INDEPENDENT REVIEW OF THE MOROCCO-CLEAN AND EFFICIENT ENERGY PROJECT (P143689) TO BE CO-FINANCED BY THE CLEAN TECHNOLOGY FUND (CTF)

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1 INTRODUCTION

Morocco has a peak demand of power of around 5,600 MW, which is in the low range for a country of 38 million inhabitants but typical for a developing economy with a small industrial sector compared to total overall demand. This peak demand is met through power generation from around 50 power plants owned by ONEE[1] (which covered 41% of the demand in 2012) and from the private power plant sector (in 1994 generation was open to independent producers) with a total power installed of 1.754 MW (which also covered 41% of the demand,13,168 GWh ,in 2012).

The electric system is interconnected to the Iberian grid through two submarine cables with a theoretical capacity of 1,400 MW but in practice average exchanges are limited to 750-800 MW due to security reasons. These imports are important for the Moroccan supply of electricity because they are of around 18% of the total demand, or 5,660 GWh in 2012. These imports are normally purchased in the whole sale Iberian electric market, which makes ONEE the fifth operator in that market by size. Additionally this interconnection to the strong European grid contributes to the grid stability of the national power system. The connection with Algeria is of around 400 MW but is mainly used for security and less used than the interconnection with Spain due to a limited synchronization capacity.

ONEE is therefore the sole electricity purchaser in Morocco's electricity system and directly supplies to end consumers around 59% of the total demand, particularly in rural areas (rural electrification program) and large consumers. The other 41% of total demand is supplied by municipalities and private concessionaries. The PPA agreements contracted under the renewable 13-09 legal framework, between producers and final consumers, include a wheeling fee for the transmission of electricity. Tariffs are modulated for consumers of low incomes in a typical model of cross subsidization following a social policy that has had an impact on ONEE's financial situation.

The average annual growth of the demand has been of 7.2% between 2002 and 2012 due mainly to the extension of the rural electrification (it reaches now to 98% of the population), development of important structural projects (such as the increase of phosphate production and the establishment of free economic zones like i.e. Tangier) and general improvement of the quality of life.

The Morocco Kingdom has a high potential for Renewable Energies, mainly wind and solar radiation, which have a complementary generation hourly rates: solar radiation during the day, with around 1,700 hours per year of nominal generation, and wind, producing during the day and night, with more than 3,000 hours of nominal generation. The combination of both, offers a unique opportunity for development of RE in the country with the positive impact on GHG emissions reduction and creation of local employment. Law 13/2009 promotes the use of these important resources guaranteeing the connection to the grid and promoting the implementation of projects through competitive biddings

[1] ONE (Office National de l'Electricité) is the public electric company created with in 1963 and with responsibilities on water supply since 2006 changing its acronym to ONEE (Office National de l'Electricité et de l'Eau). The structure, management and operational criteria follow in a large extent the French model.

This document evaluates the eligibility of the different components of the project for CTF financing based on the information provided, the best criteria of economic and technical efficiency as well as the international experience.

1.1 Project scope and objectives

The general objective of the project is to increase the efficiency of the Power Generation and the use of Clean Electrical Energy, with interventions in the supply and the demand of electricity. The project is split into four components (in brackets the budget for each sub-component):

- ONEE's Solar PV programme (1.1: US$ 91 million from IBRD and US$ 23.95 from CTF/ 1.2: US$ 250.000 from IBRD)
- Plannig and Dispatching of Renewable Energies (2.1: US$ 4.5 million from IBRD/2.2: US$ 200.000 from IBRD)
- Utility Demand-side Management and Revenue Protection program (3.1: US$ 13 million from IBRD/3.2: US$ 250.000 from IBRD)
- Technical assistance (US$ 300.000 from IBRD)

These four components are quite different because they affect several phases of the power chain (i.e: Utility demand-side management and revenues protection is a peak shaving program and the others are related to the electricity supply), but if they are well integrated and coordinated (with other ONEE initiatives[2]) they will create a more efficient and effective electricity supply for Morocco. Furthermore, they can be used as a reference to extend the experience to other regions and countries[3] mainly the PV and the smart meters program components.

The proposed project, not only the PV component, is therefore consistent with the overall objectives of CTF and in line with Morocco's energy strategy of diversifying and promoting the use of indigenous primary resources. Moreover, the goal of the "Utility Demand side Management" component is to optimize the power supply in the hours of more polluting and costly power generation. These savings can simultaneous be transferred to the final consumer as well as improving ONEE's current difficult financial situation. In the following sections more details of the different components are presented with their impacts evaluated in accordance to CTF criteria.

1.2 Brief presentation of the different components

1.2.1 Component 1 – ONEE's Solar PV program

The component is organized in two sub-components:

Subcomponent 1, 1st Phase "Talifalt" Project: This is the 1st Phase of a more ambitious program for installing 400 MW of PV projects in 16 sites located at the end of high-voltage transmission lines[4]. This program has two main goals: from the energy perspective it is to utilize the untapped solar primary resources as well as reducing power losses and avoiding voltage drops typical in long lines. From the social perspective, it will have the knock on effect of improving the economic activities in communities with significant poverty rates by providing a better quality of power supply.

In this 1st Phase, ONEE has identified three sites near the villages of Erfoud, Zagoura and Missour to develop a 25 MW plants. IBRD and CTF will finance the capital costs of these three plants, while ONEE will finance the costs of land and evacuation infrastructure.

[2] For instance the implementation of wind projects was initiated with ONEEs ownership but it has been progressively changed to IPPs (Independent Power Producers) and PPAs (Power Purchase Agreements with private consumers) which should be the model for future RE projects. The combination of contractual and technical experiences with those to be obtained with this project will facilitate the achievement of the expected results.

[3] As it is mentioned in the PAD, Morocco wants to be a reference for other African countries.

[4] This 400 MW PV plants are ONEE's initiative but taking into consideration the high solar potential and the grid topology, other projects to be owned by private developers should also be promoted.

Subcomponent 2, promote private participation in distributed PV generation: it is critical to take advantage of the good radiation conditions in Morocco and to facilitate the private involvement through specific purchase contracts and launching particular bidding procedures.

1.2.2 Component 2- Planning and Renewable energies dispatch center

This component is also split into two subcomponents:

Sub-component 2.1: Renewable Energy dispatch center, that it has the main goal of installing a Renewable energies dispatch control center to be integrated in the existing SCADA system to control the power plants connected to high voltage networks. It includes the supply and installation of the required software and hardware as well as the necessary screens to follow the operation and load flows of the whole system.

Preparatory work prior to the installation of the control center includes also drafting the following codes:

- Requirements to connect the RE power plants to the grid.
- Requirements for the operation of those power plants in permanent and transitorily situations.
- Procedures to evaluate the capacity credit of the RE power plants.
- Analysis of the impact of prediction of the generation for the following day.
- Evaluation of the impact on the ancillary services.

All these codes and the installation of the Platform will allow a more flexible integration of Renewable Energies in the system, it will make extensive use of renewable energy plants and it will allow an for easier operation of the electrical system. This component is expected to lead to a reliable operational power system with lower transmission losses and reduced emissions.

The experience of other countries, mainly Spain, has shown the clear benefits of installing this kind of Dispatching Center. For instance the “Centro de Control de Instalaciones del Régimen Especial” CECRE platform, has helped to increase the penetration of Renewable Energies from 15% (before Control Center) to 40% (after Control Center started operations) of Spain's mainland yearly demand. Despite the fact that the control center allows generation curtailment to maintain system safety, it has also allowed the connection and operation of 30.000 MW in a system with a peak load of 45.000 MW.

It is therefore realistic to assume that at least 5% of the total generation will be covered with RE in Morocco because of the installation of the proposed Dispatching Center either, which will allow an increase of the total installed power capacity and or will foster a better operation of the connected plants. Without the proposed Dispatching Center, the efficient operation of the total power to be installed in 2020 using renewable primary resources (6,000 MW are foreseen, 42% of the total, split into the three resources: solar, wind and water) would be difficult to achieve.

Subcomponent 2.2: Increasing ONEE capacity to perform long-term power planning that considers renewable and synergies with the water sector:

This subcomponent will support ONEE’s planning department by increasing their capacity and acquiring modern tools to further strengthen their capabilities in planning, taking into consideration the possible involvement of RE (wind, solar, biomass, hydro,..) projects in participating in ancillary services as well as the variability of the renewable primary resources.

1.2.3 Component 3 - Utility Demand-side Management and Revenue Protection program:

This component is composed of two subcomponents:

Subcomponent 3.1: Smart Meters Program

The peak demand in Morocco is covered by expensive fuel-oil power plants and therefore is important to reduce the load in those hours to decrease the cost of power supply and to abate gas emissions. The

most appropriate way to shift peak power to off-peak hours is to offer attractive tariffs to important consumers to displace their load to those periods. To do this, it is required to have electronic meters which are able to measure hourly consumption.

This component should be applied to 60,000 ONEE consumers whose demand is over 500 kWh/month (80% are residential consumers and the rest are different kinds of economic activities including industrial, commercial and agricultural).

Besides the reduction of load, these smart meters will record different consumption patterns to be used by ONEE for a more optimized system and load forecasting.

Subcomponent 3.2: Deepening and identifying additional opportunities for utility-implemented energy efficiency and demand side management programs.

This sub-component will support the analysis of the results of the smart metering program to scale it up based on lessons learn from the first phase. This subcomponent will also identify options, define priorities and actions plan for selected energy efficiency and demand side management programs to be driven and implemented by ONEE.

2 OVERALL COMPLIANCE WITH CTF OBJECTIVES AND CRITERIA

In the following sections, an evaluation on how the project meets the CTF criteria is undertaken.

2.1 *Objectives*

The evaluated project fulfils the CTF goal of promoting the use of renewable energies in the energy supply through two different types of actions: implementation of PV projects at the end of the HV electric lines and the creation of a RE dispatch center. Additionally, the selective introduction of smart meters and the hourly discrimination tariffs will have an indirect impact in replacing expensive and highly polluting power plants, by other less harmful generation procedures.

Nevertheless, to guarantee the fulfillment of the results and to foster a large-scale adoption of the different technologies some recommendations are included in Chapter 4 of this document.

2.2 *Overall compliance with CTF criteria*

2.2.1 Potential for GHG emissions savings

The following table presents the **reviewer's analysis of the economic impact of the three PV plants**, as well as the emission reductions assuming a specific emission of 585 g/kWh (UNFCC simplified methodology) for heavy fuel-oil power plants with a price of 2,300 MAD/ton of fuel and a 25-year project life. It has been considered 1,700 hours/kW of nominal net generation; the results are similar to the PAD with a slightly less reduction of CO2 emissions.

IMPACT	MWh	Economic savings		Reduction of CO2/emissions	
		MUS$/year	MUS$/plants life	Tons/year	Tons/plants life
Avoided oil derivatives generation	127,500	8.21	205.3	74,588	1,864,688
Losses reduction	6,603	0.4	10.6	3,863	96,573

The economic savings calculated by this reviewer for the PV plants are higher than mentioned in the PAD report. This is most probably due to differences in HFO prices and also because of this savings by loss reduction have not been included in the PAD.

On the other hand, It is difficult to estimate the actual impact on emissions reduction of the achievable peak-shaving by installing the proposed number of **smart meters**, which are devices very common in the electric systems of developed economies. The PAD shows that in previous experiences, energy savings of 3% to 5% (an economic saving because the load is the same but in different hours) were recorded. As far the capacity replaced will be a combination of coal, gas and imports, the estimation of the PAD can be considered realistic.

2.2.2 Cost effectiveness

The PV plants show clear benefits for the reduction of emissions as far as the unitary cost is approximately 82.3 $ per ton of CO2, and when the marginal cost of reducing a ton of CO2 equivalent has to be below US$ 200.[5]

On the other hand, the economic analysis of the PV component included in the PAD mentioned an average of the ERR 3.97%. This is lower than typical WACC (Weighted Average Cost of Capital) of international utilities which is normally between 6%-7%, depending on interests rates and leverage levels (this is in fact the 6% discount rate mentioned in the PAD). Therefore the project is not economically very effective but nevertheless the hedging is clear, because the generation price is known since the project start. In this sense the LCOE of the PV of 9.8 cents/kWh[6] is very competitive with future CCGT power plants and it opens the opportunity for progressing in the installation of future PV plants.

It is important to mention that there is a great competition among Asian modules manufacturers and the Japanese market is showing a certain trend to the saturation, so probably CAPEX is going even lower in the short term future.

Regarding the estimation of the reduction costs of the **dispatch center and the smart meters components** are more complex because they are based on reductions of emissions which have to be actually achieved. Following the results presented in the above section the unitary cost will never be more than 10 $/ton but it has to be measured once both systems are operational.

2.2.3 Demonstrational potential at scale

The **PV plants** should be used as a reference for similar projects in Morocco, a country with high levels of radiation and very long lines, due to topography and geographic characteristics. The combination of both factors combined with the use of indigenous resources and the improvement of the quality of power supply, makes this component as a perfect reference for similar projects.

Furthermore the three plants should be used to facilitate the involvement of the private investor in future phases such as is mentioned in this report. The goal mentioned of the 400 MW of PV only of ONEEs ownership (with a potential of reduction of more than 10.4 million tons of CO2), complementary to the other 2,000 MW of CSP to be carried out by MASEN, will be even increased if projects are implemented based on IPPs with the lower bidding price. This PV component is thus consistent with the CTF eligibility criteria but it is important that it is executed with stringent technical criteria, at the lowest possible cost and be used as a reference for similar projects.

The installation of the proposed dedicated **Dispatch Center** to maximize the penetration of renewable energies in the Moroccan generation mix could also become a model for other electrical systems in the region or emerging markets such as has been in the Spanish case. The cost and complexity of the necessary exchange of communications/signals with the RE power plants makes it only possible in countries with the high potential of Renewable Energy penetration in the overall generation mix.

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[5] This is the threshold for CTF co financing projects: the marginal cost of reducing a ton of CO2 equivalent is lower than US$ 200. It is true that there are other benefits to be also included for instance: employment creation, guarantee of supply, other emissions reductions, ..

[6] In Table 1 of the Annex 6 where different alternatives are compared the economic cost of the wind farms is estimated in 2,000 US$/kW that is clearly very high if compared with the present market conditions. With a more realistic value the cost/kWh would be of around 0.050 US$/kWh in line with the Brazilian auctions with similar wind conditions that in Morocco. This result does not affect to the goal of the project but it could be taken as a reference for other projects.

2.2.4 Development impact

The PV and Dispatch Center components will allow for a more reliable power supply and reduced GHG emissions. In parallel, these investments will strengthen the local economy by creating employment and reinforcing technological capacities at a national level. It is recommended to reinforce the collaboration with the neighboring electrical systems including with the TSO from the Canary Islands (isolated systems operation in similar weather conditions).

Only the installation of the PV plants at the end of the lines will be 127.5 GWh/year, less than 1% of the demand in 2012, which will increase 6% per year in the next ten years that it shows the high potential of this kind of plants.

2.2.5 Implementation potential

ONEE has proposed the project in its current structure. The project is in line with the Moroccan government's strategy of scaling-up the promotion of indigenous resources, reduction of harmful emissions and the strengthening of local development.

2.2.6 Additional cost and risk premium

In general, investments are of limited technical risks but they should be tested to demonstrate their feasibility working in real conditions. For instance there aren't any PV plants of this size in Morocco to facilitate the voltage control at the end of their lines. Similarly, it will be important to learn from the operation of the Dispatch Center and its functionality to integrate variable sources power while maintaining the reliability of the electrical system.

One of the main challenges of the smart meters is to demonstrate the impact on shaving the peak demand as well as their potentiality to be used in other demand side management programs.

To conclude, the integration of these four components and their coordination with other ONEE projects will be consistent with CTF financing requirements.

2.3 Technology readiness

PV Plants are commercial technologies which should be adapted to local conditions to reinforce their capability of voltage control. Therefore the technology is ready but integration of monitoring system is recommended to follow the evolution of the different electric variables. The experience will be used to lower the barriers for similar installations in Morocco and abroad.

It would also be important to demonstrate that a coordinated operation of the Dispatch Center, based on commercial SCADA and hardware solutions, will only increase the penetration of renewable energies.

Both solutions will reinforce the green power generation in Morocco due to the complementarities of PV with new and existing wind and CSP and the integration of all technologies with the proposed RE dispatch center.

3 CONCLUSIONS AND RECOMMENDATIONS

The project, with its different components, will consolidate Morocco as a green reference for other developing countries. The project will also allow a more efficient use of conventional thermal power plants, especially HFO, with higher levels of emissions and cost of generation. The project meets all CTF's eligibility criteria.

The benefits of the project in terms of reducing the GHG emissions are clear as far as they are going to replace mainly coal and fuel-oil electricity and marginally, natural gas and imports. Additionally the quality of supply is going to be improved with the reduction of losses and voltage drops. Nevertheless and taking into consideration the financial situation of ONEE and the experience of previous Wind Farm projects, it would be highly recommended to launch future projects under an IPP scheme based on competition of LCOE prices which will improve the economic effectiveness of the project and at the end, the potential impact on consumers tariffs.

The potential of all components are very high and it is recommended to introduce management and operational procedures in the PV plants which, besides a plant operation guarantee, could be used as a model for other countries. It is therefore suggested to disseminate the results of the project through articles and conferences showing their technical and economic impacts.

Finally, this consultant wants to emphasize the complexity of the project with so different components and the importance of a continuous monitoring the different activities. Part of the budget of the technical assistance could be applied to this objective

Following this evaluation, the reviewer still has the following comments to ensure the fulfillment of the expected results:

Reviewer comments	WB Response	Final comments
Solar PV Program: 1st phase - Talifalt project		
Based on international experience, between 20-30 people could be employed in each site for operation, maintenance and security; it seems a low figure, but for these small rural areas it could have a notable impact.	We agree that while direct employment impact during the operating period is limited, the local impact in a small community will certainly be important.	Ok
In the sensitivity analysis natural gas prices have been included when PV plants aren't going to replace it. It would be better to use HFO, coal or even replacing imported electricity from Spain. This price has been historically half of the CCGT prices.	PV production will certainly not displace coal production, because the amount of installed capacity coal plants (less than 3,800 MW by 2018) is even not sufficient to cover the base load, inertia of coal steam plants, hence a limited flexibility. HFO is uneconomical and will be phased out. The project economic analysis assumes that ONEE generation plan is least cost and therefore CCGT's will be used. The price of imported electricity is highly variable and subject to various types of taxes imposed by the Spanish Government which makes a comparison not easy to carry out.	In Spain CCGT covers normally the peak demand, so this response is coherent with future scenarios.
In the sensitivity analysis it is unrealistic to increase the cost of PV installation by20% and it would have been better to increase the Operation and Maintenance costs, which are normally under-estimated (it is true that they have a lower influence in the ERR).	The CAPEX cost used in our analysis is on the lower end of the estimation and a 20% stress test is merely an attempt to reflect that, and the fact that PV EPC contractors are not familiar with Morocco, where this experience will be a first.	Ok, but a 20% seems still very high. There is a fierce competition among Asian PV modules manufacturers.
The LCOE seems very low, even in the present market conditions, and it should be mentioned that it is due to privileged financial conditions. For private investors with commercial loans, it is going to be difficult to reach similar values.	Financial conditions were not included in the calculation of LCOE. The estimated LCOE is a reflection of low capex ($1700/kWp) and a 20% capacity factor. Financial conditions will certainly improve the PV generated energy price. PPA prices take into account costs (capex and opex), amount of energy generated, debt	Ok, final prices are related to solar radiation, taxes and other benefits, but it is true that prices are clearly declining. This will open the opportunity for

	conditions and expected return on equity. Private investors will offer a price to reflect the former parameters. PV PPA prices were as low as 8 cents per kWh in the US. http://www.txses.org/solar/content/austin-energys-potential-solar-deal	private investors.
The ERR is in some cases over the typical WACC or the power companies (in average in the EU is of around 7% for generation investments), taking the opportunity cost of money as far as ONEE receives public finance, which is mainly due to the good financing conditions of the CTF funds. In case of replication for private investors it could be more difficult to reach those values and the replication effect could be then be quite restricted	It is true that commercial loans are more expensive and add more conditions to secure an acceptable stream of cash flows to ensure debt payment and will yield much higher prices. The main drivers of future PV projects will be: • Lower capital investments • Increasing electricity tariffs in Morocco • The right legal framework and incentives to private sector and investors.	The evolution of the mentioned variables and the experience in other countries show that PV investments are in general very attractive.
It is unclear that the use of the discount rate for the ERR calculation is used only as a reference. It would have been different to use the NPV to calculate the economic feasibility of the project.	Discount factor is used to calculate the gas-CCGT LCOE used to value PV energy generation. In principle in an ERR calculation, discount factor is only used as a benchmark to decide on the economic viability of a project. The NPV is also calculated.	Ok, but it would have been convenient to mention the forecast of NG prices too.
In this same sense, it would be important to promote the involvement of private investors, with an initial involvement in the Talifalt project but with the promotion of IPP or PPA schemes. Is WB going to suggest and even to sign some kind of agreement with ONEE in this line? Is there any estimation of the impact on final consumers tariffs once soft loans are not anymore used?	The Bank is encouraging ONEE to involve the private sector in the project development and in operating the PV plants. ONEE has accepted to undertake a study, during project implementation, to assess the conditions required for successful IPPs in solar PV in Morocco, which could be developed in later phases of its solar PV program. Moreover, ONEE is likely to leave the operation of the PV plants to a private company. The financial cash flows of the project were assessed under three different financing scenarios (100% commercial, 100% IBRD, joint CTF-IBRD). The impact on final consumers was not investigated because of the reasonable assumption that the project will not have any price impact because of its relatively small size and hence its impact on energy mix, and also the fact that tariffs structure is fixed and does not reflect cost of generation.	The experience of wind power plants showed an initial reluctance of ONEE to facilitate the involvement of privates in the projects, position progressively changed. This lesson has to be applied to PV plants since the very beginning.
Reduction of voltage drops and in general power quality improvement is going to be one of the main goals of the project. Nevertheless it	This is an interesting recommendation. The team will discuss with ONEE the opportunity to monitor the impact of PV on local power supply and quality. Any learned lessons will certainly	Ok

would have been important to mention how this could affect to the final CAPEX as well as the procedure to follow the actual impact of the projects and voltage and other variables. It could also be useful to mention possible corrective actions if the results are not finally achieved.	be key to a successful deployment of more PV projects of similar size	
Socio-economic policies to enhance the indirect local economic activities would have been very useful. Is WB thinking in any approach to take advantage of these three projects to reinforce the local economic returns?.	The project team share with ONEE the results of the study undertaken to assess potential impact of the proposed solar PV plant on local populations and women. ONEE's management agreed to work with local authorities to maximize indirect local impacts.	Ok, the local positive impacts in the region are not so evident and it is thus important a closer follow up.
Renewable Energies Dispatching Center:		
It is also very important to extend from the very beginning the control to the Solar Thermal Power Plants (MASEN project) and to consider also the installations connected to distribution, at least the bigger ones (>500 kW).	The team will take this point into account in its discussions with ONEE.	Bear in mind that only connecting ONEE`s power plants to this Dispatch Center reduces the justification for this investment.
It would have been interesting also to present the technical and contractual arrangements of the MASEN and Wind Powers projects and the potential impact of their integration in the control system.	ONEE will unlikely disclose PPA with MASEN or other independent wind producers. However, O&M instructions and communication guidelines between private producers and ONEE are likely to be shared by ONEE during implementation of Component 2 (RE Dispatch desk).	It is not necessary to disclose any contractual arrangements but only to take into consideration new operational criteria which could affect to plants incomes.