm/ year**
1	Ndop	0.08	1	9	8l	<640l/h	<5,760l/day	1.5	1,440
2	Ndop	0.1	1	7	5l	<400l/h	<2,800l/day	1.5	560
3	Wekhe	0.1	1	9	8l	<640l/h	<5,760l/day	1.5	1,152
4	Potou	0.1	1	12	8l	<640l/h	<7.680l/day	1.5	1,536

Table 16: Water consumption in manual irrigation

Many of the fields where using a motor pump still use manual systems to irrigate a portion of the field.

Pump	**Area Ha**	**Workers**	**Hours/day**	**Volume buckets**	**Flux rate**	**Consumption (l/day)**	**Time /trip (min)**	**mm/year**
MVP5	0.8	6	8	10l	<7,200l/h	<57,600l/day	1	2,880
MVP7	0.4	2	8	10l	<2,400l/h	<19,200l/day	1	1,920
Gabar2	0.1(*)	2	4	10l	<1,600l/h	<6,400l/day	1.5	1,280
Gabar4	0.18(*)	2	3	10l	<1,600l/h	<4,800l/day	1.5	533

Table 17: Manual water consumption in fields where water is elevated by a motor pump

(*)It takes two days to irrigate the whole area. So the area irrigated manually is twice that value.

The fields are irrigated for 3 month every year.

The water consumption is calculated as follows (an example will be done with data from Ndop1):

The time spent to elevate two buckets and irrigate a soil tray is 1.5min.

$\Rightarrow$ Trips/hour: $\frac{60}{1.5} = 40\,\frac{trips}{hour}$

The volume of water carried in each trip is:

$\Rightarrow$ Water volume ($\frac{l}{trip}$): $bucketvolume * 2\frac{buckets}{man} = W_{trip}$

$$W_{trip} = 8\frac{l}{bucket} * 2\frac{bukets}{man} = 16\frac{l}{man}$$

The volume of water used every hour is:

$\Rightarrow$ Water volume ($\frac{l}{hour}$): $W_{trip} * \frac{trips}{hour} = W_{hour}$

$$W_{hour} = 16\frac{l}{man} * 40\frac{trips}{hour} = 640\frac{l}{hour}$$

The volume of water used every day is:

$\Rightarrow$ Water volume ($\frac{l}{day}$): $W_{hour} * n\frac{hours}{day} = W_{day}$

$$W_{day} = 640\frac{l}{hour} * 9\frac{hours}{day} = 5{,}760\ \frac{l}{day} = 5.76\ \frac{m^3}{day}$$

The length in time of the onion crop is 100 days, so:

$\Rightarrow$ Total Water volume (m^3): W_{day}*length (days) = W_{total}

$$W_{total} = 5.76\frac{m^3}{day} * 100 \text{ days} = 576 \text{ m}^3$$

The field takes up a surface of X ha, but not every square meter is used to grow onions. We can estimate that only half of the area is taken up by the crop (the rest of the area is taken up by land not cultivated between soil trays and area taken up by wells and aisles).

$\Rightarrow$ Cropped area (ha): X ha*0.5 = Area

Area = 0.08*0.5 = 0.04 ha = 400m^2

We can calculate the total volume of water used to irrigate the field:

$$\Rightarrow \text{Water input (mm)} = \frac{W_{total}}{Area} * \frac{1000mm}{m}$$

$$\text{Water imput} = \frac{5.76\frac{m^3}{day}}{400m^2} * 1000 = 14.4\ \frac{mm}{day} = 1{,}440\frac{mm}{crop}$$

The average water consumption per day is $\mathbf{11.72}\frac{mm}{day}$. The whole field is irrigated once a day (exceptions are signaled below table 17). If Private 2 and 4 are considered (part of the field is irrigated manually), the average water consumption per day would be $\mathbf{10.83}\frac{mm}{day}$. The water consumption in MVP5 and MVP7 is not included because the water is elevated with a motor pump and then distributed by workers with buckets.

In the video below can be seen the process to elevate the water and irrigate the field.

Senegal 661.avi

By using calculus, we can obtain how many hectares are irrigated manually every hour ($\frac{ha}{hr}$). Only the area taken up by the crop is considered (50% of total area).

$$r = \frac{\sum ha}{\sum hr} = \mathbf{0.011}\frac{ha}{hr}$$

MVP5 and MVP7 are not included in this calculus because in these two cases the water is elevated with a motor pump and not manually.

Picture 87: Buckets used to irrigate

Picture 88: Depth of well

4.4.4. Conclusions.

In 2007, the MVP plans were to provide 35 surface motor pumps to the farmers in the area of Niayes. The motor pumps would be given to the farmers association in Potou, and then they would distribute them to the farmers with financial means. All these motor pumps have been distributed so the objectives have been accomplished, although not all of the farmers put the pumps in place yet,. A drip irrigation system kit was going to be given at the same time, but there were some problems with the provider and they have not yet arrived.

The benefits obtained with the use of a motor pump are evident. For those who already had a motor pump, they are able to use a brand new motor pump. Most of the old motor pumps were broken, so the farmers did not have to go back to hiring agricultural workers. For those who did not have a motor pump, the benefits are even greater. Before using a motor pump, they irrigated the fields manually. To do so, they had to employ one or more agricultural workers. This is very expensive for the farmer since he must pay them a salary, feed them and share the crop with them. The benefits were not great and the farmers worried since if the workers fell sick or went on strike, nobody would irrigate their fields, causing large financial losses. Thanks to the use of motor pumps, no workers are needed anymore, so the farmer does not have to worry about paying salaries or sharing crops. One man is enough to irrigate the field. The farmers spend less time irrigating the fields when they have a motor pump than when they have to do it manually. Irrigating with a hose or a drip system is much easier than doing it with buckets.

Fuel consumption:

MVP motor pumps:

	Power (kW)	Area (ha)	h/day	l/day	l/hour	l/ha.hr	l/ha.crop
MVP5	2	0.8	5	5	1	1.25	625
MVP7	2	0.4	6	4	0.67	1.68	1,005
MVP12	2	0.85	4	4	1	1.18	470.59
MVP13	2	0.5	4	5	1.25	2.5	1,000
MVP18	2	0.4	8	2.5	0.3	0.75	600
MVP26	2	1.25	8	6.6	0.8	0.64	512
MVP27	2	0.7	6	5	0.8	1.14	685.71
MVP32	2	0.3	2	1	0.4	1.33	266.67

Table 18: Fuel consumption (l/hour) of MVP motor pumps (2kW)

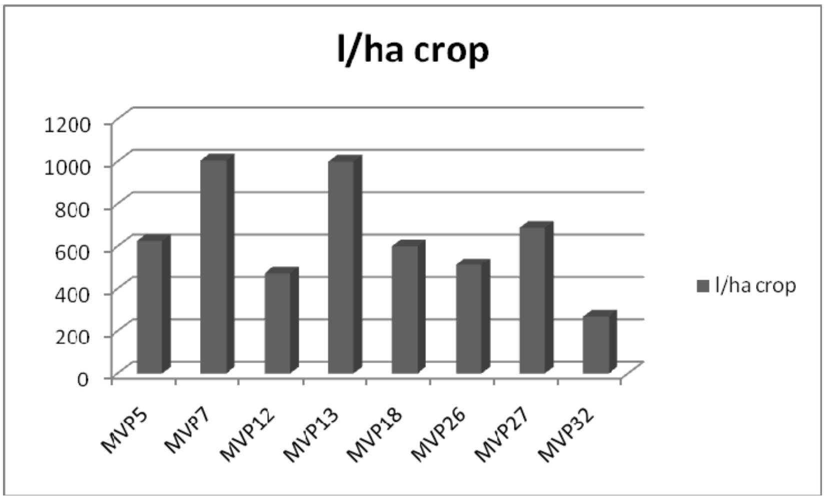


Figure 2: Fuel consumption of MVP motor pumps (2kW)

Only two values are far away from the others: MVP13 and MVP7. The average is $\mathbf{645.62}\frac{l}{crop.ha}$.

Private motor pumps:

	Power (kW)	Area (ha)	h/day	l/day	l/hour	l/ha.hr	l/ha.crop
Mourel1	(*)	0.9	6	5	0.8	0.93	555.56
Gabar2	3.3	0.3	1	2	2	6.67	666.67
Gabar3	(**)	2	8	6	1.5	0.38	300
Gabar4	3.3	0.25	2	1	0.5	2	400
Gabar5	3.3	0.5	1	1	1	2	200
Potou6	3.3- 2	0.3	1.4	1.6	1.2	3.81	533.33

Table 19: Fuel consumption (l/hour) of private motor pumps (2-3.3kW)

(*)The label of the ROC motor pump was illegible, so its power can't be estimated.

(**)There are two motor pumps in this field: a ROC one and a KAMA one. The label of the ROC motor pump was illegible, so its power cannot be estimated. The KAMA motor pump label did not specify its size, so it could not be specified either.

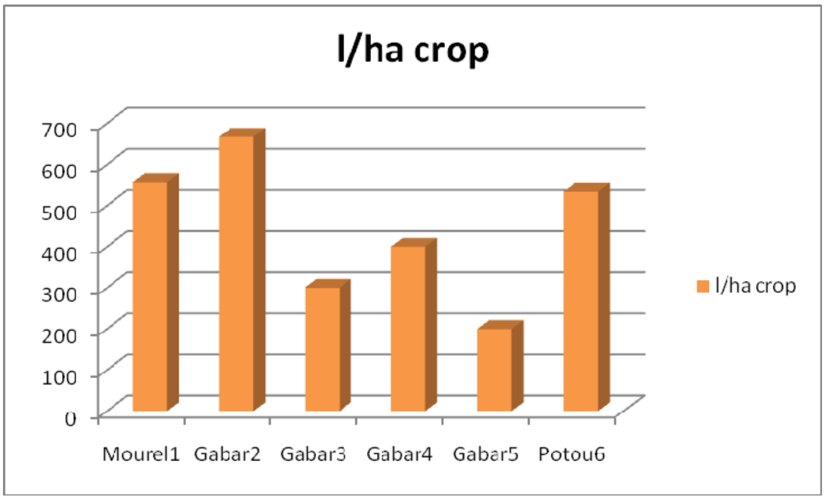


Figure 3: Fuel consumption of private motor pumps (2-3.3kW)

The fuel consumption in private motor pumps is varies widely, especially the consumption at Gabar2. Its value is almost twice as big as Potou6, even though the area of the field is the same (0.3ha) and three times the one at Gabar4 (with a similar area). The fuel consumption in Gabar4 is the same as in Gabar5 although the area is two times bigger in Gabar5. The average is **442.59** $\frac{l}{crop.ha}$.

Fuel consumption	MVP	Private	Manual
l/hour.ha	1.14	1.69	-
l/ha.crop	645.62	442.59	-

Table 20: Average fuel consumption

The MVP13 and Gabar2 are excluded from this average, because the data provided by the farmers are extremely different from that provided by the rest of the farmers.

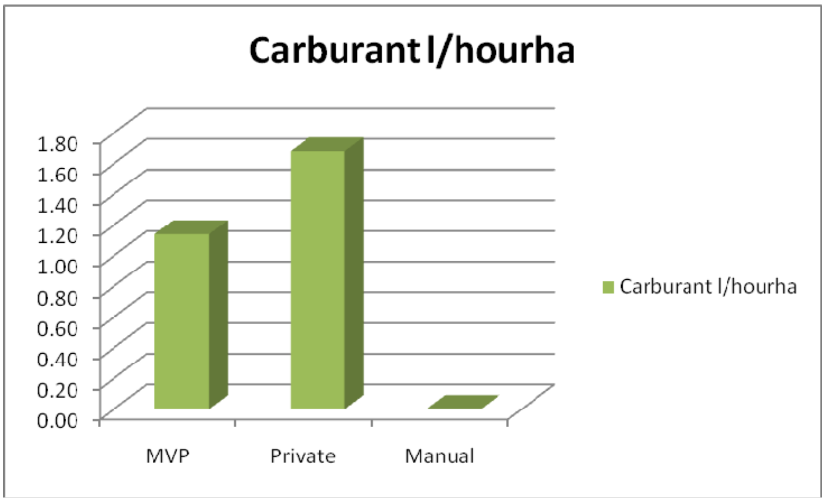


Figure 4: Average carburant consumption

The fuel consumption is a little bit higher in the fields that use a private motor pump than in those with a MVP motor pump. This might be caused by the older condition of the motor pumps. Besides, most of this motor pumps are more powerful (3.3kW) than those provided by the MVP (2kW).

Water consumption:

Water consumption	MVP	Private	Manual
mm/day	16.94	11.47	10.83

Table 21: Average water consumption

The MVP18 and Gabar4 are excluded from this average, because the data provided by the farmers are very far from those provided by the rest of the farmers.

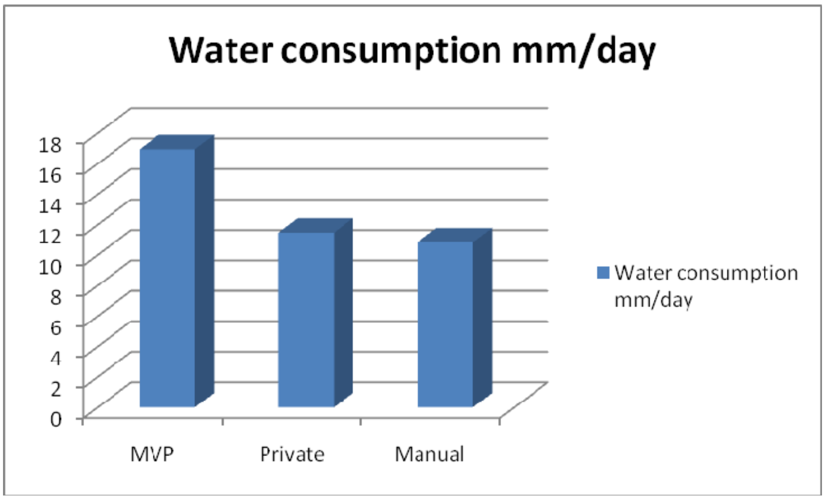


Figure 5: Water consumption

The water consumption is higher in the fields that use a motor pump to elevate it. Less water is provided to the field when irrigating manually, than irrigating with a motor pump. This is not accurate. It should be the other way, because the systems like drip or hose should consume less water than irrigating manually with buckets. The reason is that more water is lost when irrigating manually because of the percolation through the soil.

Recommendations of water contribution per day for onion cultivation depending on the irrigation system used:

	Drip	Hose	Manual
First month	3 mm	4.5 mm	6 mm
Second month	4 mm	6.5 mm	9 mm
Third month	5 mm	8.5 mm	11 mm
Total	12 mm	19.5 mm	26 mm

Table 22: Water recommendations depending on the irrigation system

We can compare these values to what is really being used:

Water consumption	Drip	Hose	Manual
mm/day	12.19	17.04	10.83

Table 23: Water consumption depending on the irrigation system

In MVP26, we could not determine the area irrigated with hose and the area irrigated with a drip system. To make these calculations, we estimate that the water consumption in the area irrigated with a drip system is the same than in the area irrigated with a hose, even though we know it will not be accurate. More water will be provided by a hose than by a drip system.

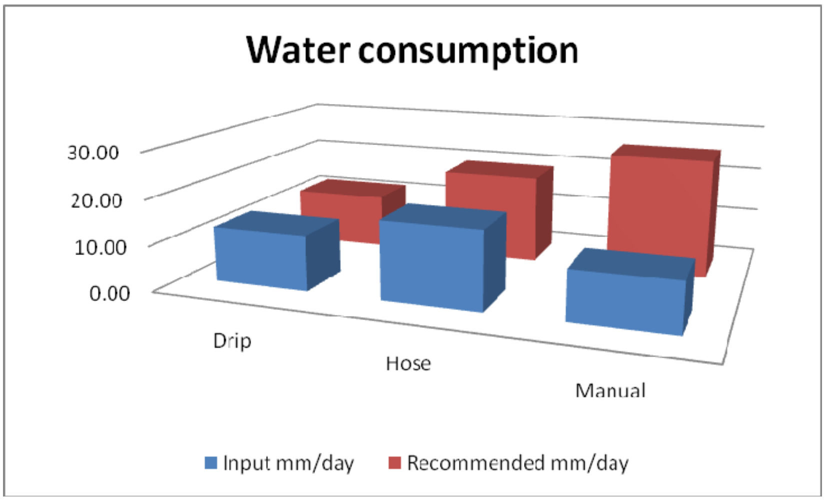


Figure 6: Water consumption depending on the irrigation system

The quantity of water provided is similar to the one recommended when irrigating with a hose or a drip. If the irrigation is manual, then the water provided is not enough.

Irrigation time:

Irrigation time	MVP	Private	Manual
ha/h	0.12	0.23	0.015

Table 24: Time spent to irrigate

The MVP18 and Gabar4 are excluded from this average, because the data provided by the farmers are very far from those provided by the rest of the farmers.

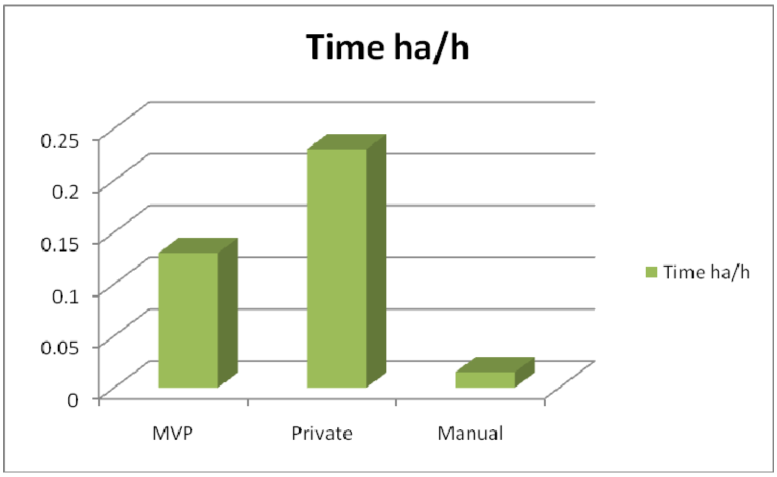


Figure 7: Time spent to irrigate

The time taken to irrigate a hectare manually is between ten and twenty times lower than the time taken to irrigate a hectare elevating the water with a motor pump.

Thus, irrigating with a motor pump is easier, faster and more efficient than irrigating manually.

Most of the farmers interviewed were very satisfied with the performance of the motor pump. Only one motor pump provided by the MVP presented a problem and had to be taken to St. Louis to be repaired. Farmers are also very satisfied with the maintenance service provided by CFAO, who provided most of the motor pumps. Some of the farmers would like a more powerful motor pump to be able to irrigate their whole fields at the same time. Most of them do not have an emergency system in case the motor pump stops working or they run out of gas. In that situation, they go to St. Louis or Louga to buy more fuel.

Many farmers who do not own a motor pump would like to use one to elevate the water from the wells, but they do not have the financial means to buy one.

Some questions can be formulated:

- Should the policy of providing small sized motor pumps to the farmers be expanded?
- Is it useful to study the difference in crop production between those who use a motor pump and those who do not?
- Would it be possible to join many fields and use a bigger irrigation system? The costs would be shared.
- Is it profitable to build a gas station in Potou? It would eliminate the trips to Louga or St. Louis by inhabitants of the cluster, farmers and fishermen to find the fuel they need to run their motor pumps or pirogues.

4.5. Energy systems for grinding mills.

At the beginning of the project, in 2006, there were 20 grinding mills and 39 hull mills. 18 of the grinding mills were in the area of the Dieri and only 2 of them were in the area of the Niayes. 5 grinding mills were broken. 36 hull mills were in the area of the Dieri while only 3 of them were in the area of the Niayes.

In 2007, the MVP plans were to provide storing and/or transformation units for agricultural or livestock products. The project would also provide an energy source for these units. The different alternatives are electricity from the grid or a PV solar system, wind or a fuel generator. This plan aimed to fulfill one of the objectives of the DSRP 2006 (Document Stratégique de Réduction de la Pauvreté or Strategy Paper on Poverty Reduction): improve the economic and social situation of rural women through the establishment of infrastructures to make domestic work more manageable, make appropriate technologies and equipment available to rural women for use in processing and preserving products. A study was made to determine the most appropriate location for these mills. Finally, three grinding mills and two Multifunctional Platforms were put in place in different villages in the cluster.

The mills will belong to the villages, and there will be a Management Council composed by women that will be in charge of its functioning and maintenance.

The location for the PFM's is being studied right now, so they have not been installed yet. The grinding mills have already been put in place in three villages: Longhor, Niayam and Whakhaldjiam. The energy source chosen is a generator that runs on diesel.

Picture 89: Shelter for the grinding mill in Whakhaldjiam.

Type	Specifications
Provider	Matforce
Flux rate	300kg/h
Engine	Diesel hatz1d81s
Framework	Steel
Power/r/min	11c.v/3,000r/min
Accesories	Sifters, starting handle, maintenance guide, etc.
Start mode	Handle
Carburant	Diesel
Warranty	6 months after delivery

Table 25: Technical specifications for the grinding mills provided by the MVP

The cost of these grinding mills was of 1,900,000F CFA (≈3,800$).

Picture 90: Grinding mill

Picture 91: Grinding mill

Picture 92: Grinding mill

Picture 93: Grinding mill

Before using the grinding mills, the women had to use mortars or other grinding mills in villages around the Community. The benefits for the women of these villages have been very important. They can now do the job much faster than with the mortar. This allows them to do other tasks, because they have more time available. The job is much easier, so they do not get as tired and have more energy to perform those new tasks. Now they do not have to go to other villages to mill the grain, which means that they do not have to spend money and time. As a matter of fact, they can make some money charging a fee to all the women that come to the village to use the mill. With this money they can pay the mill back, pay for the diesel they consume, and pay for the maintenance service and even get some savings for the future which may allow them to buy other machines.

The fees are as follows:

- Mill: 25F CFA/kg.
- Maize: 30F CFA/kg.
- Arachide: 25F CFA/kg.
- Bissap: 30F CFA/kg.

Village	Hours/day	Consumption	Costs	Transport fees	Where
Longhor	2	20l/month	10,000F CFA/month	No	Louga
Niayam	2	10l/month	5,000 F CFA/month	No	Louga
Whakhaldjiam	2	40l/month	20,000 F CFA/month	1,400 F CFA/month	Louga

Table 26: Fuel consumption of the grinding mills

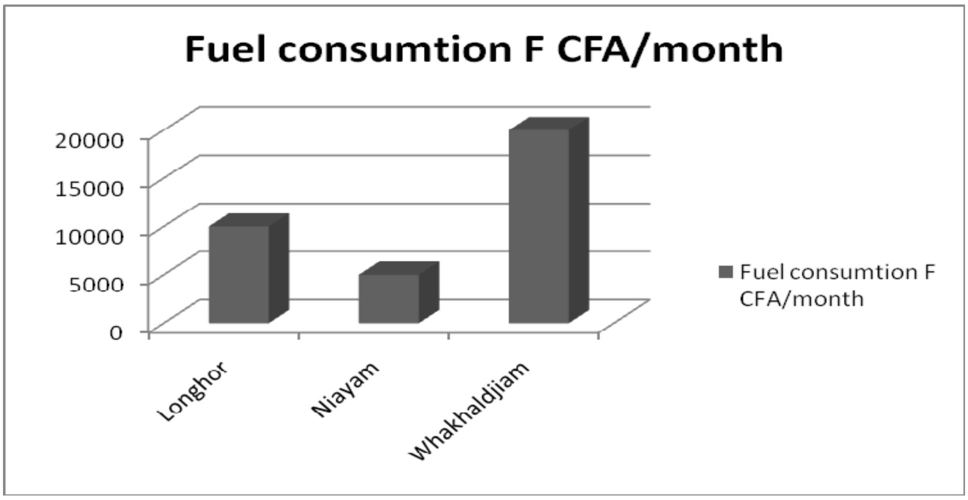


Figure 8: Fuel consumption for grinding mills

As can be seen in the table above, the diesel consumption is very different from one village to another. They all have the same working hours (two hours/day) but the consumptions are very different. The one in Whakhaldjiam spends twice the diesel spent in Longhor and four times the fuel spent in Niayam. In Longhor and Niayam there are not any transportation fees. In each of these villages there is someone who owns a car and who brings the carburant from the gas station at Louga once a month (or whenever needed) without charging any money. In Whakhaldjiam, they have transportation fees every time they must go to Louga to buy the carburant. This is the only village that suffers from diesel shortage, because it takes them a long time to go to Louga to get the diesel and come back. This is why the women who run the grinding mill would like to use another energy source such as a PV solar system or electricity from the grid. If the grinding mill stops working (because it gets broken or because there is a diesel shortage), women have to go back to the mortars to mill the grain. Another option is to bring the grain to another mill.

The maintenance of the grinding mill is being performed by a technician from Louga who was trained by the MVP. The machines were on warranty for six months, but this warranty has already expired, even though they have been put in place in December 2008. It seems that they were delivered before they could be put in place. The maintenance service was given punctually. Right now two of the grinding mills (Longhor and Niayam) are broken. One of the metal pieces, where the belt transmission from the engine joints the mill, is broken. It is a structural problem that cannot be repaired by the technician in charge of the maintenance. The broken pieces are signaled in red in the pictures below. The MVP staff is trying to contact the provider to make him repair the machines, even though they are not under warranty. They think that the machine was not well built, and that the provider should be responsible for it. This is the reason why the women from these two villages are not very satisfied with the maintenance service provided. Until the mill is repaired, they have to mill the grain with mortars, or bring it to Potou, where there are other grinding mills.

Picture 94: Piece broken in Longhor

Picture 95: Piece broken in Niayam

In 2007, the MVP plans were to provide storing and/or transformation units for agricultural or livestock products. The project would also provide an energy source for these units. In 2009, the three grinding mills have been put in place, but two of them are broken and cannot be repaired by the technician trained by the MVP. The staff of the MVP is studying the location for the MFP's. So the objectives have not been accomplished entirely.

Some questions can be formulated:

- Why is the diesel consumption so different in the villages with a grinding mill?
- Is it possible to use a solar system to provide energy to the grinding mill?
- Is it necessary to increase the number of grinding mills around the cluster?
- Is it better to put in place a grinding mill or a MFP?

4.6. <u>Energy systems for the fish preservation.</u>

The fishing captures must be conserved since the moment they are caught until the moment they are sold. If any degradation occurs to the fishes, the price the fishermen will receive for them will be considerably lower. Most of the production is sold to the markets in Dakar, Louga, Diourbel, Ghana, Mali, Togo, etc. This is why an energy source is necessary to conserve the fresh fish. Fishermen will then be able to get the highest price possible for their catches. Only a small part of the catch is sold daily in the villages of the cluster.

The energy needs in 2007 were as follows:

- Supply all the ice necessary to conserve the catch for a short period of time.
- Installation of a small ice machine, which would avoid ice supply cuts. This measure would also generate incomes to the fishermen because they would be able to sell ice to the inhabitants of the cluster.
- Installation of a cold chamber to store the catch in good conditions. This would ensure the conservation of the captures for a longer time than with the ice. This installation could be done later, once the volume of the catch grows enough. Nevertheless, the acquisition of a refrigerated truck could be another option that would improve the business of the fishermen.
- Electrification of the Fishing post in Niayam.

The solutions provided by the MVP staff in 2007 were as follows:

- Immediate installation of two PV solar systems that enable a small scale ice production.
- In the mid-term, install an ice fabric. Once this fabric is put in place, the PV solar systems could be used to provide energy to other buildings, like clinics or schools.

At the time of the trip, only the electrification of the Fishing Post with a PV solar system was accomplished. Any ice fabric has been bought or installed. Nevertheless, the MVP has provided the fish-mongers with ten isothermal cases that can be filled with ice to keep the captures fresh for at least 4-5 days. This cases (with the ice) help the fish-monger to conserve the captures fresh until the arrival of the truck that will take all the products to the market in Dakar, Lompoul or Louga. The cases can be found in Niayam, near the coast, where the fish-mongers have their posts. The capacity of each case is 600l.

Picture 96: Isothermal case

Picture 97: Fish-mongers

1kg of ice is necessary to refrigerate 2kg of fish. The ice is renewed once a day during the hot season, between April and July. The rest of the year the ice is renewed once every 3-4 days. Each case can store 25kg of ice. The ice is provided by the same truck that comes to get the captures to the markets. The price of the ice depends of the season. During the hot season, the price can be as high as 2,000F CFA/bag. Every bag has 25kg of ice. The rest of the year the price drops until 1,000F CFA/bag. The transportation fees are included in the price of the ice.

The fish-mongers are satisfied with the isothermal cases, even though they think they are a little old and would like to have new ones. They do not have an emergency system in case they run out of ice. This occurs infrequently, but has already happened. When the volume of the catch is higher than usual, the truck might not have enough ice for everyone, so part of the fish must be sold in the local markets or the transformation industries. The problem is that the price paid by these industries is much lower than the price paid in Dakar. Thus, when there is an ice shortage, fish-mongers will have financial losses. Another situation that can damage the fishermen's interests occurs when the truck from Dakar gets broken in the middle of the road and cannot get to Niayam on time. In these occasions, the fish-mongers rent a car to get more ice. As was said before, these problems are not usual. The ice needs are covered at 90-95%. Sometimes the fish-mongers cannot pay the ice, because its price is very expensive, especially during the hot season.

The only maintenance service required for the isothermal cases is to clean them frequently, at least once every 4 days. The cleaning products used are water, soap and bleach. The costs of these products are 1.500F CFA/2 weeks. This operation is done by the fish-mongers themselves.

The benefits of the cases are evident. Nowadays, the fish-mongers can conserve the catch for at least four days, so they can sell their products at higher prices. Before they had the cases, they had to sell their catches to the local merchants or the transformation industries, but the prices paid were much lower than the ones paid in the market of Dakar.

The fish agent believes that a (positive) cold chamber would be a great solution to conserve the fish without worrying about the arrival of ice or not. It would allow the fish-mongers to conserve their products for 3-4 days. He proposes another solution already studied by the MVP staff: the installation of an ice-fabric. Nevertheless, he recognizes that they are expensive solutions, and that a grid connection is also needed. The grid has not arrived in Niayam.

The solutions provided by the MVP staff in 2007 were the immediate installation of two PV solar systems that enable a small scale ice production and the installation of an ice fabric in the mid-term. None of these objectives have been accomplished, but the MVP provided ten isothermal cases to the fish-mongers instead. These cases allow them to conserve the captures for 4-5 days, before they get degraded.

Some questions can be formulated:

- Is it worth to replace the isothermal cases?
- Is it possible (and worthwhile) to get an ice machine that runs on electricity provided by a PV solar system?

4.7. Conclusions.

The energy systems provided by the MVP, like the PV solar systems installed in schools, clinics and other buildings or the motor pumps provided to 35 farmers, are working accurately. The users are very satisfied with their functioning and maintenance service provided. This maintenance service is being provided by a technician trained by the MVP, or by the provider of the system. They can perform activities like lighting or conserving vaccines that could not be done before accurately. These activities have improved the quality of life of the users (pupils, teachers, heath agents, patients, farmers, women, etc.) in the villages where these systems have been put in place. Nevertheless, everyone is waiting for the arrival of the grid to all the villages in the cluster so that they can use the electricity provided by this infrastructure. People think that electricity from the grid is easier to use and maintain, and that many more services could be provided. As a matter of fact, this attitude can be seen in Thiowor, where the grid has just arrived and most of the households of the village have asked the SENELEC to get connected to it. In Potou and Leona, where the grid arrived in 2007, most of the households and stores use electricity from the grid to get light, refrigerate products, or charge batteries. In these buildings the maintenance service is done by an electrician, but some of the persons interviewed said that it was not easy to find skilled electricians in the cluster. Batteries for flashlights and LPG canisters are the most popular energy sources that can be found in the shops of Potou and Leona.

4.8. Questions.

- Do the teachers/directors live in the schools because they have electricity?
- Is it necessary to electrify all the classes?
- Is it necessary to electrify the toilets?

- Is it helpful to build lodging and electrify it for the teachers/directors?
- The grid has not arrived in many of the villages of the cluster, even though plans have already been made. In the mean time, is it worth it to get more PV solar systems for more schools?
- If the project finishes, who will bring the solar systems to other clinics if the grid has not already arrived there?
- Is it really necessary to replace the solar systems installed by the AFDS?
- Can the Cases wait until the grid arrives to these villages (or to other villages which Cases/Posts have a solar system provided by the MVP)?
- Should agents be trained in basic solar system maintenance?
- If the grid hasn't arrived to all the villages when the project will be over, who will pay for the maintenance of the solar systems?
- Is it necessary to train one/some electricians of the Cluster in solar systems maintenance?
- Is it necessary to train one/some electricians of the Cluster for the maintenance of the households?
- There is not much light in the streets of Potou. Maybe it is caused by a bad maintenance of the street lamps. Besides the expansion of the grid, should there be some investment in the maintenance of the existing street lamps?
- Should the policy of providing small sized motor pumps to the farmers be expanded?
- Is it useful to study the difference in crop production between those who use a motor pump and those who do not?
- Would it be possible to join many fields and use a bigger irrigation system? The costs would be shared.
- Is it profitable to build a gas station in Potou? It would avoid trips to Louga or St. Louis by inhabitants of the cluster, farmers and fishermen to get the fuel they need to run their motor pumps or pirogues.
- Why is the diesel consumption so different in the villages with a grinding mill?
- Is it possible to use a solar system to provide energy to the grinding mill?
- Is it necessary to increase the number of grinding mills around the cluster?
- Is it better to put in place a grinding mill or a MFP?
- Is it worth to replace the isothermal cases?
- Is it possible to get an ice machine that runs on electricity provided by a PV solar system?

APPENDIX I: SCHEDULE AND DAILY ACTIVITIES

30 march	31 march	1 april	2 april	3 april
Health Post Leona Rural Council Leona CMC Leona Stock-farmers house Leona	Family house Potou 3 shops Leona	Health Post Potou CMC Potou Fishing Post Niayam (2) 1 Shop Leona	School Gabar Health Case Maka Tare Health Post Ndialakhar Samb School de Potou Visit Thiowor	3 Shops Potou
6 april	**7 april**	**8 april**	**9 april**	**10 april**
Market survey Leona	Health Case Gabar Health Post Sague Sathiel Health Case d'Ouassoum assal 2 shops Gabar 1 shop Tare	10 irrigation systems MVP motor pumps	Health Case Ndemba 1 Health Post Syer Peul Health Case Batleum Health Case Keur Koura Dieri Health Case Santhiou Diatji	Report
13 april	**14 april**	**15 april**	**16 april**	**17 april**
Report	Market survey Potou School Leona School Thiowor 1 shop Thiowor School Batleum School Sague Sathiel	3 shops: Tare, Thiowor, Potou	5-6 irrigation systems private motor pumps	3 grinding mills
20 april	**21 april**	**22 april**	**23 april**	**24 april**
Night market in Potou	4 irrigation systems manual	Report	Report	Report

APPENDIX II: GPS POSITIONS

NAME: Jose Ramon Barnuevo	**Datum:** WGS84
GPS UNIT: MODI 6	**Date:** Various

Way point #	Name	Location	GPS accuracy	Latitude		Longitude	
362	Rural Council	Leona	± 7 m	**E (+)** ~~**W (-)**~~	15.720013	~~**N (+)**~~ **S (-)**	16.462552
363	Stock-farmers house	Leona	± 6 m	**E (+)** ~~**W (-)**~~	15.719348	~~**N (+)**~~ **S (-)**	16.462414
364	Health Clinic	Leona	± 6 m	**E (+)** ~~**W (-)**~~	15.719935	~~**N (+)**~~ **S (-)**	16.462919
368	Convenience store nº1	Leona	± 12 m	**E (+)** ~~**W (-)**~~	15.719388	~~**N (+)**~~ **S (-)**	16.463287
369	Sewing workshop	Leona	± 5 m	**E (+)** ~~**W (-)**~~	15.719245	~~**N (+)**~~ **S (-)**	16.463406
370	Repair workshop	Leona	± 4 m	**E (+)** ~~**W (-)**~~	15.718936	~~**N (+)**~~ **S (-)**	16.463499
371	Fishing Post	Niayam	± 5 m	**E (+)** ~~**W (-)**~~	15.740283	~~**N (+)**~~ **S (-)**	16.549963
372	Fish-mongers	Niayam	± 5 m	**E (+)** ~~**W (-)**~~	15.741552	~~**N (+)**~~ **S (-)**	16.552956
373	Family House	Potou	± 4 m	**E (+)** ~~**W (-)**~~	15.729328	~~**N (+)**~~ **S (-)**	16.524959
374	Health Clinic	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.724952	~~**N (+)**~~ **S (-)**	16.519723
375	School	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.724421	~~**N (+)**~~ **S (-)**	16.518994
376	Pharmacy	Leona	± 8 m	**E (+)** ~~**W (-)**~~	15.719751	~~**N (+)**~~ **S (-)**	16.465675
377	School	Gabar	± 6 m	**E (+)** ~~**W (-)**~~	15.762691	~~**N (+)**~~ **S (-)**	16.532666
378	Health Clinic	Maka Tare	± 7 m	**E (+)** ~~**W (-)**~~	15.795364	~~**N (+)**~~ **S (-)**	16.411378
379	Health Clinic	N'Dialakhar Samb	± 5 m	**E (+)** ~~**W (-)**~~	15.775500	~~**N (+)**~~ **S (-)**	16.423319
380	Convenience store nº1	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.724040	~~**N (+)**~~ **S (-)**	16.526610
381	Fertilizers and seeds	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.725373	~~**N (+)**~~ **S (-)**	16.525769
382	Convenience store nº2	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.725670	~~**N (+)**~~ **S (-)**	16.525705
383	Health Clinic	Gabar	± 7 m	**E (+)** ~~**W (-)**~~	15.763769	~~**N (+)**~~ **S (-)**	16.532010
384	Health Clinic	Ndialegne	± 5 m	**E (+)** ~~**W (-)**~~	15.774417	~~**N (+)**~~ **S (-)**	16.520440
385	Convenience store nº1	Gabar	± 5 m	**E (+)** ~~**W (-)**~~	15.763205	~~**N (+)**~~ **S (-)**	16.531884
386	Health Clinic	Sague Sathiel	± 5 m	**E (+)** ~~**W (-)**~~	15.701489	~~**N (+)**~~ **S (-)**	16.567991
387	Health Clinic	Ouassam Assal	± 6 m	**E (+)** ~~**W (-)**~~	15.668415	~~**N (+)**~~ **S (-)**	16.582052

NAME: Jose Ramon Barnuevo	**Datum:** WGS84
GPS UNIT: MODI 6	**Date:** Various

Way point #	Name	Location	GPS accuracy	Latitude		Longitude	
388	Convenience store nº2	Gabar	± 5 m	E (+) ~~W (-)~~	15.762881	~~N (+)~~ S (-)	16.531940
389	Convenience store nº1	Tare	± 5 m	E (+) ~~W (-)~~	15.778703	~~N (+)~~ S (-)	16.535092
390	MVP motor pump nº26	Mourel	± 4 m	E (+) ~~W (-)~~	15.772421	~~N (+)~~ S (-)	16.500934
392	MVP motor pump nº18	Mourel	± 4 m	E (+) ~~W (-)~~	15.765373	~~N (+)~~ S (-)	16.496853
393	MVP motor pump nº13	Mourel	± 5 m	E (+) ~~W (-)~~	15.762149	~~N (+)~~ S (-)	16.501517
394	MVP motor pump nº5	Mourel	± 5 m	E (+) ~~W (-)~~	15.767406	~~N (+)~~ S (-)	16.503164
395	Private motor pump nº1	Mourel	± 5 m	E (+) ~~W (-)~~	15.768773	~~N (+)~~ S (-)	16.502387
396	MVP motor pump nº7	Ngouffate	± 5 m	E (+) ~~W (-)~~	15.755406	~~N (+)~~ S (-)	16.505169
397	MVP motor pump nº12	Niayam	± 4 m	E (+) ~~W (-)~~	15.750330	~~N (+)~~ S (-)	16.536445
398	MVP motor pump nº27	Mourel	± 5 m	E (+) ~~W (-)~~	15.789837	~~N (+)~~ S (-)	16.525724
399	MVP motor pump nº32	Gabar	± 4 m	E (+) ~~W (-)~~	15.765638	~~N (+)~~ S (-)	16.536418
400	Weekly Market	Leona	± 6 m	E (+) ~~W (-)~~	15.719518	~~N (+)~~ S (-)	16.463036
401	Health Clinic	Ndemba	± 5 m	E (+) ~~W (-)~~	15.657917	~~N (+)~~ S (-)	16.396852
402	Health Clinic	Santhiou Diatji	± 5 m	E (+) ~~W (-)~~	15.736153	~~N (+)~~ S (-)	16.376819
403	Health Clinic	Syer Peulh	± 5 m	E (+) ~~W (-)~~	15.669893	~~N (+)~~ S (-)	16.450527
404	Health Clinic	Batlamine	± 5 m	E (+) ~~W (-)~~	15.665659	~~N (+)~~ S (-)	16.486163
405	Health Clinic	Keur Koura Dieri	± 5 m	E (+) ~~W (-)~~	15.705871	~~N (+)~~ S (-)	16.533778
408	School	Batlamine	± 5 m	E (+) ~~W (-)~~	15.666149	~~N (+)~~ S (-)	16.485901
409	School	Thiowor	± 5 m	E (+) ~~W (-)~~	15.701194	~~N (+)~~ S (-)	16.568620
410	Weekly Market	Potou	± 6 m	E (+) ~~W (-)~~	15.726434	~~N (+)~~ S (-)	16.525646
411	School	Leona	± 5 m	E (+) ~~W (-)~~	15.720264	~~N (+)~~ S (-)	16.463278
412	School	Thiowor	± 5 m	E (+) ~~W (-)~~	15.728573	~~N (+)~~ S (-)	16.456305
413	Convenience store nº1	Thiowor	± 5 m	E (+) ~~W (-)~~	15.731347	~~N (+)~~ S (-)	16.453902
414	Convenience store nº2	Thiowor	± 6 m	E (+) ~~W (-)~~	15.730972	~~N (+)~~ S (-)	16.454200

NAME: Jose Ramon Barnuevo	**Datum:** WGS84
GPS UNIT: MODI 6	**Date:** Various

Way point #	**Name**	**Location**	**GPS accuracy**	**Latitude**		**Longitude**	
415	Convenience store nº2	Tare	± 6 m	**E (+)** ~~**W (-)**~~	15.778996	~~**N (+)**~~ **S (-)**	16.535043
416	Mechanic workshop	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.727787	~~**N (+)**~~ **S (-)**	16.525454
417	Private motor pump nº2 (1)	Gabar	± 5 m	**E (+)** ~~**W (-)**~~	15.762681	~~**N (+)**~~ **S (-)**	16.530325
418	Private motor pump nº2 (2)	Gabar	± 5 m	**E (+)** ~~**W (-)**~~	15.762552	~~**N (+)**~~ **S (-)**	16.530647
419	Private motor pump nº3 (1)	Gabar	± 5 m	**E (+)** ~~**W (-)**~~	15.760671	~~**N (+)**~~ **S (-)**	16.527942
420	Private motor pump nº3 (2)	Gabar	± 4 m	**E (+)** ~~**W (-)**~~	15.760563	~~**N (+)**~~ **S (-)**	16.528168
421	Private motor pump nº3 (3)	Gabar	± 4 m	**E (+)** ~~**W (-)**~~	15.760398	~~**N (+)**~~ **S (-)**	16.529077
422	Private motor pump nº4 (1)	Gabar	± 5 m	**E (+)** ~~**W (-)**~~	15.767673	~~**N (+)**~~ **S (-)**	16.532401
423	Private motor pump nº5 (1)	Gabar	± 4 m	**E (+)** ~~**W (-)**~~	15.768130	~~**N (+)**~~ **S (-)**	16.532895
424	Private motor pump nº6 (1)	Gabar	± 4 m	**E (+)** ~~**W (-)**~~	15.757831	~~**N (+)**~~ **S (-)**	16.530304
425	Private motor pump nº6 (2)	Potou	± 4 m	**E (+)** ~~**W (-)**~~	15.758767	~~**N (+)**~~ **S (-)**	16.530369
426	Grinding mill	Whakhaldjiam	± 5 m	**E (+)** ~~**W (-)**~~	15.754427	~~**N (+)**~~ **S (-)**	16.392584
427	Grinding mill	Longhore	± 5 m	**E (+)** ~~**W (-)**~~	15.704534	~~**N (+)**~~ **S (-)**	16.475330
428	Grinding mill	Niayam	± 4 m	**E (+)** ~~**W (-)**~~	15.738814	~~**N (+)**~~ **S (-)**	16.546408
429	Manual irrigation nº1	Ndop	± 4 m	**E (+)** ~~**W (-)**~~	15.798235	~~**N (+)**~~ **S (-)**	16.481879
430	Manual irrigation nº2	Ndop	± 5 m	**E (+)** ~~**W (-)**~~	15.798146	~~**N (+)**~~ **S (-)**	16.480785
431	Manual irrigation nº3	Whekhe	± 5 m	**E (+)** ~~**W (-)**~~	15.810697	~~**N (+)**~~ **S (-)**	16.475407
432	Manual irrigation nº4	Potou	± 5 m	**E (+)** ~~**W (-)**~~	15.724059	~~**N (+)**~~ **S (-)**	16.520884

APPENDIX III: MARKET SURVEY

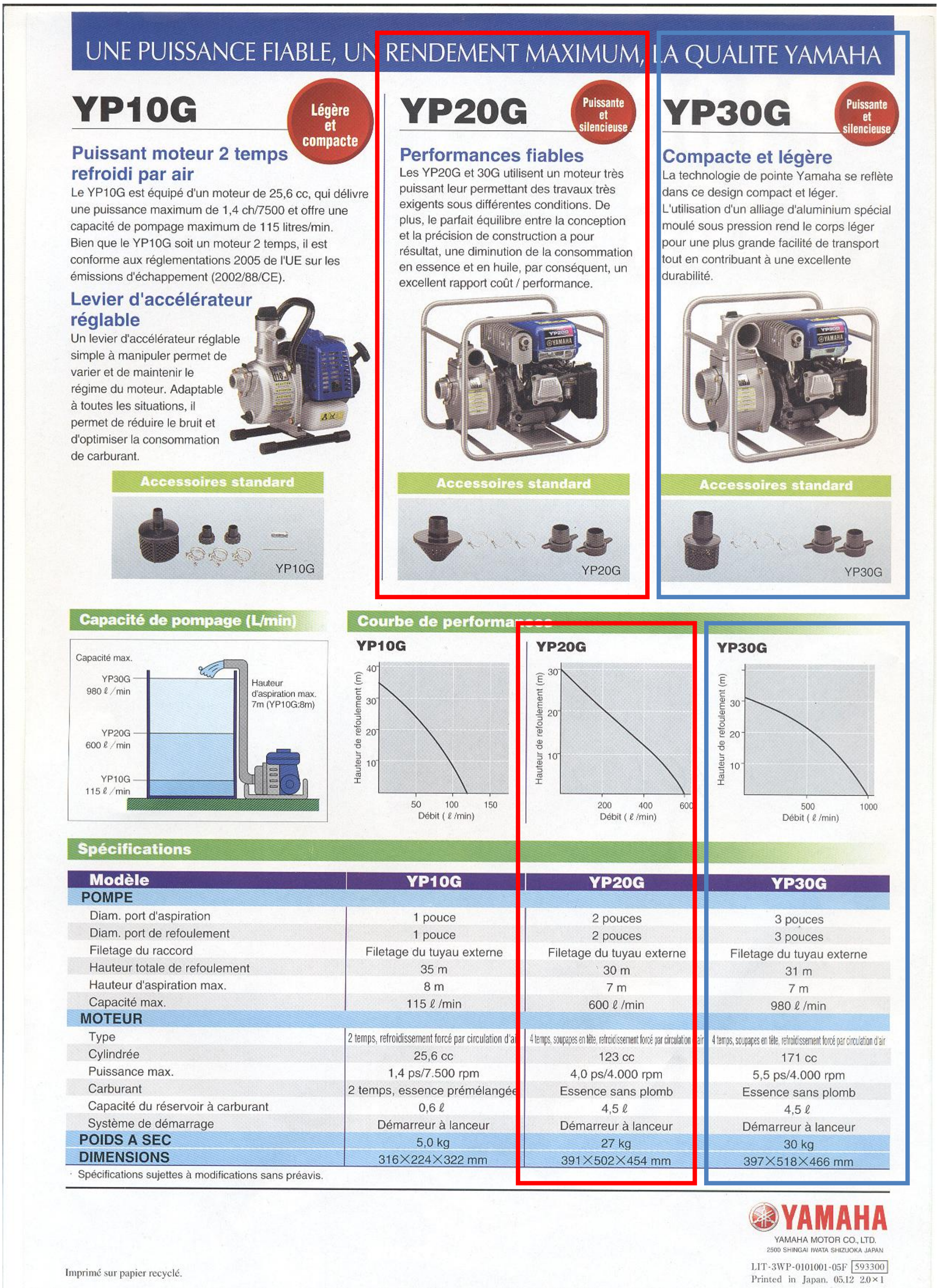
Situation	Date	Type	Quantity	Unit	Price (CFA)	Description	Notes/Comments
Market Léona	06/04/09	Unleaded Fuel	1	Liter	600		20 liters to sell
Shop 5 Leona	06/04/09	LPG	1	Bottle	2,900	Bottle 6kg	Pictures 235-236-237
	06/04/09	LPG	1	Bottle	1,800	Bottle 3kg	
	06/04/09	Batteries	1	Packet	400	Hellessens. R20. 1.5V	2 batteries per Packet
	06/04/09	Batteries	1	Packet	200	Hellessens. R6. 1.5V	2 batteries per Packet
	06/04/09	Candles	1	Unit	150	Big Model (≈30cm.)	
	06/04/09	Candles	1	Unit	35	Small model (≈20cm.)	
Market Léona	06/04/09	Batteries	1-2	Unit	115-150	Royal AAA. 1.5V	Price depends on quantity bought
	06/04/09	Batteries	1	Packet	400	Hellessens. R20. 1.5V	2 batteries per Packet
	06/04/09	Batteries	1	Packet	250	Royal R20D. 1.5V	2 batteries per Packet
Particulier	06/04/09	Coal	1	Pot	250	A little more than a kilogram	Pictures 240-241-242
	06/04/09	Wood	1	Char	7,000-8,000	Big branches	Pictures 243-244-246
	06/04/09	Wood	1	Char	3,000	Small branches	Picture 245
Shop 6 Léona	06/04/09	LPG	1	Bottle	2,800	Bottle 6kg	Pictures 248-249-250
	06/04/09	LPG	1	Bottle	1,300	Bottle 3kg	
	06/04/09	Batteries	1	Packet	400	Hellessens. R20. 1.5V	2 batteries per Packet
	06/04/09	Batteries	1	Packet	200	Hellessens. R6. 1.5V	2 batteries per Packet
	06/04/09	Battery charge	1	Recharge	1,000	Recharge complète. 12V	Every recharge
Shop 7 Léona	06/04/09	Matches	1	Packet	200	≈50 Matches/Packet	Every match 25CFA
	06/04/09	Batteries	1	Unit	250	Hellessens R20. 1.5V	Picture 042
	06/04/09	Batteries	1	Unit	200	Royal AAA. 1.5V	
	06/04/09	Candles	1	Unit	150	Big Model (≈30cm.)	
Market Potou	14/04/09	Candles	1	Packet	300	Small model (≈20cm.)	6 Candles per Packet
	14/04/09	Matches	1	Unit	25		
	14/04/09	Batteries	1	Unit	100	Hellessens R6. 1.5V	
Shop 5 Potou	14/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	
	14/04/09	Batteries	1	Unit	50	Royal AAA. 1.5V	
	14/04/09	Batteries	1	Unit	100	Hellessens AAA	
Shop 5 Potou	14/04/09	Batteries	1	Unit	100	Royal AA. 1.5V	
	14/04/09	Candles	1	Unit	50	Small model (≈20cm.)	
	14/04/09	LPG	1	Bottle	2,800	Bottle 6kg	
Shop 6 Potou	14/04/09	Fuel	1	Liter	800		
	14/04/09	LPG	1	Bottle	2,800	Bottle 6kg	
Market Potou	14/04/09	Batteries	1	Unit	100	Royal R20D. 1.5V	
	14/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	
	14/04/09	Batteries	1	Unit	50	Royal AAA. 1.5V	
	14/04/09	Batteries	1	Unit	100	Hellessens AAA	

Situation	Date	Type	Quantity	Unit	Price (CFA)	Description	Notes/Comments
Market Potou	14/04/09	Coal	1	Kg	250	One bag	
Shop 7 Potou	14/04/09	Unleaded Fuel	1	Liter	580		60l/week
	14/04/09	Battery charge	1	Recharge	1,000	24h	
Market Potou	14/04/09	Wood	1	Load	100		
Shop 1 Gabar	07/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	
	07/04/09	Candles	1	Unit	50	Small model (≈20cm.)	
	07/04/09	Candles	1	Unit	150	Big model (≈30cm.)	
Shop 2 Gabar	07/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	20 units/month
	07/04/09	Candles	1	Unit	125	Big model (≈30cm.)	30 units/month
Shop 1 Leona	31/03/09	Batteries	1	Unit	250	Hellessens R20. 1.5V	
	31/03/09	Batteries	1	Unit	200	Royal AAA. 1.5V	60 units/month
	31/03/09	Candles	1	Unit	150	Big model (≈30cm.)	12 units/month
Shop 1 Potou	03/04/09	LPG	1	Bottle	2,900	Bottle 6kg	
	03/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	
	03/04/09	Batteries	1	Unit	100	Royal AAA. 1.5V	
	03/04/09	Candles	1	Unit	50	Small model (≈20cm.)	
	03/04/09	Candles	1	Unit	100	Big model (≈30cm.)	
Shop 3 Potou	03/04/09	Battery charge	1	Recharge	1,000	24h	
	03/04/09	LPG	1	Bottle	3,000	Bottle 6kg	
	03/04/09	LPG	1	Bottle	1.500	Bottle 3kg	
	03/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	
Shop 4 Potou	15/04/09	Battery charge	1	Recharge	1,000	24h	
	15/04/09	Unleaded fuel	1	Liter	582	Unleaded fuel	200l/week
	15/04/09	Diesel	1	Liter	491	Diesel	180l/week
	15/04/09	Mix	1	Liter	650	Unleaded fuel+oil (10/1)	110l/week
Shop 1 Tare	07/04/09	LPG	1	Bottle	3,000	Bottle 6kg	60 bottles/month
	07/04/09	Batteries	1	Unit	200	Hellessens R20. 1.5V	40 units/month
	07/04/09	Batteries	1	Unit	175	Royal R20D. 1.5V	40 units/month
	07/04/09	Batteries	1	Unit	100	Hellessens R6. 1.5V	40 units/month
	07/04/09	Batteries	1	Unit	50	Royal AAA. 1.5V	40 units/month
	07/04/09	Candles	1	Unit	50	Small model (≈20cm.)	100 units/month
	07/04/09	Candles	1	Unit	100	Big model (≈30cm.)	100 units/month
Shop 2 Tare	15/04/09	LPG	1	Bottle	2,750	Bottle 6kg	
	15/04/09	Batteries	1	Unit	225	Hellessens R20. 1.5V	24 units/month
	15/04/09	Batteries	1	Unit	100	Royal AA. 1.5V	24 units/month
	15/04/09	Batteries	1	Unit	50	Royal AAA. 1.5V	24 units/month
Shop 1 Thiowor	14/04/09	LPG	1	Bottle	2,800	Bottle 6kg	10 bottles/week
	14/04/09	LPG	1	Bottle	1,400	Bottle 3kg	7 bottles/week
	14/04/09	Batteries	1	Unit	200	Royal R20D. 1.5V	24 units/month
	14/04/09	Batteries	1	Unit	100	Hellessens R6. 1.5V	24 units/month

Situation	Date	Type	Quantity	Unit	Price (CFA)	Description	Notes/Comments
	14/04/09	Candles	1	Unit	50	Small model (≈20cm.)	8 units/month
	14/04/09	Candles	1	Unit	100	Big model (≈30cm.)	8 units/month
Shop 2 Thiowor	15/04/09	Batteries	1	Unit	200	Royal R20D. 1.5V	240 units/month
	15/04/09	Candles	1	Unit	50	Small model (≈20cm.)	

APPENDIX IV: MOTOR PUMPS PROVIDED BY THE MVP

Technical specifications of the Motor pumps provided by the MVP (red) and those who are private (blue)



UNE PUISSANCE FIABLE, UN RENDEMENT MAXIMUM, LA QUALITE YAMAHA

YP10G — Légère et compacte

Puissant moteur 2 temps refroidi par air

Le YP10G est équipé d'un moteur de 25,6 cc, qui délivre une puissance maximum de 1,4 ch/7500 et offre une capacité de pompage maximum de 115 litres/min. Bien que le YP10G soit un moteur 2 temps, il est conforme aux réglementations 2005 de l'UE sur les émissions d'échappement (2002/88/CE).

Levier d'accélérateur réglable

Un levier d'accélérateur réglable simple à manipuler permet de varier et de maintenir le régime du moteur. Adaptable à toutes les situations, il permet de réduire le bruit et d'optimiser la consommation de carburant.

Accessoires standard — YP10G

YP20G — Puissante et silencieuse

Performances fiables

Les YP20G et 30G utilisent un moteur très puissant leur permettant des travaux très exigents sous différentes conditions. De plus, le parfait équilibre entre la conception et la précision de construction a pour résultat, une diminution de la consommation en essence et en huile, par conséquent, un excellent rapport coût / performance.

Accessoires standard — YP20G

YP30G — Puissante et silencieuse

Compacte et légère

La technologie de pointe Yamaha se reflète dans ce design compact et léger. L'utilisation d'un alliage d'aluminium spécial moulé sous pression rend le corps léger pour une plus grande facilité de transport tout en contribuant à une excellente durabilité.

Accessoires standard — YP30G

Capacité de pompage (L/min)

Capacité max.
YP30G 980 ℓ /min
YP20G 600 ℓ /min
YP10G 115 ℓ /min
Hauteur d'aspiration max. 7m (YP10G:8m)

Courbe de performances

YP10G — Hauteur de refoulement (m) / Débit (ℓ /min)
YP20G — Hauteur de refoulement (m) / Débit (ℓ /min)
YP30G — Hauteur de refoulement (m) / Débit (ℓ /min)

Spécifications

Modèle	YP10G	YP20G	YP30G
POMPE			
Diam. port d'aspiration	1 pouce	2 pouces	3 pouces
Diam. port de refoulement	1 pouce	2 pouces	3 pouces
Filetage du raccord	Filetage du tuyau externe	Filetage du tuyau externe	Filetage du tuyau externe
Hauteur totale de refoulement	35 m	30 m	31 m
Hauteur d'aspiration max.	8 m	7 m	7 m
Capacité max.	115 ℓ /min	600 ℓ /min	980 ℓ /min
MOTEUR			
Type	2 temps, refroidissement forcé par circulation d'ai	4 temps, soupapes en tête, refroidissement forcé par circulation d'air	4 temps, soupapes en tête, refroidissement forcé par circulation d'air
Cylindrée	25,6 cc	123 cc	171 cc
Puissance max.	1,4 ps/7.500 rpm	4,0 ps/4.000 rpm	5,5 ps/4.000 rpm
Carburant	2 temps, essence prémélangée	Essence sans plomb	Essence sans plomb
Capacité du réservoir à carburant	0,6 ℓ	4,5 ℓ	4,5 ℓ
Système de démarrage	Démarreur à lanceur	Démarreur à lanceur	Démarreur à lanceur
POIDS A SEC	5,0 kg	27 kg	30 kg
DIMENSIONS	316×224×322 mm	391×502×454 mm	397×518×466 mm

· Spécifications sujettes à modifications sans préavis.

YAMAHA
YAMAHA MOTOR CO., LTD.
2500 SHINGAI IWATA SHIZUOKA JAPAN

Imprimé sur papier recyclé.

LIT-3WP-0101001-05F 593300
Printed in Japan. 05.12 2.0×1

Farmers that were given a motor pump from the MVP and its work situation

Nº	Farmer	Village	Situation
1	Ida BOYE	MOUREL	PU
2	Assane DEME	GABANE	NPU
3	Omar Sadio BA	NIAYAM	PU
4	Ousmane BA	GABAR	PU
5	Babacar BOYE	MOUREL	W
6	El Hadji Fatel SOW	GABANE	PU
7	Sidy DIOP	NGOUFATTE	W
8	Arona DIOP	KEUR KOURA DIERI	PU
9	Samba BOYE	MOUREL	NPU
10	El Hadji Ousseynou KA	NDIALAGNE	PU
11	Djiby Aïbatou DIOP	GABAR	PU
12	Ndiaye BA	NIAYAM	W
13	El Hadji Magatte BOYE	MOUREL	W
14	Abdou SOW	NIAYAM	PU
15	Balla DIOP	NGOUFATTE	PU
16	Amadou KA	SAGUE SATHIEL	PU
17	Insa DIOP	KEUR KOURA DIERI	PU
18	Salif BA	MOUREL	W
19	Mbaye SARR	KEUR KOURA DIERI	PU
20	Baye BA	KEUR AMADOU MOUNA	PU
21	Babacar WADE	MAKA MARE MADICKE	PU
22	Ndiogou NDIAYE	GABAR	PU
23	Ahmadou SOW	MOUREL	PU
24	Marie BA	NIAYAM	PU
25	Mama SOW	GABANE PEUL	PU
26	Abdou Toute BOYE	MOUREL	W
27	El Hadji NIANG	MOUREL	W
28	Ndiogou DIOP	TARE	PU
29	Yelly NDIAYE	TARE	PU
30	Moustapha DIOP	GABAR	PU
31	Magatte BA	DIGAL	PU
32	El Hadji Mbaye DIOP	GABAR	W
33	Papa BOYE	MOUREL	PU
34	Modou DIOP	RAYETTE NIAYAM	PU
35	Standby	-	-

PU: Picked Up
NPU: Not Picked Up
W: Working