Evaluation of Solar Panel Energy Support
Senegal Case Study 2010

October 2010

Nordic Development Fund
Ex-Post Evaluation NDF Credit 286

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b) Map of Senegal showing the provincial subdivision after 2005 with 14 provinces, viz.

Dakar
Diourbel
Fatick
Kaffrine
Kaolack
Kédougou
Kolda
Louga
Matam
Saint Louis
Sédhiou
Tambacounda
Thiès
Ziguinchor

Array (PV Array): several solar modules connected together either in series or parallel.

Converter: electronic device for DC power to step up voltage and step down current proportionally or vice versa.

DC – Direct Current: type of power generated by photovoltaic modules and by storage batteries.

Inverter: an electronic device that converts DC to AC power.

Photovoltaic: the phenomenon of converting light to electric power.

PV Array Direct: the use of electric power directly from a photovoltaic array, without storage batteries. Most solar water pumping systems work this way utilising a tank to store water.

PV cell: the individual photovoltaic device.

PV module: an assembly of PV cells framed into a weatherproof unit (also called PV panel).

Stand-alone system: a solar water pumping system feeding a solar well pump without the use of a battery bank.

Watt-peak (Wp) is a measure of the nominal power of a photovoltaic solar energy device under laboratory illumination conditions.

Pumping and pump components

Bore hole: synonym for drilled well.

Centrifugal pump: a pumping mechanism that spins water by means of an impeller. Water is pushed out by centrifugal force.

DC motor – permanent magnet: all DC solar pumps use this type of motor in some form. It is a variable speed motor.

Drop pipe: the pipe that carries water from a pump in a well up to the surface. It also supports the pump.

Head: synonym of vertical lift.

Induction motor: the type of electric motor used in conventional AC water pumps. It requires an inverter to operate in PV energised system.

Pump controller: an electronic device that varies the voltage and current of a PV array to match the needs of an array direct pump. It allows the pump to start and to run under low sun conditions without stalling.

Submersible pump: a motor/pump combination designed to be placed entirely below the water surface.

Total dynamic head: vertical lift + friction loss in piping.

Vertical lift: The vertical distance that water is pumped. This determines the pressure that the pump pushes against. Total vertical lift = vertical lift from surface of water source up to the discharge in the tank.

Well seal: top plate of a well casing that provides a sanitary seal and support the drop pipe and pump.

In terms of effectiveness it can be said that for the PVP systems still in operation at present the immediate objectives of the project sub-component have been fully or partially achieved. For the systems that did operate some years but are now out of order, whatever the reason, effectiveness does no longer exist. In the villages where the PVP systems are in operation there are significant impacts in terms of lesser burden for fetching water and time spent for this daily activity. The time gain is of considerable benefit to the female members of the community, who are the ones primarily concerned with catering for the needs of the families in relation to water and firewood.

As "owners" of the pumping systems the local communities were expected to actively ensure the long term sustainability of investments, and of the derived benefits. The local communities and the management committees that were set up and to some extent trained have faced major challenges linked to the social environment. Concepts like ownership, financial management, not to mention rudimentary technical information on complicated technical systems like PV and submersible pumps cannot be passed on to a target group with no or only little school background in the matter of a short training session. The balance between sustainability to be achieved through water sales revenue and the villagers 'affordability has proven to be difficult or even impossible to strike.

As the visits in the field have confirmed it is easier to install a water supply system than to ensure its sustained operation, especially when dealing with some of the country poorest villages in far away areas. PVP systems have a number of well known advantages when compared to diesel based systems, e.g. they operate practically unattended, they do not need fuel to operate and they do not impact on climate. It is also acknowledged that they have a high up front capital cost and that they often require skilled technicians to be repaired. Even though they do not have moving parts one has to reckon with the fact that they are not maintenance and repair free. To the discharge of the PV technology it must be highlighted that faulty systems in the villages visited were mostly the result of submersible pump problems. However, such a pump is a very critical component of the system and when it fails the system is no longer able to provide water to the rural community, as intended.

Costly repairs or replacement of parts are financially out of reach for the communities involved. Even though water is charged to the users, sufficient capital reserves cannot be accumulated to cope with such situations. When a major failure occurs, systems fall then into disuse.

To increase the chances of success for projects based on the use of PV technology a number of recommendations are presented:

1. A participatory approach in project preparation is to be favoured, not only to correctly assess and understand the local communities' needs and priorities but

1. Introduction

Infrastructure and Energy is one of the Nordic Development Fund's three areas of intervention according to the Fund's new mandate, which focuses on climate change adaptation and mitigation. Within the field of energy it is expected that renewable energy projects will be supported, including projects based on the use of solar energy.

The Fund has a long standing experience of interventions in the energy sector, for the most in connection with large electrical infrastructure projects involving power transmission and distribution systems in developing countries. Some earlier interventions did support the use of renewable energy sources like solar energy. Seen in the light of the fund's new mandate it seems essential to capitalise on the experience from earlier solar energy projects. It is in this context that the NDF has decided to carry out an evaluation of two solar energy projects, one in Honduras (NDF Credit 350 – National Education Reform 2001 – 2009) and one in Senegal (NDF 286 – Poverty Alleviation Project 1999 – 2009, known in Senegal under the acronym PLCP: *Projet de Lutte Contre la Pauvreté*). The main objective of the evaluation is to provide NDF with an assessment of the present status and operation of the photovoltaic systems financed by NDF after 2 – 6 years of operation.

This report presents the results of the evaluation conducted in Senegal. Besides this introductory section the report consists of a number of sections to address the main issues specified in the TOR for the evaluation (see Appendix 1 for a copy of the TOR). The other sections of the report are the following;

- Section 2 is intended to give an overall country setting and a short description of NDF credit 286, including objectives, outputs and activities.
- Section 3 is intended to present an overview of the evaluation methodology and practical challenges faced during the field evaluation activities.
- Section 4 is intended to give the evaluator's key findings in five critical areas, as highlighted in the TOR, i.e. Status of the installed systems, Relevance, Efficiency, Effectiveness and Impact and, last but not least, Sustainability.
- Section 5, which presents an overall conclusion and a summary of lessons learned, and
- Section 6, which gives recommendations for consideration in connection with future support to solar energy projects.

A very last section (Section 7) includes a number of appendices to the report.

This introduction would not be complete without expressing the author's gratitude to Ms. Mbacke Khady Fall Ndiaye, formerly head of the PLCP, and other key persons met, who together with her were involved in implementing the project. Without their kind support and advices it would not have been possible for the author to visit in the middle of the rainy season a total of 15 sites in the five provinces covered by the PLCP.

According to Transparency International's Corruption Perception Index (CPI) Senegal is ranked as No. 99 (together with Bosnia & Herzegovina, the Dominican Republic, Jamaica, Madagascar, Tonga and Zambia) out of 180 (Somalia has the bottom ranking - No.180).

2.2 Overview of NDF Credit 286

A credit agreement was signed on 25 May 1999 between the Ministry of Economy, Finance and Planning on behalf of the Republic of Senegal and the NDF. The credit amount was SDR 5 million. At the prevailing exchange rate (SDR 1.0 = XOF 796.4) this amount converted into XOF 3.982 billion. The proceeds of the credit were intended to finance a specific component of a larger project – Poverty Alleviation Project, better known under the acronym PLCP (Projet de Lutte contre la Pauvreté).

The total cost of the PLCP was estimated at SDR 18.6 million, including a 5% provision for physical contingencies and a 3% provision for price escalation. Other financing institutions involved in supporting the PLCP were the AfDF (SDR 10 million) and TAF – Technical Assistance Fund of the AfDB (SDR 1.75 million). The Government of Senegal also contributed with an amount of SDR 1.85 million.

The PLCP consisted of four components, as follows:

I. Capacity Building for beneficiaries and partners, including:
   1) Sensitisation, literacy and IEC activities
   2) Capacity building for partners

II. Microfinance and support to income generating activities

III. Infrastructure, equipment and water supply, including:
   1) Socio-community infrastructure and equipment
   2) Rural/village water supply
   3) Community centres and socio-educative day care centres

IV. Project management

The NDF credit was used to implement sub-component (2) of component III, i.e. rural/village water supply. The immediate objective of the sub-component was to improve both in qualitative and quantitative terms water supply in the village concerned while reducing the burden of fetching water (mainly a female task).

The PLCP was implemented under the supervisory authority of the Ministry of the Family, Social Action and National Solidarity. Project management at national level was entrusted a Project Management Unit located in Dakar, the capital, and five Regional Management Units, one for each of the regions involved in the PLCP, i.e. Dakar, Diourbel, Kolda, Tambacounda and Thiès. The

Other outputs have been produced besides those mentioned above, they include a number of wells or bore holes, small piped water systems, latrines and manual water pumps.

Major activities carried out to produce the outputs encompassed design studies, bidding, sinking of wells, drilling of bore holes, civil works for water storage reservoirs, supply and installation of technical equipment such as D/G sets, PV arrays, piping and submersible water pumps.

3. Evaluation methodology

The TOR for the evaluation already provided some guidance on methodology. The methodology followed for this evaluation is based on a number of successive steps. They are as summarised below:

- Review of available project documents and other relevant background documents dealing with PV technology in general and PVP systems more particularly;
- Meeting in Denmark with the company which was given the responsibility for supply and installation of the water supply systems;
- Mission to Senegal to discuss in the capital city with persons with project knowledge, such as the former head of project and project management staff, project consultants and local representative of supplier/contractor;
- Field trips during the mission in Senegal to a representative sample of villages equipped with water supply systems in Phase I and Phase II, interviews of local stakeholders and inspection of systems, including photographing;
- Debriefing with former project management before leaving Senegal;
- Reporting.

Taking into account difficulties in accessing many of the villages during the rainy season, as well as the time frame and the budget allocated to the evaluation, it was not found feasible to visit all of the 50 villages where a PVP system has been set up in the framework of the PLCP. A representative sample of 12 villages in the five provinces covered by the project was selected in cooperation with the former head of the PLCP and a list of local contact persons was established for each one of the provinces. For comparative purposes it was decided to include in the sample a few villages with a water pumping system based on a D/G set as energy source. The sample came thus to include 8 PVP systems and 4 D/G based systems.

Field trips to the villages proved to be an exciting challenge. More than 2 or 3 villages could not be visited in a single day due to the distances involved, the road conditions and even at times difficulties to find the right village. Even so, it proved possible to increase the sample size from the anticipated 12 to 15 villages, i.e. 11 villages with a PVP system and still 4 with a D/G based system. The trips to the 15 villages took 8 days with 2,300 km of driving in a 4x4 on all kinds of tarmac roads, dirt roads and tracks and with one single tyre puncture, without serious consequences.

Additional details on technical equipment procured through the respective contracts can be found in Appendix 5.

There are discrepancies in the information and documents received as to the exact number of PVP systems actually installed and commissioned. In Phase I equipment for 37 systems was procured with 24 systems actually implemented. In Phase II equipment for 16 systems was procured and 26 systems were implemented. As the equipment available at the beginning of Phase II was indeed sufficient for 13 systems (left over from Phase I) and 16 systems (procured under Phase II), in total 29 systems, this leaves a number of three systems unaccounted for[1].

As mentioned under section 3, a representative sample totalling 15 villages/ water supply systems was visited as part of the evaluation. The operational status of the systems as revealed by the visits was as follows:

a) For PVP systems
Of the 11 systems visited, one had never been completed and 10 had been commissioned in the interval 2004 – 2007. Of the 10 commissioned systems four were still operating and six were out of order due to various technical problems.

b) For D/G based systems
The 4 systems visited all had been commissioned in the interval 2005 – 2007. Out of the four systems one was still operating and three were out of order due to various technical problems.

For each of the 15 villages visited a specific data and information sheet has been drafted. The main headings of the data sheets are:

1. Overview & status
2. Relevance
3. Efficiency & effectiveness
4. Impact
5. Sustainability

Each of the above items has been the starting point for collecting specific information through discussions with stakeholders met on site. In most of the villages it has been possible to interview the village chief and sometimes members of the village water management committee. Reference is made to Appendix 3 for details on the information gathered at each of the 15 villages visited. In order to give an overview of the situation in the visited villages a summary is presented in table form below.

[1] On the home page of the equipment supplier "Dansk Solenergi" a total number of 62PVP systems is stated. Clarification from the supplier has been attempted but not obtained.

Sare Alkaly	Kolda	PVP (S1)	Commissioned in 2008. Pump breakdown early 2010. Out of order since.

All 6 PVP systems which have stopped operating are of type S1, which is the smallest in terms of pumping capacity and lift of the systems put to use in the project (see Appendix 5 for technical details), and in five out of six instances the cause of failure is linked to the submersible pump. The last case is seemingly related to an insufficient water flow in the well, which in turn affected pump operation as sand was entering in excessive quantities the pump strainer.

All the 4 PVP systems still in operation are of type S3, which is the largest in terms of pumping capacity and lift of the systems used in the project and has a different type of submersible pump (see also Appendix 5 for technical details). Taking into account that only a sample of systems was visited one has to be careful in trying to establish some kind of pattern in the causes of system failure. However, pump problems are clearly a predominant recurrence.

In the D/G based water pumping systems visited for comparative purposes the systems not in operation any longer had all developed some kind of engine problem. In the one case, where the engine starting key had disappeared the problem should never have occurred in the first place. When it did occur, it led to a situation of complete deadlock.

4.2 Relevance

Relevance is the extent to which the objectives of a development intervention are consistent with beneficiaries' requirements, country needs, global priorities and partners' and donors' policies.

The intervention financed by NDF was conducted within the framework of a comprehensive poverty alleviation project, the PLCP, which was highly prioritised by the Government of Senegal. Poverty alleviation in general and interventions intended to provide essential basic needs like access to clean drinking water are also fully in line with NDF's development policy, even more so when it is recalled that the number of people in remote rural areas of developing countries still using unsafe drinking water sources is over 884 million (UNICEF estimate). Seen in the perspective of the Millennium Development Goals the NDF supported sub-component was also absolutely relevant.

Within the framework of the PLCP setting up of water pumping systems was intended to address three major issues:

- Make water accessible to rural communities in sufficient quantities;
- Improve the quality of the drinking water supply;
- Reduce the burden of fetching water from traditional wells and other water sources, which is mainly a female task in the rural areas.

evaluators. Incidentally, that bid was from the same company that earlier had been awarded a contract for the supply of the same type of equipment for Phase I. The bid was found responsive and acceptable and a new contract was concluded with the bidder (Dansk Solenergi).

The price schedules attached to the contracts for Phase I and Phase II are unfortunately not sufficiently detailed and it is thus not possible to see what price has been charged for the respective PV modules. The price per W_p would have been a good indicator enabling comparison with other market prices. What can be seen from the available price schedules is that between the first bidding round in October 2003 (Phase I) and the second one in April 2005, i.e. through a time span of 18 months, the PVP systems S1, S2 and S3 jumped approx. 24% in price. For the PV modules the price increase is likely to be the result of the boom in the German market that started in 2004 and led to price increases in the order of magnitude of 25% precisely for the size of modules (80 W_p) used in the project[2]. What is more surprising and cannot be readily explained is that the price of the D/G based system also increased by the same percentage from Phase I to Phase II.

It is a well known fact that limited competition in project implementation has a strong tendency to lead to higher prices. Nordic Competitive Bidding, as practised then, implied a limited number of players as compared to International Competitive Bidding. Earlier attempts at assessing the "cost" of reduced competition, as for example in tied bilateral aid showed that an extra cost to be in the range of 20 – 30%, depending on very many factors, was not unlikely. One could easily consider that the same order of magnitude would have applied to NCB procured equipment as compared to ICB procurement.

NDF's earlier requirement on Nordic content of the equipment and services to be procured may also have had a price increasing effect, as it is no surprise that manufacturing costs in the Nordic countries are much higher than in a number of emerging economies in Asia and elsewhere. This is also why many European manufacturers have delocalised wholly or partly their production to such countries. Whether the quality of the equipment procured is comparable can of course be subject to analysis.

It was stipulated in the credit agreement that 100% of goods (i.e. equipment and supplies) were to be of Nordic origin (100% of works were left as local/open and services were split 50 – 50 between Nordic and local/open). From the site inspections carried out it is evident that this requirement was not met in relation to the supply of goods. Most of the high cost/high tech equipment is not of Nordic origin, e.g. all PV modules are from TOTAL Energie, including converters and inverters to supply the submersible pumps. The submersible pumps in the S3 system are truly Nordic, but the origin of pumps in the S1 and S2 systems is not clear. In the G systems (D/G based) the Diesel generator sets are from the UK.

[2] An attempt was made to get more detailed price information from the equipment supplier after completion of the mission in Senegal. A meeting was set up with the supplier but was cancelled by the former at very short notice leaving the raised questions open.

training has taken place is has unfortunately not left any long lasting traces and measurable effect.

Some delays were experienced with the delivery of equipment for the PVP systems, but they did not have any impact on the overall implementation schedule for the sub-component. Delays that impacted on the construction of some of the systems were those experienced with civil works, including well sinking/bore hole drilling. Such delays may explain why construction of a PVP system in one of the villages visited (Hamdelaye Dega) was never actually completed, i.e. the project closed down before the technical installation could be implemented.

Two consultants were appointed in connection with the implementation of the sub-component. One, COWI (Denmark) associated to AISB (Senegal), was in charge of Technical Assistance in connection with the water supply systems, including drafting of tender documents and specifications, evaluation of tenders, supervision of systems. The other consultant, Hydroconsult International, was in charge of site supervision, including civil works and other works in connection with wells and bore holes. How the consultants were selected is not indicated in the background documents made available. However, for the Technical Assistance consultant it is likely that NCB procedures were followed whereas Senegalese procurement rules might have been applied for selecting the other consultant.

In terms of efficiency appointing one consultant only would have been a better alternative as it would have improved coordination between the two main fields of project activities in the sub-component, i.e. system design and hydrology/ civil works.

4.4 Effectiveness and impacts

Effectiveness is the extent to which the development intervention's objectives were achieved, or are expected to be achieved, taking into account their relative importance.

For the PVP systems that still are in operation at present the immediate objectives of the project component III/sub-component 2 have been achieved. That is for example the case of Keur El Hadji, commissioned in 2005. In another of the visited villages, Keur Seny Diouf, the immediate objectives have only been partially achieved as the system is experiencing water flow problems, even though the technical components are in operating order.

For the systems that did operate some years but are now out of order, whatever the reason, it is obvious that the immediate objectives are no longer achieved, hence creating a situation of disappeared effectiveness. The most critical in the villages experiencing such a situation is the prospect of having the systems repaired, as this could lead to renewed effectiveness. Unfortunately, such a prospect does look bleak in all these villages as in none of them do local communities have the financial capability that would enable them to pay for replacement of expensive parts, like a submersible pump or an inverter (approx. XOF 300,000 – 400,000 or EUR 460 – 610) and associated work.

4.5 Sustainability

Sustainability is the continuation of benefits from a development intervention after major development assistance has been completed. It is also the probability of continued long-term benefits and the resilience to risk of the net benefice flow over time.

Outputs in terms of water fetching points were achieved at a rate of 98 % (cf. Project completion report of Phase II) with approx. 70% of them equipped with electric pumps energised by a PV array or a D/G set. It is likely that a similar completion rate was achieved in Phase I (cannot be verified as a Phase I completion has proved impossible to track). As long as the project organisation was active results were generated. When the project organisation closed down the outputs out in the field were a reality and the ownership was transferred to the local communities and beneficiaries. As "owners" of the outputs (the pumping systems) the local communities were expected to actively ensure the long term sustainability of investments, and of the derived benefits.

From the villages visited it appears that the local communities were not sufficiently prepared to be confronted with such a task. To take care of system management the project approach was to set up a management committee composed of male and female members of the community in each village. This has been done in all villages probably, but with varying results. One of the strong points made when setting up village committees was the issue of water charges and acceptance of payment by the users. This principle was known and practiced in all villages visited with systems in operation, but one. The same principle was also remembered in villages where systems were no longer in use due to failure.

Even when the principle of payment for water is accepted one has to strike an extremely difficult balance between what the members of the community can afford to pay and what would be necessary to achieve a reasonably stable financial situation, at least a situation where the community can pay for operation and maintenance costs. With the PVP systems operation costs are very low, mostly related to plumbing repairs (taps, valves). On the contrary maintenance costs (whether dealing with preventive or breakdown maintenance) can be high when components like submersible pumps, inverters or converters are to be replaced. Visits to the villages have shown that expenses up to approx. 40,000 – 50,000 (EUR 60 – 75) can be paid by the communities, whereas higher expenses, XOF 300,000 – 400,000 (EUR 460 – 610) are beyond their financial capabilities. When major failures occur they seal the fate of the faulty system, which will be left as such and gradually fall into a state of disrepair.

The prices charged for water, which are likely to have been determined by the PLCP with due regard to the difficult balance mentioned above, are not sufficient to ensure financial

The lack of technical documentation and manuals was a recurring problem in practically all visited villages. To the extent it existed, documentation was written in French, which did not make it readily accessible to most of the system operators and other community members. There were very diverging information as to the extent of training provided, and in many cases it was alleged that no training had been provided at all. Insufficient technical documentation compounded by lack of training has serious consequences in the event of technical failure. System operators and community members are left without guidance on actions to be taken when abnormal situations occur. It was symptomatic of the situation that in none of the villages visited a simple log book to register operation parameters and possible incidents was found. All such weaknesses make it difficult if not impossible to establish some kind of technical long term sustainability.

5. Conclusions and lessons learned

As the visits in the field have confirmed it is easier to install a water supply system than to ensure its sustained operation. The target group of the PLCP, i.e. some of the country poorest villages in far away areas made the prospect of achieving sustainability an even more daunting task. It was nonetheless attempted by the project organisation, which succeeded to a large extent in producing the planned outputs, in casu 50 or so PVP systems, a number of D/G based pumping systems and a number of manually operated water pumps, together with wells, bore holes, small water distribution systems, stand posts, etc.

The participatory approach adopted through the project was a suitable choice, and through that approach it was attempted to set up water management committees in the villages. Still as part of the approach some training was provided to members of the communities involved, mostly with regard to management. Taking the social environment into account the actions conducted proved not sustainable as they could not be repeated again and again, as they should have been, if long term and durable effect was to be achieved. When implementing Phase II the project ran into a time problem as the closing date was approaching and training activities had to be hurried through. The foundation laid in order to achieve organisational and financial sustainability was not sufficiently consolidated and rather quickly began to smoulder.

PVP systems have a number of well known advantages when compared to diesel based systems, to name but a few they operate practically unattended, they do not need fuel to operate (with the ever increasing cost of petroleum products this is by no means a minor advantage) and they do not impact on climate. It is also acknowledged that they have a high up front capital cost and that they often require skilled technicians to be repaired. Even though they do not have moving parts one has to reckon with the fact that they are not maintenance and repair free.

To the discharge of the PV technology it must be highlighted that faulty systems in the villages visited were mostly the result of submersible pump problems. However, such a pump is a very businesses involved in PV applications like water pumping and public lighting. Training is to be made a recurrent activity in a period of no less than 5 years. If the starting level for training at community level is deemed to be too low (if reading and writing are for example not mastered) literacy courses should be conducted as a start. To the extent feasible, taking into account lack of transportation means and distances involved, exchange of experience between villages where system operation is successful and villages faced with difficulties could also be a useful tool.

3. Financial sustainability: the starting point has to be local communities' ability to pay tariffs, e.g. for water or electricity, and assessing whether what the community is able to pay would ensure sustainability. When sustainability cannot be achieved through low level tariffs, mechanisms have to be developed to provide access to capital to cover repair and maintenance related expenses. Mechanisms should preferably be based on Government contributions through the state budget (resort Ministry, national agency). A pre condition to financing any project should be a written Government guarantee that annual state budgets will provide the agreed amount to ensure long term sustainability, i.e. min. for a 10-year period. In some instances/countries other financial tools could be considered like micro-finance or support trough NGO's dealing with energy aspects including PV applications.

4. Maintenance manuals and technical documentation have to be adapted to the local communities' language abilities and general knowledge level. Use of pictograms for showing actions to be taken in connection with operation and maintenance should be considered. Use of laminated information sheets should also be considered, as well as use of waterproof filing boxes to keep documentation.

5. A Technical Assistance (TA) mechanism able to provide unbiased advice to local communities in the event of system failure is to be set up in order to ensure system sustainability. Whether such a mechanism should be state run (e.g. national agency dealing with RE technologies and PV applications) or be the result of a Public Private Partnership will have to be determined on a case by case basis taking into account a number of factors like the degree of penetration of PV technology in the country, the public sector performance in the energy sector and/or other relevant sector like water/hydraulic resources, the strengths and weaknesses of the private sector dealing with RE and PV technology, including local consultancy companies and individual experts.

6. Servicing of PV based systems (maintenance and repair) is a task that requires specific know how and a dedicated external organisation with well trained technicians. This organisation, which should be able to operate at three levels, i.e. national, regional and local, should also be able to provide for the needed spare parts within short delays. Any project intending to use PV technology should assess what capabilities are available on the local market in terms of servicing. If capabilities are low, boosting of capacity in the companies involved should be promoted or undertaken within the project.

Appendix A

Terms of Reference

Evaluation of Solar Panel Energy Support

Impact and Sustainability

Senegal Case Study 2010

1. Background

The Nordic Development Fund (NDF) has provided financing to the energy sector in more than 25 countries during the past two decades. While much of this support went to traditional energy solutions NDF credits have also financed a number of renewable energy solutions such as solar energy.

The new NDF mandate to support climate change projects in poor countries follows a strategy with three focus areas:

a) Infrastructure and Energy
b) Natural Resources
c) Capacity Development

The new grant projects to be supported within the Infrastructure and Energy focus area will include solar energy systems. In order for NDF to be able to secure long-term sustainability in the delivery of renewable energy solutions it has been decided to evaluate the experiences of the same type of technology transfer in concluded NDF credit projects. The evaluation will focus on the following two projects:

- NDF 286 Senegal: Poverty Alleviation project 1999-2009
  Installation of 62 solar energy systems to provide electricity to water pumps in rural areas of Senegal in the period 2004-05.

- NDF 350 Honduras: National Education Reform 2001-2009
  Installation of 151 solar energy systems in the period 2005-06, and installation of additional 102 solar energy systems in 2008 to provide electricity to rural schools in Honduras

- Describe the institutional integration of the solar energy technology into local institutions including demand and ownership among local stakeholders.
- Describe relevance with regard to geographical location including urban and rural settings.

Efficiency and Effectiveness

- Have the solar energy systems been acquired with due regard for economy (compare to local/regional price levels)?
- Assess the competence and suitability of the chosen company for delivery in Senegal; with particularly attention to the commitment and resources of the local company, and the local market potentials and risks;
- Assess the guarantees made in the contracts by the technology providers and identify whether the companies have complied with their contractual guarantee responsibilities?
- Have the activities been carried out as simply as possible?
- Have the decisions regarding their installation and use been made as close to where the products or services are delivered?
- Were operation and maintenance manuals provided and how is the quality, language?
- Describe and assess extend and quality of the training that took place as part of the installation and delivery of the solar system.
- Who was trained and what sector were they from? (e.g., teacher, local government, NGO, private.)
- How many people were trained and what were the main areas of training?
- What were the main types of skills acquired and are the new skills being used?
- Who provided the training and what methods were used?
- Is there a system in place to secure that the skills are transferred to other locals if necessary?
- Have possible conflicts been addressed and resolved?
- Have the deliverables been achieved on time and on budget?
- Major constraints faced regarding delivery of the solar systems and measures taken to overcome the constraints.

Impact

- Measure the extent to which the solar energy systems intended outcomes have been achieved.
- What impacts have the installation of solar energy systems had in the local communities, including social, cultural and economic (if any).
- Describe the climate change impacts of the solar energy systems.

Sustainability

- List major functional and equipment failures and how these were handled by operators/supplier.

7. Timing

The assignment will take place in the period April-May 2010, and comprise a total of 25 working days including time for preparation, travel, data collection, interviews and reporting. The draft report will be forwarded not later than the 15 June 2010.

8. Reporting

All reporting will be in English. The report will be a maximum of 15-20 pages plus annexes with a map, tables, charts, and other relevant material. The report will have the following structure and include:

Evaluation report:

1) Introduction
2) Short description of the country setting and NDF 286 including objectives for solar energy provision, deliverables and activities
3) Methodology
4) Summary of Key Findings
    - Relevance
    - Efficiency
    - Effectiveness and Impact
    - Sustainability
5) Conclusions and Lessons Learned
6) Key Recommendations

Appendix section:

i) List of the persons met/interviewed during the mission
ii) Bibliography of the reports, materials and other data sources used
iii) Overview regarding technical details of installed solar systems.
iv) + other appendices

Longer descriptive chapters and long analyses can be placed in the appendix section.

Helsinki, 26 March 2010

Aage Jorgensen
Country Program Manager

APPENDIX 3

Bibliography of reports, materials and data sources used

1. Credit agreement between the Republic of Senegal and Nordic Development Fund (25 May 1999)
2. Contract No. 266 between PLCP and Dansk Solenergi (2004)
3. Contract No. 010 between PLCP and Dansk Solenergi (2005)
4. Addendum No. 1 to contract No.010 between PLCP and Dansk Solenergi (2006)
5. Project completion report from AfDB (23 May 2008)
6. Project completion report for Phase II from Ministry of Women, Family and Social Development (23 November 2007)
7. PLCP Presentation booklets
8. Note on REPDEN (Réseau pour l'élimination de la pauvreté et le développement de l'entreprenariat)
9. Tender from Dansk Solenergi for Phase I of the project (13 October 2003)
10. Tender from Dansk Solenergi for Phase Ii of the project (2005)
11. Tender evaluation report for Phase II of the project (April 2005)
12. SELF Solar Electric Light Fund, A cost and Reliability comparison between solar and diesel powered pumps (2008)
13. Ten-year reliability assessment of photovoltaic water pumping systems in Mexico, Robert Foster, New Mexico State University, American Solar Energy Conference, Portland (July 2004)
14. Feasibility assessment for the replacement of diesel water pumps with solar water pumps, Ministry of Mines and Energy of Namibia (2006)
15. L'électricité photovoltaïque, Luc Chancelier & Eric Laurent, ADEME, GRET, French Cooperation Ministry.

Summary of Information collected during site visits

Name of village: Kelle

Region: Dakar

Date of visit: 22 July 2010

Persons met: Ousmane Gueye, Village Chief

Abdourahmane Samb, Focal point PLCP

1. Overview and status:

System: borehole equipped with a submersible pump supplied by a diesel generator.

The system was commissioned end of 2006 or 2007. It did not operate for very long and was still not in operation at the time of the visit. The hour meter for diesel generator running hours showed 284 hours only.

The problem is a broken part on the diesel engine. The function of the broken part could not be fully ascertained. It seems that it is used to seal the oil sump. It was alleged by the persons on site that it had been broken by the TOTAL Energie staff during installation (TOTAL Energie was subcontracted by Dansk Solenergi to carry out installation works on site). It was not clear why the problem never was solved, but it may have to do with delays that occurred in connection with civil works, which resulted in late installation of technical equipment near the end of the project period. The project is said to have been closed down on 30 June 2007 and subsequently no follow-up has been possible.

Diesel engine is manufactured by Lister Petter (UK). Alternator is from Construc. Mecc. Alte SpA (Italy), 3-phase, type ECO 28/1VS/4 - 1,500 rpm, 7.8 kVA, p.f. 0.8, insulation class H, ambient temperature 40° C.

The submersible pump is from Grundfos, type SQ or SQE (information from leaflet shown on site).

The system itself is located within the enclosure of the local health post (called "Case de Santé"). The latter was not functioning on the day of the visit but it was said that vaccinations of children was performed there twice a week. The rooms inside were all very dusty and did not give the impression that much activity was going on at any time. The last entry in a register for weight monitoring of babies was from September 2009. The village was said to have another larger health clinic with permanent staff able to attend patients with minor health problems. This could explain why the health post on site is relatively less used (or no more used?). The health post was equipped with its own PV system to provide indoor lighting.

As mentioned earlier, three persons did receive some training. The persons interviewed told that the formation had focused on financial management with a limited review of theoretical aspects on the technical side, but no practical training was given.

b. Effectiveness

As the system has never operated on a sustained basis the objectives set for in the PLCP have not been achieved as far as the village of Kelle is concerned.

4. Impact

The village population is still using the traditional wells. The failure of the system to operate has lead to a situation where no impact could be registered. At least no negative climate change impact was generated by the Diesel generator intended to supply the water pump.

5. Sustainability

Financial and organisational sustainability: when the system was in operation water was sold for XOF 15 per 20 litre plastic can (or basin) or XOF 10 per 10 litre bucket at the water stand post close to the well. At the water stand posts in the village price was XOF 25 per 20 litre plastic can (or basin). Whether this price level would have been sufficient to ensure full sustainability cannot be assessed due to the short operating time. At least the financial management set up shows that there was some degree of understanding among the local community as to the necessity of securing revenue to take care of depreciation, maintenance and repair costs and even some salary element.

Technical sustainability: to the extent the management committee may have attempted to solve the problem mentioned under item 1, it proved unsuccessful. This in turn can be related to insufficient training and capacity building at local level as well as poor technical documentation for fault finding and guidance on actions to be taken.

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Within the PLCP the local population was involved in an overall evaluation of community needs and prioritization, e.g. water supply, health, access to finance (micro-credits). There is no doubt that improved water supply ranked high on the population's priority list.

A system management committee consisting of a system manager and two women (Mrs. Coumba Sow and Fatimata Bâ) was set up. As the system operated less than one year it is not possible to assess the performance of the committee and the institutional integration among the local community.

Kagnac is a Peuhl village whose first inhabitants moved out of Yoff (a village near Dakar) some 55 years ago.

The total number of inhabitants in Kagnac is 720 with approximately 40 households.

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved but proved not sustainable.

No leaflets/manuals could be found on site. A toolbox with a few tools provided by the project for the maintenance was shown.

The persons interviewed said that no technical training had been given, neither regarding the PV system nor the water pump. Hands on training was said to have been given together with information on security measures of importance for pump operation.

b. Effectiveness

As the system has never operated on a sustained basis the objectives set for in the PLCP have not been achieved in that case.

4. Impact

The village population is using the well in a traditional manner, as mentioned above. Owners of a number of orchards in the vicinity give also access to their wells to members of the village community.

Summary of Information collected during site visit

Name of village: Gorou

Region: Thiès

Date of visit: 23 July 2010

Persons met: El Hadj Bâ, Sous-préfet de Sessene

Racine Mbaye, Chef du Service Départemental du Développement Communautaire de MBour

Thérèse Diouf/Ndiaye, SDCC, MBour

Guedji Dieng, Village Chief

Omar Ngieng, Pump Operator

1. Overview and status:

System: borehole with submersible pump supplied by diesel generator.

The system was commissioned in 2004. It developed engine problems in 2007 that were repaired with difficulty. Repair cost was XOF 115,000. The amount was paid out of the community's own funds through individual contributions from the households

Diesel engine is manufactured by Lister Petter (UK). The D/G set is identical to the one seen in Keur El Hadji.

The level switch in the water reservoir had also to be repaired. Later on the windows and the start battery for the D/G set got stolen. Engine starting was then done manually (a start handle was provided with the D/G set – as required in the specifications).

The Diesel engine broke down in May 2010 and has not operated since. A mechanics was called to investigate and his diagnostic was that the engine governor had to be replaced (estimated cost XOF 400,000). This amount is beyond the local community's financial capabilities.

The flow meter read 7,666 m^3 and the operating hour meter on the D/G panel read 9,949 hours and 44 minutes.

A stand post with a supporting column and three taps was located close to the system. It was no longer used by the local community and all taps were broken.

5. **Sustainability**

Financial and organisational sustainability: when the system was in operation water was sold for XOF 10 per 20 litre plastic can (or basin)from the water stand post close to the system or XOF 400 per m^3 for larger usages, e.g. vegetable gardening. Each household was also asked to contribute with a monthly amount of XOF 1,000. The revenue generated was intended to cover depreciation, operating cost (fuel) and maintenance and repair cost (distribution: 50% for depreciation and maintenance/repair costs, 25% for fuel and 25% for the system operator). One litre of diesel oil which used to cost XOF 350 – 400 has at present reached XOF 650. Diesel oil is available at a distance of 7 km from the village.

Faced with a major engine breakdown as referred to before the community is not in a position to cover the cost required for replacing the faulty part, a sign that financial viability could not be achieved through the prices practised.

Technical sustainability: the interviews on site give the same impression when it comes to training and capacity building (or lack of same) as already witnessed in other villages. The insufficient technical documentation for fault finding and guidance on actions to be taken in the event of technical problems seems to be a recurring phenomenon. Such weaknesses are a serious threat to long term sustainability.

Summary of Information collected during site visit

Name of village:	Mbelonghout
Region:	Thiès
Date of visit:	23 July 2004
Persons met:	The village chief could not be met (was out in the fields). Some villagers were met on site and were interviewed.

1. Overview and status:

System: well equipped with submersible pump supplied by a PV array. The PV array consisted originally of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The system was commissioned in March 2005. In September 2008 the pump broke down and the diagnostic done through the PLCP showed that it could not be repaired and would have to be replaced. Replacement (estimated cost XOF 400,000) could not be carried out due to insufficient financial means. Before the pump breakdown the system had performed correctly.

In March 2009 the PV array and the pump were stolen. A declaration of theft was done by the management/village but nothing has happened since.

The water meter on the outlet pipe could not be read (disappeared together with other stolen equipment). A stand post with a supporting column and three taps was located in the vicinity of the PVP system. It was no longer in use and all taps were broken.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Mbelonghout has 737 inhabitants and 66 households. The whole area is said to be suitable for market gardening, an income generating activity for the villagers.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Gorou is a village of approx. 1,260 inhabitants with 102 households. The system was used not only to cater for the water supply of the community but also for market gardening. When the system was in operation flow problems usually occurred in April (i.e. before the rainy season sets in)

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved and the system has operated in the period 2004 – 2010
From the interviews on site it appears that some hands on training was given on the spot. The number of persons trained could not be clarified. No technical documentation or manuals was found in the D/G room.

b. Effectiveness

The objectives set for in the PLCP were achieved during the operating period. This came to an end in May 2010. As the prospect of having the system repaired looks bleak one must consider that long term effectiveness will not be achieved.

4. Impact

Before the system was installed traditional wells with limited flow were used by the local population. There has thus been a positive impact as long as the system was kept in operation, i.e. water supply and water quality were improved, and the burden of women in connection with water fetching was lessened. Water was also used for vegetable gardening, which is an income generating activity, even though it is likely that the system had not been dimensioned for this purpose (hence the flow problem reported earlier). After the system failed satisfaction was replaced by frustration.

Through another project (POGV 2 – Projet Organisation and Gestion Villageoise) financed by IFAD (French FIDA) through the West African Development Bank (French BOAD) a larger water supply system was established in 2006 – 2007 in the Gorou area. This system includes a water tower (100 m^3) and a small piping network to supply 11 stand posts, 2 watering points for livestock and 4 schools. This system should also be sufficient for to supply water for irrigation of vegetable fields in the dry season.

Summary of Information collected during site visit

Name of village:	Kagnac
Region:	Dakar
Date of visit:	22 July 2010
Persons met:	Abdoul Dia, Village Chief Moussa Sow, CLEC President Abou Dia, System Manager

1. **Overview and status:**

System: well equipped with a submersible pump supplied by a PV array. The PV array consists of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The system was commissioned in 2007 but operated less than one year. The problem is the water flow (seemingly insufficient) with the pump strainer sucking in sand. The system supplier is said to have twice replaced the pump strainer (cost XOF 400,000) but refused to replace the same part a third time and required the well to be dug deeper.

The flow achievable from the well may have been wrongly estimated from the outset or the well may have been dug at an insufficient depth in the first place.

The water meter on the outlet pipe showed 137 m^3 (assumed to have been set at 0 on commissioning). The bottom of the elevated water reservoir showed signs of leakages (infiltrations). The door to the wire mesh fence around the PV array was locked and the key could not be found. A closer inspection of the PV array and PV modules was not possible.

A stand post with a supporting column and three taps was located close to the PVP system. The taps being no longer in use were padlocked.

The well head base plate has been opened to give access to women fetching water for their household.

2. **Relevance**

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

A water stand post with a supporting column and three taps was located inside the health post enclosure. One or two other stand posts were said to be located in the village.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Within the PLCP the local population was involved in an overall evaluation of community needs and prioritization, e.g. water supply, health, access to finance (micro-credits). There is no doubt that improved water supply ranked high on the population's priority list.

A system management committee consisting of three persons was set up in 2007. Mr. Ibrahima Diouf was appointed system manager and Mrs. Thioro Ndiaye and Codou Thiamdoum were entrusted with financial management. As the system operated only very shortly it is not possible to assess the performance of the committee and the institutional integration among the local community.

Kelle is a fisherman's village, i.e. a rural context with a few secondary residences (week end residences owned by wealthy families from Dakar). Many active fishermen live there and practise traditional fishing in dug-out canoes (pirogues). They can stay up to two weeks at sea and keep their catch on board with crushed ice in cool boxes. They normally land their catches on the village shore wherefrom it is transported to Dakar by lorry.

The total number of inhabitants in Kelle is around 1,000 with approximately 90 households. Average household size is said to be 10.

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved late, hence the unsolved problem mentioned under 1 (as far as can be ascertained). The company entrusted with installation has seemingly not responded to the problem (assuming that it has been correctly informed).

One multilingual leaflet (including French) for the immersed pump was found in the diesel generator room. No manual or information could be found on the PV system.

APPENDIX 4

Villages visited (in chronological order)

Kelle
Kagnac
Gorou
Mbelonghout
Keur El Hadji
Ndiamsyl Sessene
Keur Seny Diouf
Ndine
Tambasoce
Sinthiou Thidy
Safalou II
Bagadadji
Sare Gagna
Hamdalaye Dega
Sare Alkaly

Summary of Information collected during the site visits

APPENDIX 2

List of Persons met/interviewed during the mission

Ms. Mbacke Khady Fall Ndiaye, Head of PALAM, formerly head of PLCP
Mr. Abdou Ndiaye, formerly CSO/PLCP
Mr. Lamine Mouhamadou Ndiaye, Manager AISB Sarl, formerly consultant to the PLCP
Mr. Boubacar Sow, Manager TENESOL Senegal
Mr. Ken H. Jensen, Manager Dansk Solenergi ApS
Mr. Ousmane Gueye, Village chief in Kelle
Mr. Abdourahmane Samb, PLCP focal point in Kelle
Mr. Abdould Dia, Village chief in Kagnac
Mr. Moussa Sow, CLEC President, Kagnac
Mr. Abou Dia, System manager, Kagnac
Mr. Adama Gueye, Village chief in Keur El Hadji
Mr. El Hadj Bâ, Deputy Prefect in Sessene
Mr. Racine Mbaye, Head of regional development office in Mbour
Ms. Thérèse Diouf Ndiaye, regional development office in Mbour
Mr. Guedji Dieng, Village chief in Gorou
Mr. Omar Ngieng, Pump operator, Gorou
Ms. Marone Ndeye, regional development office in Diourbel
Mr. Seydina Oumar Sow, Head of local development centre in Baba Garage
Mr. Mbaye Sankey Fall, Village chief in Ndiamsyl Sessene
Mr. Modou Ngow, President of management committee, Ndiamsyl Sessene
Mr. Ali Bebe, Village chief in Keur Seny Diouf
Mr. Khondia Basse, System manager, Keur Seny Diouf
Mr. Medoune Ndiaye, Village chief in Ndine
Mr. Thiano Seck, System manager, Ndine
Mr. Samba Cissokho, Head regional development office in Tambacounda
Mr. Sadhio Bâ, Village chief in Sinthiou Thidy
Mr. Hamadi Sylla, Village chief in Safalou II
Mr. Kalidou Kande, Village chief in Bagadadji
Mr. Doudou Dramé, Volunteer, Regional development office in Kolda
Mr. Samba Diamanka, Village chief in Sare Gagna
Mr. Hamadou Bande, Village chief in Hamdalaye Dega
Mr. Ousmane Kante, Kindergarten watchman in Sare Alkaly

- Have there been any major accidents related to the solar systems?
- Assess the potential risks in the present guarantees and recommend on ways to improve guarantees in future contractual arrangements.
- What could be done with regard to training and capacity building in future technology transfers?
- Assessment of whether the solar energy systems are likely to be maintained and the extent to which they will be used and provide benefits in the future.
- Have the solar systems been expanded after the initial installation?
- What is the plan/practice to dispose the used batteries, has the collection been organised?
- Availability and quality of replacement batteries.
- Consider the effects of the photovoltaic technology in the local communities and the costs of providing and maintaining this technology versus the benefits generated.

Conclusions and main lessons learned

- Conclusions based on findings and analyses
- Identify lessons that have been learned concerning technology transfer, training, and community use of technology, including achievements and shortfalls overall with regard to the activities
- Good practice for support to solar energy systems

Recommendations

- Directed at future NDF support to solar energy systems and renewable energy technology.
- Provide guidance on how NDF could improve future technology transfer.

5. Organization of Work

The consultant will refer to the overall team leader of the evaluation Mr. Aage Jorgensen, NDF, E-mail: aage.jorgensen@ndf.fi The consultant will further more work in close cooperation with representatives of IDB, the Ministry of Education plus other relevant key institutions and stakeholders.

6. Methodology

The consultant will review relevant project reports, technical studies, academic publications, and conduct a round of interviews with relevant staff from the *Ministere de La Famille du Developpement Social et de La Solidarite Nationale*. During the field visits meetings and focal group discussions will be held with key stakeholders and resource persons in selected communities and at departmental level. During the field visits the consultant should also take time to secure photo documentation of the solar systems and the local setting.

The evaluation will include two separate field assessments of the results of the solar energy components in the above mentioned NDF projects. The following TOR has been prepared to define the scope of work and deliverables for the consultant undertaking the field assessment of the solar energy systems in Senegal.

2. Objectives

The objective of the evaluations will be to provide NDF with an assessment of present status and operation of photovoltaic systems in Honduras and Senegal financed by NDF after 3-5 years of operation. The evaluation will make an assessment of relevance, efficiency, effectiveness, sustainability, impact and major lessons learned. The evaluations will be used as an input to design and planning of future NDF support in renewable energy sector and technology transfer

3. Outputs

The consultant will deliver the following outputs:

1) Inception report with description of approach and methodology, and work plan.
2) A short, concise evaluation report concerning present status, operation and sustainability of the solar energy systems delivered in NDF 286 plus recommendations for the future.
3) Photo documentation on sample of solar energy systems delivered in NDF 286.

4. Scope of work

The work shall include but not necessarily be limited to the following tasks:

Overview and status:

- Provide a narrative and a timeline of the procurement operation (2004-07), companies involved in the delivery of the 62 solar systems, including delivery strategy by the companies, field activities undertaken and the present status of the energy systems.
- Provide the details of the technology that have been installed including panels (type, size), batteries (type, capacity), control units, inverters (if any), accessories, with information on effect (Wp), voltage (V,AC/DC), etc. (to be presented in table format).
- What is the main use of solar power (lightning, computers, etc.) and has the capacity been sufficient to serve the loads (overloading)?
- Describe the condition of the panels and batteries and wiring (dust, leakages, fixing).
- Provide an overview of the geographical locations for the 62 solar systems including significant variables such as urban, rural, and socio-cultural.

Relevance:

- Assessment of whether the development activities of which the solar energy systems form part are directed towards areas accorded high priority by the affected parties.
- What are the perceptions of stakeholders such as local communities, municipalities and the Ministere de La Famille du Developpement Social et de La Solidarite Nationale?

The recommendations above are by far and large applicable to all PV applications, like for example PV for public lighting in villages or SHS. In such systems and additional component, the battery needed for energy storage, is a complicating factor that also gives rise to an environmental problem as batteries have to be replace every 3 – 5 years.

Last but not least, taking into consideration the problems evidenced by the evaluation mission, it would make sense if an initiative could be launched so that funds could be mobilised (Government, donors, NGOs) to rehabilitate the water supply systems at present in a state of disrepair. This would imply a general inspection of all systems implemented through the PLCP. Such a rehabilitation program should be set up on the condition that Government earmarks in all coming annual budgets a specific budget line to provide resources sufficient to sustain the systems in the coming 5 – 10 years. Some of the recommendations above should also be taken up at the same time.

7. Appendix Section

a. TOR for the evaluation
b. List of persons met/interviewed during the mission
c. Bibliography of reports, materials and other data source used
d. Summary of information collected during site visits (village data sheets)
e. Overview of technical details of installed PVP systems
f. Selected photographs of visited PVP systems

critical component of the system and when it fails the system comes to a complete stop and is no longer able to provide what is its raison d'être, viz. water to the rural community.

Costly repairs/replacement of parts are out of reach financially as the communities involved are poor and even though water is charged to the users, sufficient capital reserves cannot be accumulated to cope with such situations. When a major failure occurs, systems fall then into disuse. In such circumstances there is no credit mechanism that could assist the communities in financing the cost of parts and works needed to overcome the technical problem experienced. There does not seem to be any assistance available from the regional and local authorities, including those involved in water resources and water supply in the rural areas. This is likely linked to the insufficiency of resources in the local administration, including resources earmarked for maintenance.

When the communities are faced with a serious technical failure they are practically left without any kind of reliable technical assistance. Such a mechanism, which could have three levels – local, regional and national – does not exist. There were several reports of attempts of call for assistance from the supplier in the capital, but without avail. In any such situation it is critical that a correct diagnosis is put before resources are mobilised to any kind of further action. That kind of technical assistance mechanism should have expertise in the following main fields: wells, boreholes including issues like flows and outputs and pumping based either on PV or D/G sets.

The absence of quality manuals and technical documentation adapted to the level of general knowledge and the language abilities of the local communities, combined with no or little training at local and regional level have not contributed to achieve technical sustainability. Clearly, the level of efforts needed in that field has to be at least ten fold and repetitive in order to secure long term results.

6. Key recommendations

To increase chances of success projects based on the use of PV technology should focus on the following aspects:

1. A participatory approach in project preparation is to be favoured, not only to correctly assess and understand the local communities' needs and priorities but also to provide clear cut information on the advantages and limitations of PV technology. The latter is of particular importance in projects where energy supply of individual households is on the agenda.

2. Training of local communities in system management including financial aspects and basic training on technical aspects related to electricity and PV technology is essential. Training on the local plan should be directed at artisans or whatever technical skills are present. Training is also to be provided at regional level to electricians, technicians, private

sustainability. Sooner or later the systems now in operation may be faced with a major breakdown with the same consequences as witnessed during this evaluation.

Setting up management committees and providing training to their members and system operators are relevant initiatives. The challenge is that of the social environment. Concepts like ownership, financial management, not to mention rudimentary technical information on complicated technical systems like PV and submersible pumps cannot be passed on to a target group with no or only little school background in the matter of a 5-day training session. The perceptions and understanding of the stakeholders in the villages can only be improved through a sustained long term effort at recurring intervals.

Technically the PVP systems have been affected by a number of failures resulting in 6 out of 4 systems inspected in a situation of complete standstill with no prospect of repair/rehabilitation due to lack of financial means. However, none of the systems so affected did develop problem with the PV arrays or with the other High Tech electronic components like the inverters or converters used to supply the pump motors, with one exception. There was a situation with a faulty converter (in Sare Gagna) which got replaced by the supplier (presumably as part of the contractual obligations under the5-year guarantee period). Failures are predominantly affecting one type of submersible pump used in the S1 and S2 PVP systems.

Whether some of the pump failures should have been repaired under the guarantee will remain an open question. The 5-year guarantee requirement in the contract is in itself fully appropriate but the problem perceived is rather one of lack of follow up aggravated by difficulties for the communities confronted with a technical problem to contact the right persons at the right organisation or company. In such situations the communities do not have access to a neutral adviser that could guide them and assist in mobilising assistance to first of all put the correct diagnosis, and then plan for the next step (e.g. repair or replacement).

Lifetime expectancy for PV modules and PV arrays is in the range 20 – 25 years. Lifetime expectancy for other system components like electronic inverters and converters is in the range 5 - 10 years, for the submersible pumps it is also 5 – 10 years, although this does not line up with the experienced lifetime of pumps installed in connection with the S1 and S2 systems.

As in any technical system failures can happen during operation. They are usually expressed by a MTBF (Mean Time Between Failure) figure. For PVP systems an average MTBF is approx. 2.5 years (it is 3 to 4 times lower for diesel systems). Such a figure shows that PVP systems are not repair and maintenance free and that technical capability is needed to assess the origin of the failure and determine a specific course of action. This kind of capability does not exist or is very weak and this is detrimental to the survival of the systems when a fault occurs. It is true that the only maintenance normally required by a PVP system is the cleaning of solar modules, a task the system operator easily can carry out. This a huge advantage of PVP systems compared to diesel systems. However, all other maintenance or repair actions require dedicated know how and expertise, as mentioned before.

Impacts are positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended.

In the villages where the PVP systems are in operation there are significant impacts in terms of lesser burden for fetching water and time spent for this daily activity. In some villages water had earlier to be fetched rather far away (1 -2 km) from wells with limited output, which meant that several hours were spent each day on such a task. With a PVP system time needed to get sufficient water for one family, as explained by one woman in Keur Seny Diouf, was less than one hour per day. The time gain is of considerable benefit to the female members of the community, who are the ones primarily concerned with catering for the needs of the families in relation to water and firewood. The time saved in water fetching is usually spent to take increased care of family and children or to attempt new income generating activities like small scale trading. The improvement achieved with regard to water supply is not matched by corresponding improvements in firewood collection due to the scarcity of the resource.

Another easily noticeable impact when visiting the villages with an operating PVP system is the aspect of water coming out of the taps at the stand posts. The water looks clear and clean, as compared to the water hauled from some of the wells in other villages, which is somewhat muddy. No analysis of water quality could be made during the visits but the better look of the PV pumped water is certainly indicative of a different and better quality.

In terms of climate change impact the impact of PVP systems is positive, as no Diesel generator has to be operated in order to energise a submersible water pump. The quick calculation given below illustrates the positive impact of PVP systems compared to Diesel operated systems.

The PVP systems installed through the project are of three types (S1, S2 and S3) but all designed for the same daily output of 20 m^3. The diesel systems likewise installed through the project have been designed for an output of 5 m^3/hour, in other words four hours of operation are needed for a diesel system to give the same output as a PVP system.

The carbon content of one litre of diesel oil is equivalent to 2.66 kg (IPCC guidelines). The diesel generators used in the project have a rated power of 3.6 kW (cf. Technical specifications in contract documents). The average fuel oil consumption of the diesel generators can be estimated at approx. 1 litre/hour, giving a 4 l consumption to provide the daily output of 20 m^3 after 4 hours of operation. The corresponding CO_2 emission would be 10.68 kg/day.

If the 50 PVP systems in the project had been 50 diesel based systems total daily CO_2 emissions would have been 534 kg/day. On a yearly basis the emissions would be in the range of 194 tons, which are avoided by using PVP systems in lieu of D/G based ones (obviously assuming the effective operation of all systems).

The company (Dansk Solenergi) who was awarded the contracts for the supply and installation of the pumping systems in Phase I and Phase II of the sub-component selected a company in Senegal (TOTAL Energie, nowadays TENESOL a subsidiary of TOTAL and EDF group) as sub-supplier/contractor. This company is the largest in the field of PV technology in Senegal with more than 10 years of experience. All field activities, including training, were carried out by TOTAL Energie.

The contracts with Dansk Solenergi included specific guarantee clauses covering respectively a 5-year period and a 1-year period. The 5-year guarantee period applied to the PV modules, converters and inverters and pumps, including cabling accessories and junction boxes in the event of manufacturing defect, material failure or faulty installation. The 1-year period was applicable to all other system components. The supplier/contractor was also contractually bound to carry out two technical inspections of all sites, respectively 6 and 12 months after the taking over date of each system.

From the site visits carried out for this evaluation it appears that in some of the villages some of the operating problems that did occur within the 5-year guarantee period have been rectified by the supplier/contractor (TOTAL Energie/TENESOL) like for example in Kagnac and Sare Gagna. In other villages, e.g. in Safalou II and Sare Alkaly incidents relating to the submersible pumps that occurred within the 5-year guarantee period were not addressed by the supplier/contractor. It is difficult on the basis of the information provided to determine why outside assistance has not been provided. In some cases this may simply be the result of poor communication, or of insufficient information (including written documentation) provided to the village water management committee. Whether the above mentioned two technical inspections were ever carried out could not be ascertained.

Even in the couple of villages where some technical documentation was found it was of extremely poor quality and not in conformity with the contractual requirements. In the vast majority of villages no technical documentation was available and interviewed persons claimed most of the time that no such documentation had been handed over. The language of documentation is also an issue. The contract requested technical documents to be provided in French, but in practice this is of little help when the local users do not understand the language.

With regard to training the information obtained by interviewing members of the local communities was very contradictory. In some villages it was said that training had been provided, in others the opposite was alleged. When training was acknowledged as having been provided it was usually mentioned that two persons of the community had participated. This is in line with what was contractually requested (5-day training sessions were foreseen to cover a region/several sites and include a group of attendants, 30 – 40 persons).

Whether training had actually taken place or not was not significantly noticeable, meaning that answers to questions and discussions were not better in the villages that had been trained. When

Villages selected by the PLCP were among the poorest in the country, often geographically very isolated and for some of them without access to the outside world during the rainy season due to the lack of roads. From the outset it was known to the project management that addressing the most pressing problems in such villages would be a daunting task and this explains to some extent some of the sustainability problems that will be described under section 4.5.

Since most rural areas are not and will not be electrified for many decades to come it was relevant to consider, besides the use of manual pumps that have their limitations in terms of water flow and lift and only marginally reduce the burden of fetching water, the two most commonly encountered electric pumping options, i.e. diesel generator based pumping and photovoltaic pumping systems. The latter two have the advantage of offering a considerable reduction of the human effort needed to fetch water. All three types of pumps have actually been financed through the NDF intervention in Component III, sub-component 2 of the PLCP.

All visited villages are highly relevant as a target group: they have a population ranging from 300 to approx. 1,200 inhabitants and were depending on traditional wells in their area to haul water before the project was implemented. Some of the villages had barely access tracks to be reached. Two of the sites visited were a primary school and a kindergarten where a PVP system had been set up to provide water for the children, which also is relevant in this context.

Within the PLCP local communities were involved in an overall evaluation of needs, e.g. water supply, health post, access to micro-credit, and their prioritisation. The PLCP also endeavoured to set up a water management committee in each village involved. Such a committee was foreseen to consist of three persons from the community (male and female) and take responsibility for the financial management and daily operation of the water system. Some of the sustainability problems the systems are confronted with are related to the understanding (or lack of) and perception of committee members in dealing with concepts that are foreign to them and difficult to grasp, the influence of the village chief and other sociological factors. This will be further detailed in section 4.5 dealing with sustainability.

4.3 Efficiency

Efficiency is a measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results (outputs).

Equipment for the PVP systems was procured through Nordic Competitive Bidding, according to the then applicable NDF policy. This bidding method was followed for both Phase I and Phase II of the sub-component implementation. Due to the lack of background documents on procurement in connection with Phase I it is not possible to assess how much competition did actually take place. In connection with Phase II it is known that two Danish companies made a proposal and the bid from one of the two was found not to be in compliance with the requirements of the bidding documents. On that background the bid was disqualified, which left one bid only to the

Village name	Region	System Type	Status
Kelle	Dakar	D/G based	Commissioned end 2006 or 2007. Out of order due to Diesel engine problem
Kagnac	Dakar	PVP (S1)	Commissioned mid - 2007. In operation less than one year. Flow problem, sand in the pump strainer.
Gorou	Thiès	D/G based	Commissioned in 2005. Minor problems in 2007 and 2009 were solved. Major breakdown in May 2010. No longer operating. Possible flow problem. Engine start battery and engine room windows stolen.
Mbelonghout	Thiès	PVP (S1)	Commissioned in 2005. Major breakdown of pump in September 2008. PV array stolen in 2009. System in disuse.
Keur El Hadji	Thiès	D/G based	Commissioned in 2005. Electrical problem solved in 2009. Still in operation.
Ndiamsyl Sessene	Diourbel	PVP (S3)	Commissioned in 2005. A few minor problems have been solved (taps, valve, floating switch). Still in operation.
Keur Seny Diouf	Diourbel	PVP (S3)	Commissioned in 2005. Water flow problems but still in operation.
Ndine	Diourbel	D/G based	Commissioned in 2005. Operated one week. Start key disappeared and has not operated since.
Tambasoce	Tambacounda	PVP (S1)	Commissioned end 2008. Two problems repaired in 2009 and 2010 (pump supply cable). Still in operation. Water reservoir shows signs of serious water infiltration.
Sinthiou Thidy	Tambacounda	PVP (S3)	Commissioned in 2006. Still in operation with a number of leakage problems.
Safalou II	Tambacounda	PVP (S1)	Commissioned in 2006. Major breakdown of water pump in 2009. Out of order since. Possible flow problem.
Bagadadji	Kolda	PVP (S1)	Commissioned in July 2004. Out of order since April 2009. Likely to be a pump breakdown.
Sare Gagna	Kolda	PVP (S1)	Commissioned in 2004. Converter replaced end 2006. Major breakdown of water pump in May 2008. Out of order since.
Hamdalaye Dega	Kolda	PVP (S?)	Well and Civil works completed but pumping system never installed.

Another major challenge in the villages was communication as very few of the people met understood or spoke French. All questions and answers required translation by an interpreter, which made communication more cumbersome and increased the risk for misunderstandings and errors. Being a one-man mission it was also difficult to do the talking and the writing at the same time during interviews.

The last challenge should prove to be getting access to copies of some important project documents like the initial socio-economic studies, the detailed price schedule for the winning bid or the project Phase I tender evaluation report. As in some point in time the project changed from one umbrella ministry to another documents and files were moved and this has seriously complicated the traceability of all project documents. Attempts made during the mission in Senegal to access a number of relevant documents remained unsuccessful.

4. Key findings

4.1 Overview and status

Technical equipment and related services were procured through Nordic Competitive Bidding. A contract (No. 266 – signed without date) for the supply and installation of all technical equipment for the water pumping systems of Phase I was awarded in 2004 to a Danish company, Dansk Solenergi, with a Senegalese sub-contractor TOTAL Energie (a local subsidiary of the French TOTAL company). The contract amount was XOF 640,321,871, excl. taxes and duties (XOF 680,323,927 including taxes). The scope of delivery included supply and installation of technical equipment for 35 D/G (Diesel/Generator) based water supply systems and 37 PVP systems (Photovoltaic Pumping Systems). As specified in the tender documents pumping systems had been divided into categories according to the rate of flow required (expressed in m^3/hour or m^3/day) the vertical lift and total dynamic head (in meters) applicable in different locations, viz. S1, S2 and S3 for the PVP systems and G1, G2, G3 and G4 for the D/G based systems.

In 2005 a second NCB round was conducted in connection with the supply of technical equipment for Phase II. This resulted in a new contract (No.010 – signed without date) being awarded to the same company as for Phase I. The contract amount was XOF 345,636,738, excl. taxes and duties (XOF 422,796,369 including taxes). The scope of delivery was identical to the one in the first contract, but for the number of systems to be supplied and installed, which were 15 D/G based systems and 16 PVP systems. In 2006 an addendum to the second contract was signed to have another 9 D/G based systems delivered and installed. The addendum amounted to XOF 86,003,493, excl. taxes and duties (XOF 106,292,453 including taxes).

Exemption of duties and taxes was granted by the Senegalese state.

Total investment in technical equipment for the water supply systems amounts thus to XOF 1,071,962,102 equivalent to EUR 1,634,337.71.

Project management Unit worked under the supervision of a National Steering and Coordination Committee comprising representatives from the concerned ministries, relevant stakeholders and donors.

During a mid-term review of the project the FND, considering the results achieved at that stage, indicated its willingness to provide additional funds for a larger number of water supply systems. A request in that sense was presented by the Government of Senegal to NDF and this resulted in the signing on 1 October 2004 of an addendum to the credit agreement of 25 May 1999.The additional funds provided with this addendum amounted to SDR 2.5 million or XOF 1.991 billion, bringing NDF's total contribution to SDR 7.5 million, equivalent to XOF 5.9 billion.

With the additional fund provided by NDF, a second phase was implemented in the framework of component III/sub-component 2, and additional procurement for goods and services was subsequently organised.

For both Phase I and Phase II NDF procurement rules applied, i.e. with specific requirements regarding eligibility and Nordic content of goods, works and services. This implied that 100% of equipment, furniture and supplies were requested to be of Nordic origin through Nordic competitive bidding, but that requirement was reduced to 50% for services (i.e. studies and supervision, training and other specialist services). 100% of Works for construction and rehabilitation (item B below) were foreseen procured on the local market or open to ICB.

The items that made up Component III, sub-component 2, were categorised into the following:

- A) Studies and supervision (estimated cost SDR 357,892)
- B) Construction/rehabilitation (estimated cost SDR 2,757,772)
- C)Equipment, furniture and supplies (estimated cost SDR 1,265,369)
- D) Specialist services (estimated cost SDR 96,848)
- E) Training (estimated cost SDR 61,025)
- F) Operating costs (estimated cost SDR 90,777)

Of special interest for the evaluation were Item B), C) and E). Item B) included among others the sinking of wells and construction of water storage tanks; Item C) included the supply and installation of pumps (manual and electric) as well as the supply and installation of diesel generator sets and photovoltaic arrays to energise electric pumps.

The outputs of sub-component 2 of relevance to the evaluation are:

✓ 52 village water supply systems with a Diesel/generator set as energy source (35 systems in Phase I and 17 in Phase II);
✓ 50 village water supply systems with a PV array as energy source (24 systems in Phase I and 26 systems in Phase II).

2. Country setting and overview of NDF Credit 286

2.1 Country setting

A former French colony, Senegal (Republic of Senegal) became independent in 1960 and celebrated this year on 4 April the 60th anniversary of her independence. Located in West Africa, Senegal borders the Atlantic Ocean between Mauritania and Guinea Bissau and has an area of 196,722 km^2.

According to the latest estimate (2010) Senegal's population is 14.08 million. The age structure is as follows: 42% between 0 - 14 years; 55% between 15 – 64 years and 3% in the age group 65 years and above. The population growth rate is 2.68% (2010 estimate). Urban population is equivalent to 42% of total population (2008) and the rate of urbanization is 3.1% (2005 – 2010 estimate). Life expectancy at birth is 59.3 years for the whole population. The HIV/AIDS adult prevalence rate is 1% (2007 estimate).

The literacy rate is 39.3% for the total population (male 51.1% and female 29.2% - 2002 estimate).

Senegal's GDP (PPP) is USD 22.38 billion (2009 estimate). GDP per capita (PPP) is USD 1,600 (2009 estimate). GDP composition by sector (2009 estimate) is as follows: agriculture 13.8%; industry 23.3% and services 62.9%. The unemployment rate is estimated at 48% (2007) and the percentage of population below poverty line is estimated at 54% (2001).

Main agricultural products are peanuts, millet, maize, sorghum, rice, cotton, tomatoes and green vegetables. Main industries are agricultural and fish processing, phosphate mining, fertilizer production, oil refining, iron ore, zircon and gold mining, construction materials, ship building and repair.

Senegal real growth rate in GDP averaged 5% annually in the period 1995 – 2008. The latest estimate (2009) for GDP real growth rate is 1.7%. Senegal is member of WAEMU (West African Economic and Monetary Union) and ECOWAS (Economic Community of West African States), working toward greater regional integration. The high unemployment rate continues to prompt illegal immigrant to flee the country in search of better job opportunities in Europe.

Senegal still relies heavily upon donor assistance and has benefitted under the HIPC initiative from eradication of two thirds of her bilateral, multilateral and private sector debt.

Senegal has signed and ratified the climate change – Kyoto protocol.

also to provide clear cut information on the advantages and limitations of PV technology.

2. Training of local communities in system management including financial aspects and basic training on technical aspects related to electricity and PV technology is essential. Training is also to be provided at regional level is to be made a recurrent activity in a period of no less than 5 years. Training may even include literacy courses.

3. In relation to financial sustainability the starting point has to be local communities' ability to pay tariffs, e.g. for water or electricity, and assessing whether what the community is able to pay would ensure sustainability. When sustainability cannot be readily achieved through tariffs, mechanisms have to be developed to provide access to capital to cover repair and maintenance related expenses. Mechanisms should preferably be based on Government contributions and a pre condition to financing any project should be a written Government guarantee that annual state budgets will provide the agreed amount to ensure long term sustainability.

4. Maintenance manuals and technical documentation have to be adapted to the local communities' language abilities and general knowledge level, including use of pictograms.

5. A Technical Assistance (TA) mechanism able to provide unbiased advice to local communities in the event of system failure is to be set up in order to ensure system sustainability.

6. Servicing of PV based systems (maintenance and repair) is a task that requires specific know how and a dedicated external organisation with well trained technicians. A service organisation able to operate at three levels, i.e. national, regional and local should be set up. Any project intending to use PV technology should assess what capabilities are available on the local market in terms of servicing. If capabilities are low, boosting of capacity in the companies involved should be promoted or undertaken within the project.

v) Summary

This report deals with the evaluation of solar powered water pumping systems in one of the sub-components in a poverty alleviation project in Senegal. The project is known under the acronym PLCP – *Projet de Lutte Contre la Pauvreté* in Senegal. The evaluated sub-component was financed by NDF Credit 286 signed in 1999 and focused on rural/village water supply. The initial credit amount was SDR 5 million. An additional SDR 2.5 million was provided by NDF in 2004 through an addendum to the credit agreement. Total cost of the PLCP was estimated at SDR 18.6 million. Other contributors to the project finance were the AfDF and the Government of Senegal.

The immediate objective of the NDF financed sub-component was to improve water supply in some 112 villages, both in qualitative and quantitative terms, while reducing the burden of fetching water (mainly a female task). Out of the 112 villages 50 were to be provided with a photovoltaic (PV) water pumping system. The PLCP was implemented under the supervisory authority of the Ministry of the Family, Social Action and National Solidarity. The NDF financed project sub-component was completed in 2007.

The evaluation was conducted on the basis of a representative sample of villages in all five provinces covered by the project. In total 15 villages were visited, i.e. 11 villages with a PV pumping (PVP) system and for comparative purposes 4 villages with a diesel generator (DG) based pumping system. The operational status of the systems as revealed by the visits was as follows:

1. Of the 11 PVP systems visited, one had never been completed and 10 had been commissioned in the interval 2004 – 2007. Of the 10 commissioned systems four were still operating and six were out of order due to various technical problems.
2. Of the 4 DG based systems visited one was still operating and three were out of order due to various technical problems. The 4 systems visited had been commissioned in the interval 2005 – 2007.

The intervention financed by NDF was highly relevant as it was a sub-component of the PLCP, a priority project of the Government of Senegal, and also seen on the background of the Millennium Development Goals. The villages selected for the project were among the poorest in the country.

Equipment for the PVP systems was procured through Nordic Competitive Bidding, according to the then applicable NDF policy. This implied a limited number of players as compared to International Competitive Bidding and in terms of efficiency most likely resulted in higher cost for the procured equipment.

ii) Abbreviations and acronyms

AfDB	African Development Bank
AfDF	African Development Fund
CPI	Corruption Perception Index
D/G	Diesel Generator
ECOWAS	Economic Community of West African States
GDP	Gross Domestic Product
ICB	International Competitive Bidding
IPCC	International Panel on Climate Change
MTBF	Mean Time Between Failure
NCB	Nordic Competitive Bidding
PLCP	Projet de Lutte Contre la Pauvreté
PPP	Purchasing Power Parity
PV	Photovoltaic
PVP	Photovoltaic Pumping
SDR	Special Drawing Right
SHS	Solar Home System
TAF	Technical Assistance Fund of the AfDB
UNCS	United Nations Cartography Service
WAEMU	West African Economic & Monetary Union

iii) Currency and units

The national currency is the CFA Franc (Communauté Financière Africaine).
International symbol of the CFA Franc is XOF.
Since 1 January 1999, the CFA franc has been pegged to the euro at a rate of 655.957 CFA francs for 1 EURO.

EUR 1 = USD 1.28 (14 August 2010)

USD 1 = XOF 514.08 (14 August 2010)

SDR 1 = XOF 796.4 (1999)

iv) Glossary of technical terms

Energy

AC – Alternating current: the most usual form of electrical current supplied by the utility grid.

i) Maps of Senegal

a) Map of Senegal (source UNCS) with the provincial boundaries in existence in 2005.

In 2008 three new provinces were established, Kaffrine in central Senegal, Kédougou in the south eastern corner of the country and Sédhiou in the southern part (Casamance).

The next map shows the present situation with the country subdivided into 14 provinces.

The project subject to evaluation covered five provinces according to the 2005 provincial division, i.e. Dakar, Diourbel, Kolda, Tambacounda and Thiès. Tambacounda and Kolda provinces were by then larger than they are today.

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3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved but the technical part of it has subsequently been stolen, as referred to above. Theft of this kind of equipment is a problem in the sub region where there seemingly exists a cross border market for stolen PV modules.

It was said that training had been provided and that 2 persons had attended a 5-day training session held in ? (name of place not registered properly). Training had included technical matters (submersible pump and PV). Manuals in French were said to be kept by the village chief.

b. Effectiveness

The immediate objectives set for in the PLCP were actually achieved during the operating period, i.e. 2005 - 2008. As there is practically no hope that the PV array will be recovered and that the cost of procuring a new array as well as a new pump are far beyond the village community's financial capabilities long term effectiveness will not be achieved.

4. Impact

Before the system was installed traditional wells were used by the local population. The system when operating has without doubt had a positive impact on the quality of the village water supply while the burden of women in connection with water fetching was lessened. As the area is well suited for market gardening a reliable water supply (assuming a sufficient water flow all through the dry season) would be a prerequisite for that type of income generating activity. Such activity would in turn have a positive impact in financial terms. However, this opportunity is at present out of reach.

5. Sustainability

Financial and organisational sustainability: women members of the GPF (Groupement Promotion Féminine) were responsible for water management when the system was in operation. Water was sold for XOF 10 per 20 litre plastic can (or plastic basin) from the water stand post close to the system and a monthly contribution of XOF 500 had to be paid by the head of each household. The revenue generated was distributed at the end of the month as follows:

- 25% for the manager salary
- 25% for depreciation and maintenance/repairs
- 50% on a bank account

It was mentioned that a revolving credit had been set up, but it was not clear from the explanation given how this had any relation to the financial management of water (likely to have been an activity linked to component II of the PLCP). An amount of XOF 300,000 had enabled the community to continue with the revolving credit. An amount of XOF 124,000 was said to have been available when the PV array was stolen.

Technical sustainability: the issue is no longer critical in that particular village as the system has disappeared. However, one can fear that training and capacity building to the extent they were provided would not have been sufficient to ensure a sufficient degree of long term sustainability, as witnessed in other villages.

Summary of Information collected during site visit

Name of village: Keur El Hadji

Region: Thiès

Date of visit: 23 July 2010

Persons met: Adama Gueye, Village Chief

1. Overview and status:

System: well with submersible pump supplied by diesel generator.

The system was commissioned in 2005. It was affected by an electrical problem in 2009. An electrician called upon by the village succeeded in alleviating the problem.

Diesel engine is manufactured by Lister Petter (UK). Alternator is from Construc. Mecc. Alte SpA (Italy), 3-phase, 1,500 rpm, ? kVA, p.f. 0.8, insulation class H, ambient temperature 40° C.

The operating hour meter read 594 hours. It was said that the D/G set has to operate during 2 hours to supply the pump in order to fill the water reservoir up to its max. capacity, i.e. 15,000 l or 15 m^3. Every approx. 6 days the water reservoir has to be filled up again.

The meter on the outlet pipe read 4,350 m^3. A stand post with a supporting column and three taps was located in the vicinity of the elevated water reservoir.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Keur El Hadji is a village of 694 inhabitants with approx. 70 households. Household size is on average 10 persons (size variation from 19 – 30 persons). The village is electrified (connected to the distribution network from Sessene 3 km away) but only 3 household have been connected so far.

Surveys carried out in the context of project preparation revealed that the village had a serious water supply problem. The village well(s) (33 m deep) often dried up and the water was of poor quality (not drinkable).

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved and the system is still in operation. Persons interviewed on site alleged that no training had been provided. The pump operator has some mechanical knowledge acquired through work with cereal mills in the village. It was said that a maintenance manual in French had been handed over. The problem is that the operator is not able to read French but only Arabic.

b. Effectiveness

The objectives of the project have indeed been attained thanks to a continuous operating period since commissioning in 2005.

4. Impact

The system provides the village community with water of good quality and the flow is also sufficient. Women's' burden in connection with water fetching has been considerably reduced and the village women have now more time to deal with other activities, such as small scale trading and time for the children. The impact on women's lives was considered as positive.

Persons interviewed expressed the opinion that another bore hole would enable villagers to grow vegetables and other crops (like millet, peanuts, beans, water melons, sorrel) on a sustained basis, hence bringing in additional revenues to the households.

5. Sustainability

Financial and organisational sustainability: the system is managed by women who sell water to the villagers. Women take care of management on a rotating basis. The charge for a 20 litre plastic can (or basin) from the water stand post close to the system is XOF 10. All village households were required to provide initial funds so that fuel and lube oil could be purchased.

The revenue generated by the water sale is divided into four parts, i.e. ¼ for the operator salary, ¼ for the fuel, ¼ for lube oil and ¼ for maintenance and repairs (may also include depreciation – but this was not clear from the information given).

It was mentioned that funds to an amount of XOF 3 million had been provided through a revolving credit system (likely to refer to component II of the PLCP). All loans had now been reimbursed (there was no grace period) and this type of financial support was no longer available. Loans had been given for the purchase of seeds, but poor yields had subsequently given rise to serious difficulties for the community in connection with reimbursement.

The above indicates some understanding of financial mechanisms and constraints in system operation but also on a larger basis with the revolving credit set up.

Technical sustainability: the system has not been subject to any major breakdown since commissioning, thus the ability of the management and the villagers to find solutions in such a situation has never been put to test. There are certainly weaknesses in terms of technical capacity as the operator cannot read what technical documentation has been made available and the operator's experience is solely hands on with no basic theoretical know how.

Summary of Information collected during site visit

Name of village: Ndiamsyl Sessene

Region: Diourbel

Date of visit: 24 July 2010

Persons met: Marone NDeye, Monitrice d'Economie Familiale, SRDC Diourbel

Seydina Oumar Sow, Chef CADL Baba Garage

Mbaye Sankey Fall, Village chief

Modou NGow, Président du comité de gestion du forage de Ndiamsyl Sessene

1. **Overview and status:**

System: well equipped with a submersible pump powered by a PV array. The PV array consists of 24 PV modules (6 x 4) type TE 850 from TOTAL Energie. Main specifications of type TE 850 are:

Typical Peak Power (P_{max}): 80 Wp
Voltage at Peal Power (V_{mp}): 17.3 V
Current at Peak Power (I_{mp}): 4.6 A
Short Circuit Current (I_{sc}): 5.0 A
Minimum Power (P_{min}): 77.5 Wp
Maximum System Operating Voltage: 730 V

The system was commissioned in 2005. Only a few minor problems have disrupted system operation. They related to the maximum water level switch in the water reservoir, a water valve and water taps. A plumber from Dakar was called up to assess the damage and identify the parts to be replaced. Costs for repairs, including the plumber's travel expenses, amounted in total to XOF 130,000 and were covered by the management committee through the committee's funds.

The water meter on the well outlet pipe read 18,396.9 m^3. A stand post with a supporting column and three taps was located in the vicinity of PVP system. Only one of the three taps was intact. The water meter at the stand post did not operate any more, but this did not prevent the system to operate correctly.

The free space under the system water reservoir has been closed by cement blocks to provide additional protection. This space is used by a watchman paid XOF 15,000 a month to ensure security.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Ndiamsyl Sessene has 353 inhabitants and 26 households. The household size ranges from 8 to approx. 20 persons.

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved and are still benefitting the local community. Training is said to have been provided on the spot as hands on training. No maintenance manuals had been handed over but a telephone number to be used in the event of technical problems had been given.

b. Effectiveness

The immediate objectives set for in the PLCP have been achieved.

4. Impact

Before the system was installed women had to fetch water from other villages approx. 1 km away. Donkey carts had to be used to transport containers and buckets over the distance, often at night time. Since the system has been in operation village women have saved considerable time. The saved time has been used to take increased care of the family and children as well as to attempt new activities like small scale trading.

5. Sustainability

Financial and organisational sustainability: a water management committee has been set up. Water is sold for XOF 10 per 20 litre plastic can (or plastic basin) from the water stand post in the vicinity of the system. Revenue from water sale is divided into two parts; viz. 50% is handed over to the treasurer and kept aside to cover depreciation and maintenance/repair costs and the other 50% is used to finance a revolving credit mechanism managed by the female members of the community.

Loans from the revolving credit system are to be reimbursed over 6 – 7 months. A loan of for example XOF 20,000 is to be reimbursed with an interest of XOF 3,500. Loans have been granted to both male and female members of the community to assist in starting up activities like sheep fattening (a male activity) and small scale trading of foodstuff in the neighbourhood (a female activity). There are also some ideas of developing market gardening, but this would also necessitate that an appropriate fencing system is set up to protect crops from grazing animals. Women are also interested in running mechanical mills, e.g. for millet. Public lighting with PV cells is also in demand.

Technical sustainability: It is likely that training and capacity building to the extent they were provided (the absence of technical manuals is rather symptomatic of the prevailing situation) will not be sufficient to ensure long term sustainability, as witnessed in other villages.

Acronyms:

SRDC	Service Régional de Développement Communautaire
CADL	Centre d'Appui au Développement Local

Summary of Information collected during site visit

Name of village: Keur Seny Diouf

Region: Diourbel

Date of visit: 24 July 2010

Persons met: Ali Bebe, Village Chief

Khondia Basse, System Manager

1. Overview and status:

System: well equipped with a submersible pump powered by a PV array. The PV array consists of 24 PV modules (6 x 4) type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The system was commissioned in 2005. From the very beginning the water flow has been insufficient and it has never been possible to fill up the water reservoir to its maximum level. After filling up 30 basins water flow decreases considerably. The persons interviewed were of the opinion that the well depth was insufficient. It was said that the village community had never called to complain about the situation. The system is in operation with the limitations imposed by the water flow problem.

The water meter on the well outlet pipe read 884.9 m^3. A stand post with a supporting column and three taps was located in the vicinity of the PVP system.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Keur Seny Diouf has 1,000 inhabitants and 26 households. The household size ranges from 7 to approx. 20 persons.

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved and are benefitting the local community, albeit not fully as expected. No training is said to have been provided and no technical documentation was handed over.

b. Effectiveness

The immediate objectives set for in the PLCP have only been partially achieved due to the existing water flow problem.

4. Impact

Before the system was installed traditional wells with long ropes were used to haul water. With the solar powered system the situation has improved in terms of water quality and lessened work burden, but not in quantitative terms (the available water flow does not fully meet the demand). Even so, the village women felt that the system had a positive impact on their life. A woman told that she fetched each day two basins of water in the morning and in the evening in less than one hour. A cereal mill provided through the PLCP was mentioned as also having had a positive impact. The women mentioned that wood fuel for cooking was becoming a scarce resource and wished to have access to bottled gas as a substitute.

5. Sustainability

Financial and organisational sustainability: Water is sold for XOF 10 per 20 litre plastic can (or plastic basin) from the water stand post in the vicinity of the system. Revenue from water sale is managed by the village water committee. More specific information on the financial management set up was not obtained. It was stated that the committee had an amount of XOF 30,000 at its disposal. An enquiry on the cost of deepening the well had been made and the price quoted was approx. XOF 100,000, i.e. beyond the committee's financial capabilities for the time being. Persons interviewed had a number of ideas as how to generate additional revenue, e.g. bull-calf fattening, storage of foodstuff for further resale and market gardening in the dry season. They may have hoped that revenue from the water sale may have provided a basis for loans to trigger such activities.

Technical sustainability: if, as alleged by the persons interviewed no training has been provided and no technical documentation has been handed over, it will not be realistic to hope that any kind of technical sustainability can be achieved in this village.

Summary of Information collected during site visit

Name of village: Ndine

Region: Diourbel

Date of visit: 24 July 2010

Persons met: Medoune Ndiaye, Village Chief

Thiano Seck, System Manager

1. **Overview and status:**

System type: bore hole equipped with a submersible pump powered by a diesel generator.

The system was commissioned in 2005 but operated for one week only. It was alleged that the engine starting key had been taken away by the contractor/supplier and was never returned. Several attempts by the system manager to get the key back remained unsuccessful. In principle the engine should be able to start using a starting handle, i.e. bypassing the electric starting system. This possibility was seemingly not attempted; in any case it was not mentioned by the persons met on site (the starting handle may have been omitted from the supply?).

Diesel engine is manufactured by Lister Petter (UK). The D/G set is of same time as the one seen in Kelle. After several years without operating it is highly likely that the starting battery is fully discharged and no longer able to pick up charge.

The diesel generator running hours meter read 6 hours only.

2. **Relevance**

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Ndine has a population of approx. ?

3. **Efficiency and effectiveness**

a. Efficiency

Outputs have been achieved but the system has never operated on a sustained basis. It was alleged that no training had been provided and there was no evidence of manuals or technical documentation having been handed over.

b. Effectiveness

As the system has operated for a few hours only the immediate objectives set for in the PLCP have not been achieved as far as the village of Ndine is concerned.

4. Impact

The villagers are still using traditional wells to cater for their water supply. The failure of the system to operate has lead to a situation where no positive impact could be registered. At least no negative climate change impact was generated by the Diesel generator intended to supply the water pump.

5. Sustainability

Financial and organisational sustainability: if a water management committee was ever set up it never actually went into function, no water was ever sold and management capabilities are likely to have vanished by now.

Technical sustainability: there does not seem to exist any sign of technical capacity on site due to insufficient (or lack of) training and lack of technical documentation.

Summary of Information collected during site visit

Name of village: Tambasoce

Region: Tambacounda

Date of visit: 26 July 2010

Persons met: Samba Cissokho, Head SRDC, Tambacounda

All school staff was away on "summer" holidays

1. Overview and status:

System type: well equipped with a submersible pump powered by a PV array. The PV array consists of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The system is located within the compound of the village primary school. It was commissioned in 2008. The supply cable to the submersible pump got disconnected twice in 2009 and 2010. In both cases the problem was solved by an electrician from Tambacounda. The elevated water reservoir is not fully tight. There are clear signs of water infiltration and stalactites are actually forming along the bottom edges of the concrete water tank. Poor concrete quality is likely to be the cause of such infiltrations.

The PVP system is still in operating order. At the time of the visit the school was closed for the annual "summer" holidays (a 3-month period covering the rainy season, i.e. July, August and September).

A stand post with a supporting wall and three taps was located on the side of one of the school buildings. Two out of the three taps were broken but it was said that they would be repaired before the school reopened.

The water meter on the well outlet pipe read 9,188.5 m^3.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply to the school and surrounding area;
- Improve the quality of water supply;

- Reduce the burden of fetching water from conventional wells (mainly a female task).

The school has 290 pupils in the age 5 – 12/13 years.

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved and are benefitting the school children and the rural population in the neighbourhood. Training was said to have been provided to two persons (the deputy school principal and a member of the parents' association) who attended a training session in Tambacounda arranged by the equipment supplier. A manual for the PV modules was said to have been handed over and kept by the deputy principal. No technical information had been provided on the submersible water pump.

b. Effectiveness

The immediate objectives set for in the PLCP have been achieved.

c. Impact

Before the PVP system was established water had to be fetched at the airfield using a donkey cart. Every three days two journeys were made to transport each time 15 cans of 20 litres, or in total 600 litres. With the PVP system situation has improved considerably. Water for the school can be easily fetched from the stand post in sufficient quantities. Water is also used for watering the school garden and the school mango tree and is sold to households in the neighbourhood. Some households use water for brick making.

d. Sustainability

Financial and organisational sustainability: management is the responsibility of the school deputy principal and money is paid by the APE (schoolchildren's parents association). Water is sold to households in the neighbourhood at a cost of XOF 25 per 20 litre plastic can. No calculation had seemingly been made to determine the price of water. The price charged is said to be equivalent to the price charged in Tambacounda. Crops from the school garden are sold. Revenue from this small scale market gardening is shared between the school's account (55%) and the gardener (45%). The school operates a canteen with funds contributed by the parents and funds generated by market gardening. Foodstuff (rice, maize) for the canteen is also obtained through WFP.

As the school staff was not available it was not possible to have more precise information on the financial situation and in particular the school's ability to pay should there occur a major breakdown on the PVP system. The prospect of achieving organisational sustainability should be better in the case of Tambasoce as the persons dealing with the system are likely to have a better understanding of the need for a performing organisation to operate a PVP system on a sustained basis.

Technical sustainability: as training has been provided and some technical documentation handed over the chances of securing some kind of technical sustainability seem better in that case. A major risk for technical sustainability is the staff turnover. New staff coming to the school will not have the opportunity to be trained or directly receive information by the system supplier, like has happened for the staff now in charge.

Acronyms:

SRDC: Service Régional du Développement Communautaire

Summary of Information collected during site visit

Name of village:	Sinthiou Thidy
Region:	Tambacounda
Date of visit:	26 July 2010
Persons met:	Sadhio Bâ, Village chief

1. **Overview and status:**

System: bore hole equipped with a submersible pump powered by a PV array. The PV array consists of 24 (6x4) PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The PVP system was commissioned in 2006. There has been no technical problem with the PV array and the system is still functional. The only problems registered are water leaks on piping (leaking joints) under the elevated water tank and on the bore hole outlet pipe. The village chief has stopped the leaks himself using old rags.

A stand post with a supporting column and three taps has been installed in the vicinity of the PVP system. One of the three taps had a broken handle but could still be opened and closed. The other two were intact and in operation.

The meter on the bore hole outlet pipe read 24,346.7 m^3. The meter at the stand post read 17,981 m^3 and had a leaking packing.

2. **Relevance**

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

The village has 20 households ranging from 6 – 20 persons. The village population is approx. 300 persons (there were contradictory information on the matter). The village chief's household was said to include 22 persons.

3. Efficiency and effectiveness

a. Efficiency

Outputs have been achieved and are still benefitting the local community. It was alleged that no training had been provided. A toolbox with a few tools was kept by the village chief. The village chief had also some leaflets in French with technical information. They were of little use as the chief could not read.

b. Effectiveness

The immediate objectives set for in the PLCP have been achieved.

4. Impact

Before the PVP system was installed water was fetched from three traditional wells in the village. Two of them were said to still be in use. Village women can fetch water from the stand post supplied from the PVP system from 7 a.m. till 7 p.m. From the visit it is obvious that many women come to the stand post to get water. Some of them were asked about how many times they did come every day and with how many cans each time. Women had difficulties in answering that question and the answers provided were highly diverging. It seems that 3 – 6 times a day was rather common, each time transporting a 20 litre can or basin.

In terms of quality wise and quantity wise improvements in relation to water supply the PVP system in operation has a positive impact on living conditions including fewer burdens for the village women.

5. Sustainability

Financial and organisational sustainability: one of the villagers has been appointed to look after the PVP system, both in terms of maintenance and security. Sinthiou Thidy is a special case among the villages visited as households there are not charged for their water consumption. Water for livestock is charged XOF 100/month/head for a horse or a donkey. Smaller animals like goats and sheep are not charged. The village has thus no financial resources available to take care of coming expenses in the event of breakdowns, not to mention depreciation.

With the prevailing situation in Sinthiou Thidy financial and organisational sustainability cannot be achieved. Trough a discussion with the village chief the matter of financial and organisational sustainability was taken up and an argumentation was developed in order to try to convince the village chief to adopt a different and more sustainable approach.

Technical sustainability: under the prevailing circumstances the prospect of achieving some form of technical sustainability seems doubtful (insufficient or no training provided, technical documentation not accessible to the decision making person).

Summary of Information collected during site visit

Name of village: Safalou II

Region: Tambacounda

Date of visit: 26 July 2010

Persons met: Hamadi Sylla, Village chief

1. **Overview and status:**

System: well equipped with a submersible pump powered by a PV array. The PV array consists of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The system was commissioned in 2006. System operation has from the beginning suffered from a flow problem. It has been noticed that sand entered the pump strainer. Attempts were made to convince the well-sinker to increase the well depth, but to no avail. No corrective intervention took place during the guaranty period. A specialist was called in on three occasions to investigate the pumping problems but never managed to find a suitable solution.

The system operated in the beginning, albeit with the above mentioned constraints, but it suffered a major breakdown in 2009 (approx. one year ago). The submersible pump was taken up by an electrician who concluded that the pump was burnt down and had to be replaced. The damaged pump has until further been kept by the village chief.

No problem was experienced with the PV array when the system was in operation.

A stand post with a supporting column and three taps is located in the vicinity of the PVP system. One of the three taps was missing. The stand post is no longer in use. The well head base plate has been removed and an elevated circular structure made of cement blocks has been erected on top of the well head so that the well can be used as a traditional one where water can be hauled using buckets.

The dismantled water meter, which used to seat on the well outlet pipe, read 4,908 m^3. The meter together with the piping and the submersible pump were found in the village where they are stored.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Safalou II has approx. 350 inhabitants and 26 households. The village chief claimed to have 50 persons in his household.

3. Efficiency and effectiveness

a. Efficiency

Outputs were achieved but are no longer benefitting the local community. Training is said to have been provided with two persons attending a training session in Tambacounda. Training was said to have focused on setting up of a management committee and financial aspects. Technical issues were not on the agenda. The participants were given telephone numbers to be used in the event of technical problems.

It was stated that no maintenance manuals had been handed over.

b. Effectiveness

The immediate objectives set for in the PLCP were partly achieved (not fully due to the recurrent flow problems) in the 3-year period of system operation. This is no longer the case after the system broke down in 2009.

4. Impact

Before the system was installed traditional wells were used to haul water. With the solar powered system the situation improved in terms of water quality and lessened work burden, but not in quantitative terms (due to the recurring flow problems). In the three years the system was in operation it had a positive impact but this came to an end in 2009.

5. Sustainability

Financial and organisational sustainability: water was sold for XOF 20 per 20 litre plastic can (or plastic basin) from the system stand post. Each household had also to contribute with a monthly amount of XOF 150. Water for livestock was charged XOF 200/head/month. The revenue from water sale proved not sufficient to accumulate funds to cope with major repairs. The broken submersible pump has thus not been replaced due to lack of funds.

As the PVP no longer operates no financial and organisational sustainability will be achievable.

Technical sustainability: the recurring flow problems experienced during the operating period, and which never found a suitable solution, are likely to be the cause of the pump breakdown in 2009. It is obvious that during the three years of system operation technical sustainability was not properly achieved. With the system out of operation technical sustainability will remain out of reach.

Summary of Information collected during site visit

Name of village:	Bagadadji
Region:	Kolda
Date of visit:	27 July 2010
Persons met:	Kalidou Kande, Village chief Doudou Dramé, Volunteer, Ministry of Communitarian Development

1. **Overview and status:**

System: well equipped with a submersible pump powered by a PV array. The PV array consists of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The PVP system was commissioned in July 2004. A technical problem was experienced in 2006 and solved at no cost to the village by the system supplier (TOTAL Energie). The system may at the time still have been under guarantee. A new incident developed later (date was not communicated) but this time the village did not succeed in getting assistance from the supplier.

In April 2009 pumping stopped and the system has not operated since. The problem is likely to be a pump breakdown, but no further investigation has seemingly taken place.

A stand post with a supporting column and three taps is located in the vicinity of the PVP system. It was difficult to access as it actually was right in the middle of a maize field. The stand post is no longer in use.

2. **Relevance**

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Bagadadji has approx. 415 inhabitants and 26 households. Household size was said to be around 30 persons. The village chief told that he had 26 persons in his household.

3. Efficiency and effectiveness

a. Efficiency

Outputs were achieved but are no longer benefitting the local community. Training is said to have been provided with two persons attending a training session in Kolda. A tool box with a few tools had been handed over by the supplier but no technical manuals.

b. Effectiveness

The immediate objectives set for in the PLCP were achieved in the period 2004 – 2009 when the PVP system was in operation. This is no longer the case after the system ran into a major problem in 2009, a problem still waiting to be solved.

4. Impact

Before the system was installed traditional wells were used to haul water. With the solar powered system the situation improved in terms of water quality and quantity as well as lessened work burden. This positive impact came to an end in 2009, i.e. after approx. 5 years of operation when the system ran into a major failure. The villagers have since been forced back to the old wells.

5. Sustainability

Financial and organisational sustainability: water was sold for XOF 20 per 20 litre plastic can (or plastic basin) from the system stand post when the system was in operation. Revenue from the water sale was divided into three parts, i.e. one to take care of maintenance and repairs, one to take care of depreciation and the third one for a community fund. The lack of action to have the system pump checked and possibly repaired or replaced is linked to the lack of funds at the community level.

As the PVP system no longer operates there is no realistic way of achieving financial and organisational sustainability.

Technical sustainability: it is obvious that during the years the PVP was in operation technical sustainability was not properly achieved. When a major technical problem did occur the person(s) in charge were either not able to take action in order to have the problem investigated and solved, or did take some action but did not succeed in getting any kind of positive feedback leading to a situation of permanent standstill. With the system out of operation technical sustainability will remain out of reach.

Summary of Information collected during site visit

Name of village:	Sare Gagna
Region:	Kolda
Date of visit:	28 July 2010
Persons met:	Samba Diamanka, Village chief
	Doudou Dramé, Volunteer, Ministry of Communitarian Development

1. Overview and status:

System: well equipped with a submersible pump powered by a PV array. The PV array consists of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The PVP system was commissioned in 2004. The system operated without problem until December 2006 when it stopped. The supplier TOTAL Energie was contacted and came on site to test the system. The DC/AC converter was found defective and was replaced on 19 December 2006. In 2008 a second system failure was experienced. TENESOL (earlier TOTAL Energie) was contacted by phone and a team of two technicians came on site on 12 May 2008 for an inspection. Their conclusion was that the pump and a hydraulic arm had to be replaced. A quotation for the work to be done, including transportation expenses, amounted to XOF 1.3 million. As this amount exceeds the community's financial capabilities no replacement was carried out and the system has remained out of order ever since.

The water meter on the well outlet pipe read 3,429.6 m^3.

A stand post with a supporting column and three taps is located in the vicinity of the PVP system. The stand post is no longer in use.

2. Relevance

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

supplier in order to find solutions. The last problem encountered was unfortunately of such magnitude that it could not be solved with the financial means available at community level. This has resulted in a situation of permanent standstill. With the system out of operation technical sustainability will remain out of reach.

Summary of Information collected during site visit

Name of village: Hamdalaye Dega

Region: Kolda

Date of visit: 28 July 2010

Persons met: Hamadou Bande, Village chief

Doudou Dramé, Volunteer, Ministry of Communitarian Development

1. **Overview and status:**

System: should have been a well equipped with a submersible pump powered by a PV array. The well, the elevated water reservoir and the stand post have been wholly or partly implemented, but the technical installation consisting of the submersible pump, piping, cables, PV array, etc. was never carried out.

The reasons for the non completion of the works could not be clarified through the questions raised on site. The most likely explanation is a delay in the implementation of civil works, which did not leave sufficient time for the installation of the technical equipment before the closure of the project.

2. **Relevance**

Like in all the other villages selected within the framework of the PLCP the water pumping system in Hamdalaye Diega was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply in the village area;
- Improve the quality of water supply;
- Reduce the burden of fetching water from conventional wells (mainly a female task).

Hamdalaye Diega has approx. 400 inhabitants. The number of households could not be established (likely to be in the range 20 – 30).

3. **Efficiency and effectiveness**

a. Efficiency

Outputs were never achieved.

Summary of Information collected during site visit

Name of village: Sare Alkaly

Region: Kolda

Date of visit: 28 July 2010

Persons met: Ousmane Kante, Watchman

Aliou Diallo (telephone interview only)

1. **Overview and status:**

System: well equipped with a submersible pump powered by a PV array. The PV array consists of 7 PV modules type TE 850 from TOTAL Energie. See summary sheet for Ndiamsyl Sessene for main specifications of type TE 850.

The PVP system is located within the compound of the village kindergarten (Case des Tout Petits) built by the PLCP. The system was commissioned in 2008 (could also be 2007, uncertainty about the year of commissioning).

At the time of the visit the kindergarten was closed for the annual "summer" holidays (a 3-month period covering the rainy season, i.e. July, August and September). Consequently, no staff was available for questioning.

The PVP system operated satisfactorily until early 2010 when it stopped. A technician based in Zinguinchor was contacted and came to inspect the system. The problem was seemingly found to be a pump breakdown. The technician took the pump to his workshop and it has so far not been returned (the technician is likely still waiting for some payment to carry out a repair). It was said that a quotation for the pump repair amounted to XOF 40,000. This amount did not seem to be readily available.

The PVP system supplies stand posts with supporting walls and taps inside the kindergarten compound.

2. **Relevance**

Within the framework of the PLCP the water pumping system was intended to address the following major issues:

- Contribute to solve a quantitative problem in terms of water supply to the kindergarten/school;

APPENDIX 5

Overview of technical details of procured and installed PVP systems

The tender documents and technical specifications required the PVP systems to be designed according to the three different types mentioned below:

Type	Pump installation depth	Total head	Output
S1	15 m	25 m	20 m^3/day
S2	30 m	40 m	20 m^3/day
S3	45 m	55 m	20 m^3/day

Equipment to be supplied for each of the three types included the following main components:

- A drop pipe in the well or borehole
- A submersible pump
- A submersible cable to connect to the pump motor
- A well or borehole seal
- An outlet pipe with valves and water meter
- A PV array with a pump controller/converter (S1 and S2 systems) or an inverter (S3 systems), including the PV array supports and their foundations and a wire mesh fence to protect the PV array
- Technical documentation and manuals
- Training of operators
- Maintenance tools

Components provided/installed through other contracts included for each system type the well or borehole, an elevated water reservoir made of concrete and piping to the reservoir.

All three system types are designed to operate as stand-alone systems without the use of batteries.

The PV arrays consist of a number of PV modules made of polycrystalline silicon. Two types of modules from TOTAL Energie have been used: TE 850 and TE 1250.

Main specifications for both types are given below:

TE 850

Typical Peak Power (P_{max}): 80 Wp
Voltage at Peal Power (V_{mp}): 17.3 V
Current at Peak Power (I_{mp}): 4.6 A
Short Circuit Current (I_{sc}): 5.0 A
Maximum System Operating Voltage: 730 V

TE 1250

APPENDIX 6

Selected photographs of visited PVP systems

1. Village stand post in Keur Seny Diouf
2. PV Array in Keur Seny Diouf
3. PV Array in Ndiamsyl Sessene
4. Electronic inverter under PV Array in Ndiamsyl Sessene
5. Disused stand post in Safalou II
6. Elevated water reservoir and PV Array in Safalou II
7. Elevated water reservoir in Sinthiou Thidy
8. Village stand post in Sinthiou Thidy (PV Array visible in the background)

2. PV Array in Keur Seny Diouf

4. Electronic inverter under PV Array in Ndiamsyl Sessene

6. Elevated water reservoir and PV Array in Safalou II

8. Village stand post in Sinthiou Thidy (PV Array visible in the background)