JRC Scientific and Technical Reports

A New Scheme for the Promotion of Renewable Energies in Developing Countries:

The Renewable Energy Regulated Purchase Tariff

Editor: M. Moner-Girona

EUR 23284 EN - 2008

EUROPEAN COMMISSION

Institute for Environment and Sustainability

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JRC 43625

EUR 23284 EN
ISBN 978-92-79-08705-9
ISSN 1018-5593
DOI 10.2790/11999

Luxembourg: Office for Official Publications of the European Communities

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Preface

The Working Group 4-Developing Countries was created within the framework of the European Photovoltaic (PV) Technology Platform. This group promotes the use of PV, in combination with other renewable energies, as a suitable and cost effective option to provide sustainable access to electricity in the developing world and to help fight poverty and climate change.

WG4 is mainly composed of experts in the field of photovoltaics and is currently developing a number of activities to enhance the role of PV within developing countries. These include the identification of appropriate mechanisms to increase electrification rates. Within this frame, the Working Group has developed a powerful scheme based on the traditional Feed-in Tariff concept that will contribute to attract financial flows towards the areas where they are the most needed.

Magda Moner-Girona
Ispra, Italy
May 2008

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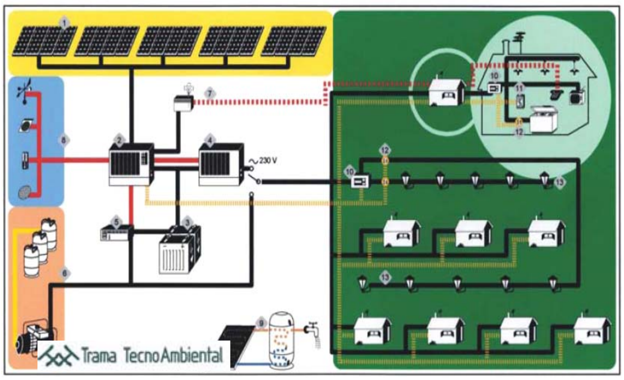
Executive Summary

This report sets out the main findings of the discussions carried out by the Developing Countries Group of the European Photovoltaic (PV) Technology Platform [1]. In particular, the findings of identifying and defining an effective financial mechanism to bolster renewables in mini-grids as part of a least-cost strategy for rural electrification at village-scale in Developing Countries.

It is now widely accepted that for many rural locations an alternative to grid-connected power is required. Stand-alone Photovoltaic systems have been confirmed as an appropriate option for bringing electricity to scattered households. Moreover, in off-grid rural villages where the households are clustered together, centralised hybrid mini-grid* can be the appropriate alternative to stand-alone Photovoltaic systems. In addition, when the location is far away from the grid, grid extension is not an economically viable option and mini-grids are a competitive alternative.



Rural electrification implementers often give priority to minimise initial cost and maximise the number of beneficiaries, giving little chance to renewable energy alternatives. Nevertheless, renewable options are becoming more popular due to the steady increase of fuel prices, the elevated operating costs and the high needs of maintenance of diesel generators, and their acoustic and environmental polluted nature [2, 3]. In fact, hybrid systems represent a suitable replacement for diesel mini-grid systems, standing for a more advantageous solution for rural areas.

The main aim of this policy-support document is to **attract policy-makers' attention** in **renewable energies** deployment, offering to energy and development stakeholders an alternative subsidy-scheme to support electrification in a **village-scale mini-grid based on the good performance of the renewable electricity generation**. Market support mechanisms are required to stimulate the deployment of most renewable energy technologies becoming already competitive with existing energy technology options for off-grid areas. Historically the

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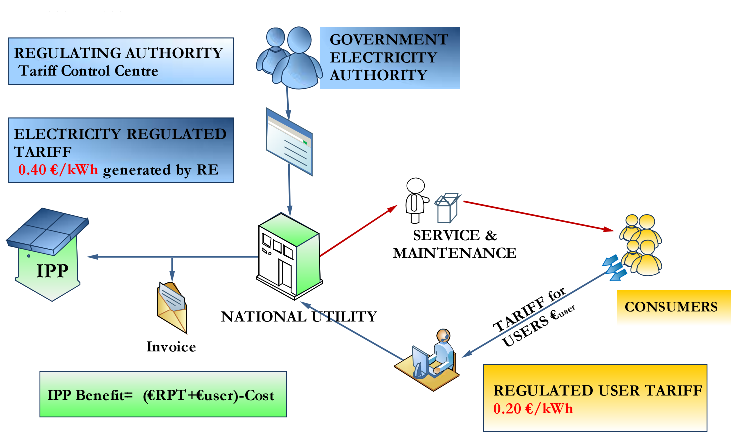
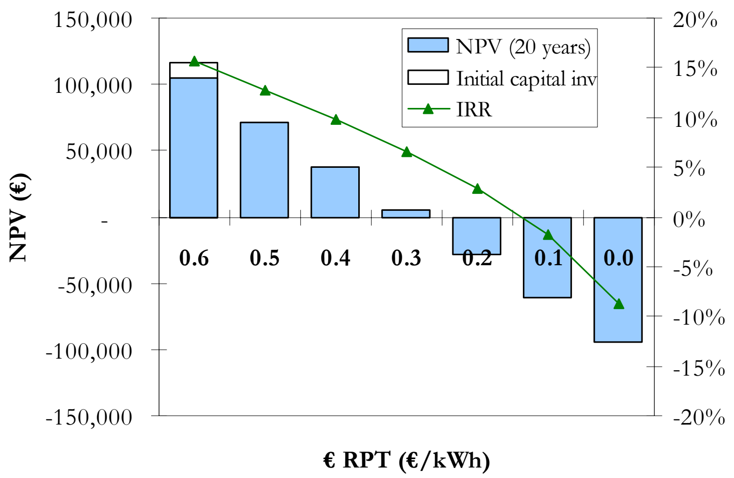
* Hybrid systems capture the best features of each energy resource and can provide "grid-quality" electricity with a power range between several kW to several hundred kilowatts. Hybrid systems are integrated in small electricity distribution systems (mini-grids) combining renewable sources and diesel generators.

promotion of renewable energy technologies (RET) in isolated areas has involved international donors or government subsidising the initial capacity investment. Instead, the renewable electricity generation support scheme, the Feed-in Tariff (FiT) combined with financial schemes, has been a successful mechanism to increase the deployment of renewables in the country's electricity grid [4]. The basis of the FiT mechanism involve the obligation on the part of an electricity utility to purchase electricity generated by renewable energy producers at a tariff determined by public authorities and guaranteed for a specific period. This study provides **a comprehensive evaluation of a locally-adapted variation of the FiT scheme, the Renewable Energy Regulated Purchase Tariff (RPT)** that **pays for renewable electricity generated,** to encourage the production of renewable electricity in mini-grids in Developing Countries. The proposed mechanism has been designed to provide a cost-effective scheme and to achieve different purposes such as to provide sustainable and affordable electricity to local users from remote areas in Developing Countries, to make renewable energy projects attractive to policy-makers.



Although capital costs of renewable energy projects are much higher than a conventional genset, reducing operation and maintenance costs together with the support of the RPT scheme, helps to offset the large capital costs associated with RET. The determination of an optimal set-up of the RPT values among various conditions plays an important role in the implementation of the RPT mechanism. In order to identify which renewable electricity purchase values make the renewable energy mini-grid most financially viable, a cost–benefit analysis is carried out calculating the Net Present Value (NPV) and Internal Rate of Return (IRR) for each of the renewable electricity purchase values



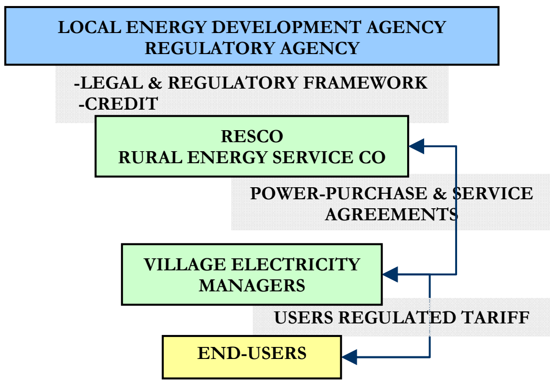
(€$_{RPT}$ from 0.1 €/kWh to 0.6€/kWh), using the cost and revenue streams over a 20-year period. The cost–benefit analysis determines the minimum renewable electricity purchase values that make the project financially viable (an NPV above zero). However, higher renewable electricity purchase values are generally more viable, delivering the best value for money over the period.

It should be noted that RET mini-grid projects often keep money in the local area, boost the local economy and help to bring about community regeneration, through the provision of jobs in the local area. The NPV and IRR calculations consider only the directly quantifiable costs and benefits; consequently, the calculations did not take into account indirect economic benefits such as the employment of local people in installing and maintaining the technologies. Consideration of these benefits may act to improve the financial viability of small-scale schemes.

The report is divided into ten sections. The first section provides background information about the current situation of renewable energies in the developing world and the need of a conjunction of effective policies, well-adapted financial schemes, and international co-operation.

Section 2 presents the new **"Renewable Energy Regulated Purchase Tariff" support scheme** specifically planned to operate mini-grids employing renewable energy technologies. The aim of this new financial scheme is to make renewable energy projects attractive to implementers, to decrease the financial risk, to attract private sector investment and to guarantee the recovery of invested capital.

Section 3 discusses the **role of the policy, regulatory and institutional frameworks** on the success of the implementation of the new locally-adapted RPT mechanism. The section integrates evaluations of the legal incentives that can provide insights to the government and policymakers into whether legal incentives are sufficient to attract investments. To achieve these goals, governmental administrations and utilities have to commit to provide the framework for



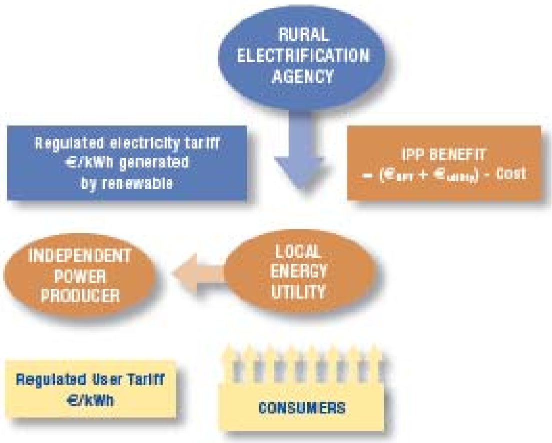
creating the necessary policy and regulatory changes, for instance, providing the **guaranteed regulated renewable electricity prices**.

Section 4 examines the **suitability of three variations of the support mechanism** for the generation of renewable electricity in isolated areas among the **different regulated frameworks** and different **types of ownerships**.

Information for decision-making for exploiting local renewable energy sources, under the adapted mini-grid FiT scheme, are facilitated in Sections 5, 6 and 7. The results are presented not as precise predictions but as an indication of the actors involved in the incentive scheme and the involved cash flows.

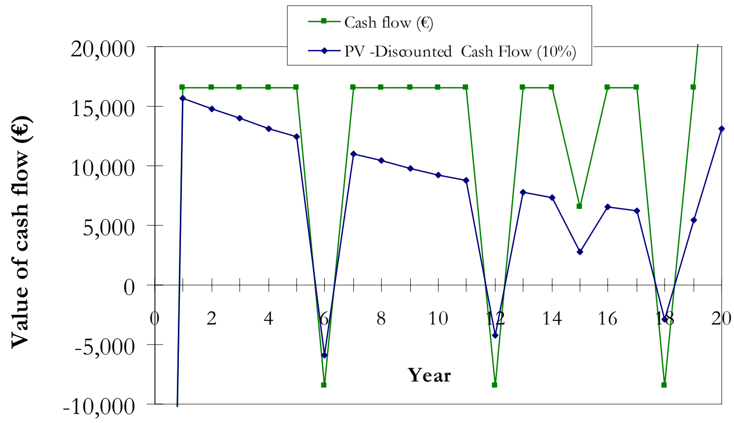
Section 6 describes the **Renewable Energy Regulated Purchase Tariff (RPT)** mechanism when involving an **Independent Power Producer (IPP).** This chapter gives information for decision-makers such as under which sufficient regulated tariffs and what conditions an investment for renewable technology is profitable. The results are presented not as precise predictions but as an indication of the actors involved in the incentive scheme and the cash flows involved.

In the RPT financial flow scheme when an IPP is involved (below), the arrows represent the money flows. In some isolated areas, the real electricity costs are not affordable for the majority of remote customers.



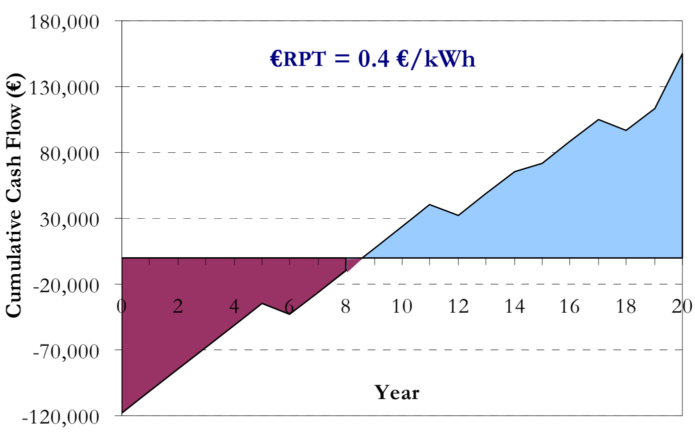
Therefore, the Local Energy Utility charges below the production cost to the end-consumer ($€_{user}$). The rural electrification agency provides to the independent power producers an additional value ($€_{RPT}$) per KWh produced by renewable energies through the Local Energy Utility. Financing the necessary additional sums enables numerous customers to afford access to electricity and allows the Independent Power Producer a guaranteed benefit.

Section 8 examines three pilot cases in different countries for the implementation of the support scheme, and presents the financial assessment and cost analysis for each of the pilot cases. A cost/benefit analysis of the alternatives will be required to decide which option is appropriate for each location, to include economic analysis, fuel availability, ownership, and management of the scheme and operation and maintenance issues.



Several software tools (HOMER, RETScreen, spreadsheets…) combined with actual data of the projects is utilised to characterise the RET potential and costs in the three pilot cases. Data relating to the costs (capital and operational) of each technology are acquired from the technical reports of each of the cases. Quantitative economic analyses are performed in this section modifying the $€_{RPT}$ values, including financial indicators such as the simple payback, Internal Rate of Return (IRR) and Net Present Value (NPV). The NPV determines today's values of future cash flow at a given discount rate. As might be expected, when comparing alternative investments, the project with the highest cumulative NPV is the most attractive one. The IRR approach seeks to determine the discount rate (or interest rate) at which the cumulative NPV of the project is equal to zero. This means that the cumulative NPV of all project costs equals the cumulative NPV of all project benefits if both are discounted at the IRR. The financial analysis under the RPT scheme has resulted with IRR between 8 to 15% and positive NPV, which simply means a significant 8-15% return.

The results are used to compare the conventional mini-grid with the proposed support mechanism in terms of total costs and the average incentive costs relative to the end-user price for electricity. The results indicate that the RPT mechanism can provide the least costs to the community over a 20-year period in case of specific $€_{RPT}$ values. The report also provides a sensitivity



analysis of the support mechanism calculations for the three pilot cases by varying default parameters, such as the RPT value, and the assumed investment risk levels.

Finally, the report closes summarising the main findings of the analysis: The cost-effectiveness of energy projects under the "Renewable Energy Regulated Purchase Tariff" has been quantitatively determined, showing that under this financial scheme, optimally-designed mini-grids powered by renewable energy can provide the energy supply for small communities at positive net present cost even in the case of high initial investment cost associated with RET. The report has integrated evaluations of the potential resources, cost analyses, legal incentives, and analysis of returns on investments and evaluates the economic feasibility of investments in exploiting local renewable energy sources.

Background

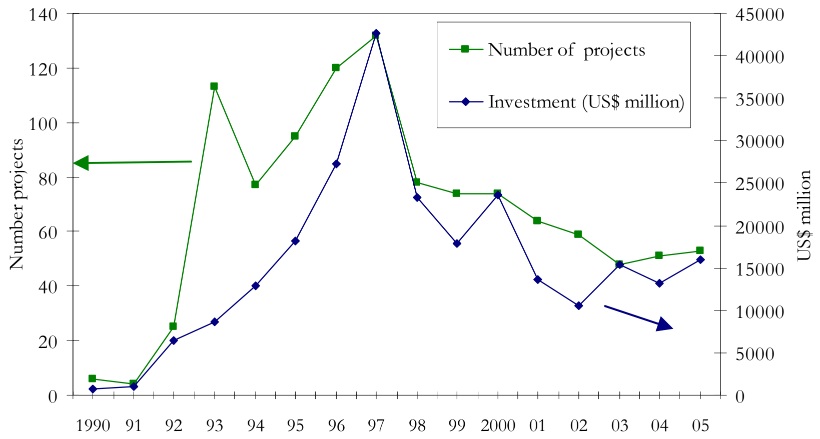
Energy access is a key to poverty alleviation, the astonishing fact is that only 36% of the African population has electricity and more than 80% of its rural population has none [5]. This disquieting situation has not been improving, the rate of access to modern energy in rural areas in some African countries has dropped to as low as 1%.

Reaching the unelectrified rural population is often only possible through decentralised energy systems, due to low potential electricity demand and economic development in these areas and sometimes also for political reasons, grid extension is not a feasible option. The high cost of energy transport and transmission infrastructure, such as high voltage power lines, oil and gas pipelines, is one of the factors responsible for the low progress in expanding national distribution electricity grids [6]. A 2000 World Bank/UNDP study on rural electrification programmes placed the average cost of grid extension at between $8,000 – 10,000 per km, rising to around $22,000 in difficult terrains. Under these circumstances, Renewable Energy Technologies, RETs, offer a cost-effective alternative solution to the extension of the grid.

Furthermore, RETs are able to provide meaningful levels of energy for high-priority needs, including residential lighting, community services (education, health, clean water, telecommunications, etc) and for economically productive uses. Indeed, RETs are currently contributing to the realisation of important economic, environmental, and social objectives by the enhancement of security of energy supply, the reduction of greenhouse gases and other pollutants and by the creation of employment, which leads to the improvement of social welfare and living conditions.

Globally, energy access, particularly in rural areas, has remained **static**, with the number of people living in unserved areas (approximately two billion) remaining unchanged in the last 25 years [7]. Until now, many of the developing world governments have been unable to finance the expansion or renovation in the power sector or to attract private sector investment. For example, the total installed power capacity of Africa is 103 GW, the equivalent to that of one typical industrialised country (i.e 120 GW for Germany), with 80% of the capacity installed in South Africa (46%) and North Africa (34%). More specifically, the power sector in Sub-Saharan Africa is characterised by insufficient capital for electricity generation and expansion of the grid, the low electrification levels, inadequate maintenance, low capacity utilisation and transmission and distribution losses up to 40% in some countries [8]. As an example of the insufficient capital for electricity, the International Finance Corporation estimated that between 1990 and 1998, foreign direct investment in the power sector in Sub-Saharan Africa was only 6% of all infrastructures. In comparison, telecommunications accounted for 89% of all foreign investment inflows in this period [9]. Figure I shows the decrease of private investment in electricity infrastructure from 1997 to 2005 in emerging markets, including both investments in power generation capacity that supplies the public power system, and investments in capacity by industrial and commercial users to provide electricity for their own needs.

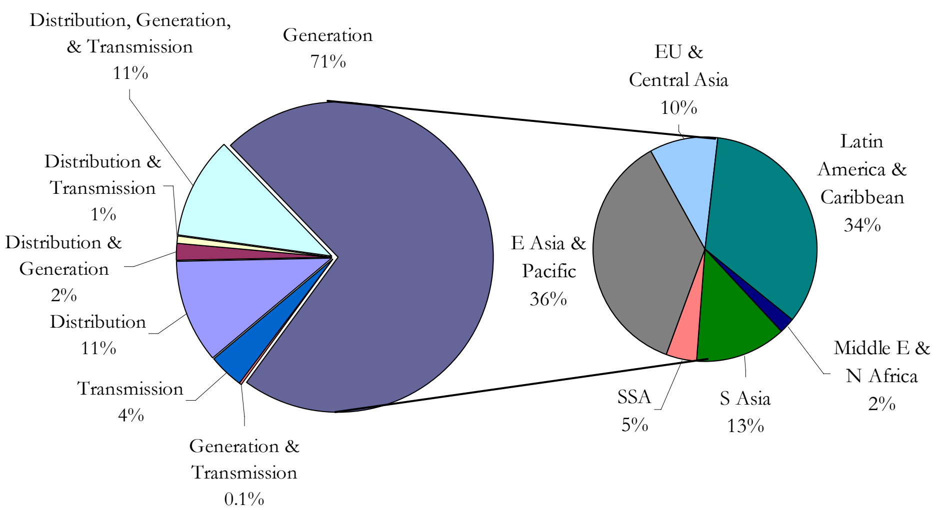
Figure I. Evolution of the Private Investment in Electricity Infrastructure for low and middle income countries



Source: Data from the World Bank Private Participation in Infrastructure (PPI) Project Database http://ppi.worldbank.org [10].

More bilateral, multilateral, and private-investment partners are essential to mobilise resources for the development of the electricity sector and alleviate the budgetary burden on state-owned power utilities [11]. The majority of private investments in electricity markets in Developing Countries are invested in generation projects (Figure II). This fact may favour the investment in renewable energies for applications in rural electrification.

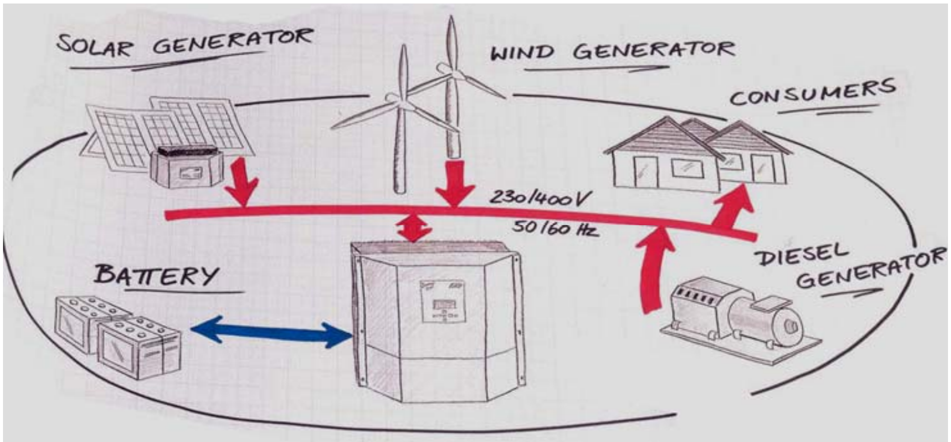
Figure II. Shares by sector of Private Investment in Electricity Infrastructure for low and middle income countries. Close-up of shares by regions on electric generation.



Source: Data from The World Bank Private Participation in Infrastructure (PPI) Project Database http://ppi.worldbank.org.

Traditionally, diesel generators or mini-hydro power plants have powered mini-grids in remote areas and in islands. As oil prices rise, generation from solar, wind, or biomass, often in hybrid combinations, can replace or supplement diesel power in these grids. Given the appropriate geographic resources and regional-specific costs of competing fuels, decentralized hybrid systems are already economically competitive with conventional diesel power (see section 5). The savings, compare to grid extension, are attributable to the reduced transmission and distribution costs and are often the only accessible option for bringing electricity to isolated users. Village-scale mini-grids can serve hundreds of households in settings where sufficient geographical density allows economical interconnections to hybrid power generators. However, at present, only a few hybrid mini-grids exist (approximately 150 systems in Developing Countries) that employ combinations of solar PV, wind, and diesel [12].

Figure III. Hybrid mini-grids based on renewable energy technologies: Decentralised hybrid systems (based on renewable energy technologies) combine the use of photovoltaic, wind turbines, heat pumps, biomass, and biofuels cogeneration technologies, depending on the available local resources, with conventional decentralised energy technologies (usually diesel-generators) and storage systems (i.e. battery banks).



Source: SMA "Off-grid power supply brochure" 2005.

Lack of investments, inadequate policy frameworks, and low technical capacity are among numerous other causes responsible for the low level of development of renewable energies in the developing world. Many public programmes have relied on equipment donated through bilateral development assistance programmes; only some have included sustainable mechanisms for servicing installations or continued commercial viability [13]. Therefore, achieving sustainable economic and widespread use of decentralized RE systems will require **a conjunction of effective policies, well-adapted financial schemes,** and international co-operation.

Innovations in policy and financing are essential to facilitate the use of renewables on any significant scale, both for grid-connected and off-grid use.

In this document, a tailored "Renewable Energy Purchase Agreement Tariff" **(RPT)** financial scheme is specifically planned to be applied in mini-grids employing renewable energy technologies. The proposed mechanism has been designed to provide a cost-effective scheme to provide affordable electricity to remote areas in Developing Countries and at the same time decrease financial risk to attract private sector investment. The new financial scheme described here is not only limited to the promotion of the use of PV, although it is also promoting the use of combined renewable energy technologies using hybrid off-grid mini-grids.

1. INTRODUCTION TO THE "RENEWABLE ENERGY PURCHASE AGREEMENT TARIFF" SCHEME FOR RURAL ELECTRIFICATION

The RPT financial scheme has been created following the basis of the "classic " **Feed-in Tariff (FiT)** [14] model mostly applied in Europe; where FiT involves the obligation on the part of an electricity utility to purchase electricity generated by renewable energy producers at a tariff determined by public authorities and guaranteed for a specific period (generally 20 years). In the "classic FiT", different tariffs are defined for different technologies (wind, solar, bioenergy...) and different regions depending on the resource conditions (e.g. solar irradiation, average wind speed, biomass potential …).

This document focuses on adapting the "classic FiT" financial scheme (applied to grid connected systems) to independent mini-grids in Developing Countries. The RTP flow will be tailored depending on the socio-economical and technological barriers (being designed to overcome the problem of feeding solar electricity in the mini-grid if the electricity demand is lower than the electricity produced). The type of ownership applied will also have an impact on the design of the RPT and on the success of the project, since who owns the electricity generation also has an effect on the costs. Different ownership schemes have different cost structures imbedded in them, as well as different financial, political, and regulatory drivers (already existing FiT laws, regulated tariff …). For instance, under very specific social and political conditions of the country, each household could own its own system and act as producer/consumer by being connected to the mini-grid and sell the electricity at the regulated price (similar to the "classical" FiT). Under different social and economical conditions, it would be not be possible for the consumers to own the system, thus the ownership scheme would be modified accordingly. For example, the entity receiving the renewable energy regulated value would be a renewable energy generator feeding into the mini- grid, a similar approach to a small scale Independent Power Producer (IPP) (see section 2.3 for further details).

The guarantied RPTs value payments (€/kWh) for the renewable electricity delivered in mini-grids can make renewable energy technologies economically attractive for local governments, mini-grid operators, and investors. The implementation of the financial model in Developing Countries would increment predictability and consistency in electricity markets, dropping the financial risk in the capital investment for renewable energy technologies.

2. POLICY, REGULATORY AND INSTITUTIONAL FRAMEWORKS

The RPT financial scheme is designed to achieve different economic purposes such as affordability for local users, to guarantee the recovery of invested capital, to achieve a return of investment, and to generate earnings for energy service companies. From the investors point of view the long-term credibility of the institution that provides the RPT incentives in the particular country is almost as important as the rate of the RPT itself. The investor can take account of the long-term cash flow generated by the RPT only if the there is low risk of policy change.

Despite the power-sector-reforms undertaken by many developing nations, the transmission sector has remained mostly under the control and management of governments. The success of the implementation of RETs by RPT mechanism will require the umbrella of a strong policy support and a specific regulatory framework. Such frameworks are essential to support the proper economic and political climate for public and private investments in RETs under the RPT mechanism, helping to overcome the main barriers to its development [15] and to extend modern energy services to populations currently without access [16,17,18]. The central and local governments (or local agencies) should be involved from the beginning and demonstrate commitment to decentralized rural electrification by supporting the guaranteed RPT values [19] and act as a link between all actors involved.

Martinot et al [20] suggest that the main successful policy and regulatory framework supporting renewable energies are:

(*a*) policies that promote *production-based incentives,* rather than investment-based incentives, are more likely to spur the best industry performance and sustainability;

(*b*) power-sector *regulatory policies* for renewable energy should support IPP/PPA frameworks that provide incentives and long-term stable tariffs for private power producers;

(*c*) regulators need skills to understand the complex array of policy, regulatory, technical, financing, and organisational factors that influence whether renewable energy producers are viable;

(*d*) financing for renewable power projects is crucial but elusive.

The suggestions mentioned above reinforce the initiative proposed in this document of applying a renewable energy regulated tariff based in production of RE electricity.

Existing Renewable Energy Promotion Policies in Developing Countries

It must be highlighted that there are existing many countries already with targets for RET such as Brazil, China, Dominican Republic, Egypt, India, Korea, Malaysia, Mali, South Africa, and Thailand. REN21 [21] reports that "several African countries have subsidy policies supporting modest amounts of rural solar PV, including Mali, Senegal, Tanzania, and Uganda (also micro- hydro). South Africa had a policy for subsidies to rural energy service concessions for solar PV that now appears to be dormant. Several Developing Countries are planning renewable energy strategies and/or are expected to enact new or additional policies in the future, including Algeria, Armenia, Colombia, Egypt, Guatemala, Jordan, Macedonia, Mexico, Peru, South Africa, Vietnam, and Yemen". Few others with feed-in tariff laws such as Ecuador, India, Brazil, China, Costa Rica, Argentina, Indonesia, Nicaragua, Sri Lanka, Thailand, and Turkey [4]. REN21 states that "among Developing Countries, India was the first to establish feed-in tariffs, followed by Sri Lanka and Thailand (for small power producers only), Brazil, Indonesia, and Nicaragua. In the first half of 2005, feed-in policies were enacted in China, and Turkey. China's feed-in policy was part of a comprehensive renewable energy promotion law enacted in February 2005" [21]. At the moment, in most of these countries the legal framework exists, but unfortunately their implementation has not been established. It is important to underline that almost none of the FiT named mention the possibility to be applied in isolated areas.

Table I. Renewable Energy Promotion Policies Power Markets

Country	FiT	RE portfolio standard	Capital subsidies, grants or rebates	Investment excise, or other tax credits	Sales &energy tax, VAT reduction	Energy production payments/ tax credits	Net metering	Public investment, loans or financing	Public competitive buildings
Argentina			✓			✓			
Brazil	✓							✓	
Cambodia			✓						
China	✓		✓	✓	✓			✓	✓
Costa Rica	✓								
Guatemala				✓	✓				
India	*✓	*✓	✓	✓	✓			✓	✓
Indonesia	✓								
Mexico				✓			✓		
Nicaragua	✓			✓					
Philippine				✓	✓			✓	
Sri Lanka	✓								
Thailand	✓	✓	✓				✓		
Turkey	✓		✓						

* Some province

Source: REN21 "Renewables 2005: Global Status Report"

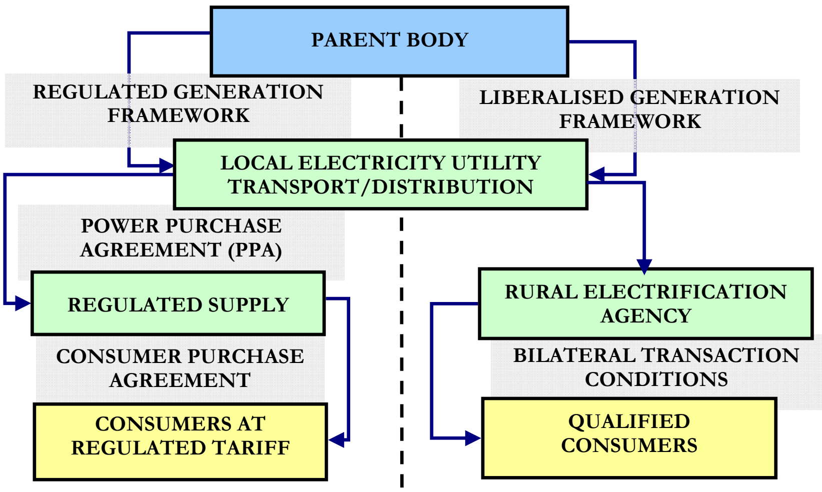
Several mechanisms could be offered providing incentives to RES entrepreneurs, such as offering tax reductions to foreign investors, tax exemptions for the imports of RET equipment, customs, and excise duty relief, and soft loans. The combination of the RPT supporting scheme with such mechanisms has to be designed depending on the specific legal, political, and economical framework of the country.

Legal framework: regulated/liberalised

There are two main legal frameworks to approach rural electrification: regulated and liberalised regimes. When rural electrification is under a **regulated** approach, the local government offers a regulated energy service concession in which a private-sector firm is competitively selected to provide off-grid electrification exclusively to designated rural areas [22]. With the energy concession, the government selects one company exclusively to serve a specific geographic region, with the obligation to serve all potential electricity users. The government also provides subsidies and regulates the fees and operations of the concession.

Under the **liberalised** approach, the private sector is allowed to participate within the areas of energy generation and distribution; therefore, there is a free choice of electricity providers and the possibility of establishment of free producers to competitively supply the customers of this market. Utilities will have to compete with the private sector, prices would be liberalised and subsidies would be phased out. The expectation is that competition will deliver the benefits of efficiency, enhanced reliability and lower prices, as well as fostering economic growth and development [23]. The degree of liberalisation will define which of the above characteristics are put in place.

Figure IV. Rural electrification under regulated and liberalised frameworks



Frameworks/agreements in grey, main actors coloured: government in blue, distribution/production in green, end-users in blue

Further legal/political actions to reinforce the RPT implementation

Depending on the legal framework (regulated or liberalised) adapted by the government and the local conditions, a correct combination of some of the actions proposed below will reinforce the implementation of the RPT financial scheme:

Under regulated and liberalised regime

1. Guarantee the RPT values of the produced renewable energy electricity for a fixed period.
2. Protection of the continuance of the guarantee and property, in case of occurring future changes of renewable energy laws.
3. Elaboration of laws and targets that require a minimum percentage of generation from renewable energy for energy production.
4. Regulatory mandates requiring environmental assessment in energy planning (full cost pricing)
5. Tax incentives and credits on equipment (i.e. tax credits for RET purchases for residential and business sectors).
6. Sales tax, import duties, and VAT exemptions/reductions on RET .

Under regulated regime

7. Public competitive bidding for specific quantities of electrical generation (licenses and concessions). Concession models hinder the development of a free market but on the other hand, they offset the financial risk, long payback times against investment requirements and low returns.
8. Power-sector regulatory policies for renewable energy support frameworks that provide incentives and long-term stable tariffs for power producers.

Under liberalised regime

9. Fair access to the public (mini) grid for the RES producers.
10. Laws allowing the private operators to provide energy services, thus eliminating the exclusive right usually granted to the national or regional utility.

In order to achieve a success of the proposed RPT financial scheme the legal and regulatory framework should be as simple as possible, which means emphasising mostly the aspects number 1 and 2 of the above list. Targets for renewable energy production, as well as liberalised foreign investment procedures, may also be helpful, but these are not mandatory preconditions.

A good example of the importance of an appropriate combination of measures is the development of the German PV market. From 2000 to 2003, Germany launched a combination of a FiT law with very low interest loans. The process for the application for the loan was simple. In 2004, the FiT value was increased and the low interest loan was discarded. Economically it was the same return on the investment, but it was easier to calculate and the market increased enormously in 2004 compared to the previous years [24].

3. OWNERSHIP AND FINANCIAL FLOWS IN VILLAGE-SCALE MINI-GRIDS

In a village-scale mini-grid the power installation uses a hybrid mixture of solar, wind, hydro, bioenergy, diesel generator, and battery storage. The correct choice of the ownership of the renewable electricity generator depends on the socio-economical conditions of the country/region and it will have a strong impact on the success of the project.

Ownership structures for the village-scale mini-grid

This document differentiates three possible structures for the ownership of the village-scale mini-grid: Independent Power Producer, Rural Energy Service Company, and Co-operative.

1. **Independent Power Producer (IPP)** is an entity that without being a public utility* owns facilities to generate electric power for sale to utilities and end-users and that has no affiliation to a transmission or distribution company. The IPP is privately-held facility and depends on investors to produce electricity. When the generators are not connected to the grid the IPP are often called "captive plants" [25]. When the ownership of the renewable energy facilities stays in the IPP, the IPP sells bulk electricity into the mini-grid under a long-term Power Purchase Agreement (PPA). In this case, the agreement involves an entity such as a single buyer or the distribution company, to purchase the power generated by the IPP under specified terms for a multiyear period.

2. **Rural Energy Service Company (RESCO)** is a quasi-governmental body that provides electricity to the rural customers. It can issue bonds or tax property to get its funding, so its costs of energy are typically lower than an IPP. A RESCO is responsible to the public and has a board of elected commissioners. RESCO can, besides provide electricity, assist in developing a broad array of community services, such as water, waste, transportation, telecommunications, and other energy services. Because the ownership of the renewable energy facilities stays in the RESCO, the company provides installation, operation, maintenance, repair, and additional services to end-users in return for monthly fees for connection and service. While end-users may never own a system, they are able to receive guaranteed services from the company.

* In general, the IPP's are highly regulated by the state

3. **Co-operative** (such as self-organised "solar communities") is a not-for-profit organisation that serves their members. The Co-operative can borrow money at lower rates. Since they are no-profit making, they cannot get the tax rebate advantages provided by the government to IPPs and in some cases to governmental power-producers, but generally their energy comes cheaper than that produced by an IPP. A Cooperative would provide electrical service exclusively. Co-op members vote for a board of directors, and the board makes the management decisions.

Tariff setting /financial flows

Besides the ownership of the electricity generator, the tariff setting is a critical issue. Currently, a wide variety of tariff structure-modes of charging for electricity are used in the developing world. In the particular case of the "classic FiT" Law, the Feed-in tariffs are set by being revenue neutral to the government, with the difference between cost and prices paid implicitly by all utility consumers. Due to the lack of financial possibilities from the rural users in some Developing Countries, a key factor for the success of the financial support is to define the financial flows involved to compensate the difference between cost and prices paid and to identify which entity should bear the cost of compensation for the renewable energy production.

The tariffs are set taking in account the expectations of the entities enrolled. For instance under a regulated generation regime, when a Rural Energy Service Company or IPP owns the RE facilities the distribution electricity utility operates its businesses according to various requirements from the regulator and the customers, as well as the profit requirements from the owners. The customers are confined to a certain exclusive company, which supplies them with electricity and receives a certain income from the customers, and a RPT value as an extra income from the production of RE electricity. Customers in return expect a certain quality to the delivery as well as reasonable prices. The regulator works on behalf of these customers. In the case of a Co-op ownership (i.e. municipalities) the company is owned by the customers and therefore do not require any specific profit.

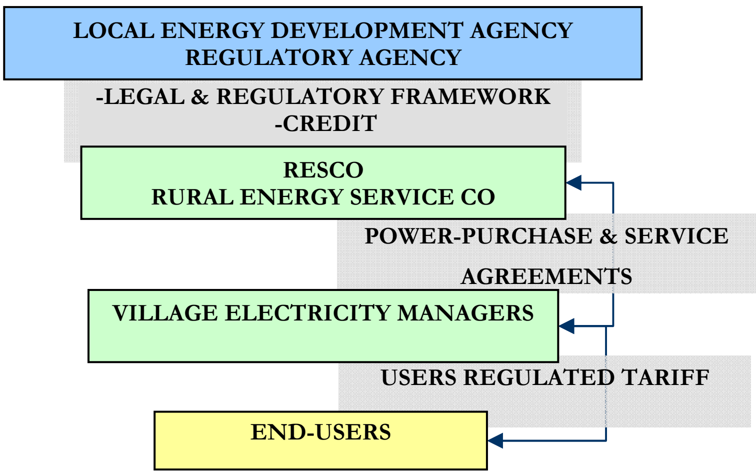
The three following sections (from section 5 to 7) present three different scenarios where the RPT is adapted to different renewable energy legal frameworks, types of ownership and financial flows. Section 5 introduces the RPT mechanism for off-grid rural electrification under an energy-service concession. Section 6 introduces the RPT mechanism under an IPP power production regulatory framework. Finally, Section 7 describes the financial framework when independent renewable producers receive an RPT value per kWh of renewable electricity produced.

4. RPT UNDER REGULATED ENERGY SERVICE CONCESSIONS

Legal and Regulatory Framework

In recent years there has been growing interest in the use of regulated energy-service concessions and other public-private regulatory mechanisms as a way to provide affordable electricity services to rural populations not connected to central electric power grids [6]. Rural energy-service concessions may employ a mixture of energy sources to serve customers, including, photovoltaic, wind, bioenergy, mini-hydro, and diesel generators. The affordability of electricity can be extended to a greater number of consumers when the energy service company offers electricity to a village-scale mini-grid under the RPT financial mechanism, rather than grid extensions. Under this legal arrangement, the government offers a regulated energy service concession in which one private company is competitively selected to provide off-grid electrification exclusively to designated rural areas with the obligation to serve all who request an electricity service [22]. The terms of these concessions may last up to 15 years.

Figure V. Framework for an energy-service concessions under RPT scheme for off-grid rural electrification.



Arrows indicate regulated purchase agreements

The government provides the RPT mechanism as an additional support and regulates the fees and operations of the concession. The main role of the Local Energy Development Agency [26] (Regulatory Agency or an equivalent governmental institution) is to set up the renewable energy policy and legal framework, to supervise the power-purchase and service agreements, the tariff setting, and the monitoring and regulation of the concessions. The tasks of the Regulatory Agency in rural energy-service concession include the bidding and contracting process, to establish the electricity tariffs, the supervision of the power-purchase and service agreements, regulation of the concessions, and creating regulated evaluations and audits [27]. Besides these tasks, similar to the "classical FiT", the Regulatory Agency fixes the renewable electricity tariff.

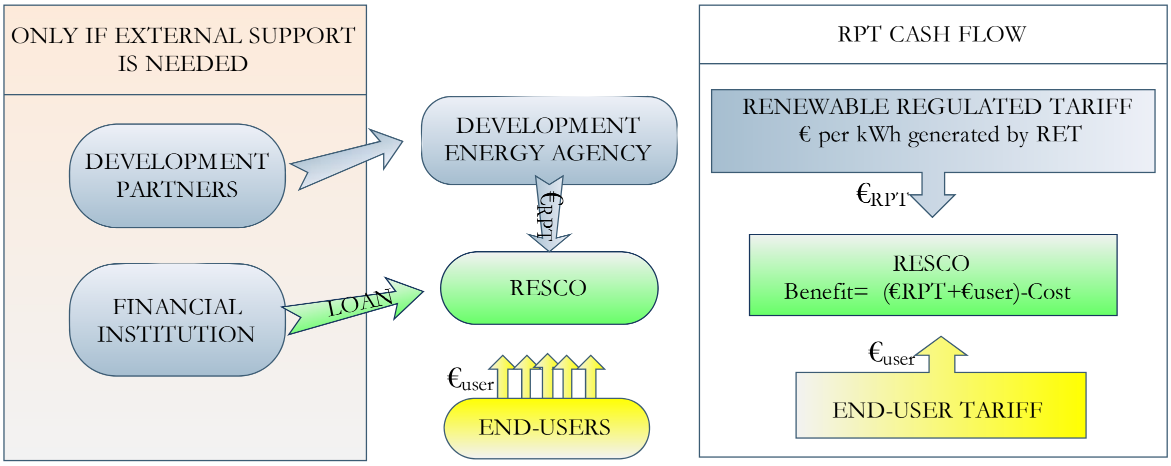
The Local Electricity Utility (rural grid utility or RESCO) deals with the electricity generation and distribution in the mini-grid. The RESCO retains the ownership of the equipment and is responsible for installing the electricity measuring devices (with a simple design with two-direction measurements) for controlling the amount of electricity generated by renewable energies. Unlike a management contract, a concession involves considerable private capital expenditure. The RESCO recovers its costs over a long period of time (see pilot case in section 9.2). If the RESCO can obtain long-term credit at relatively low interest rates, this option can be an effective way of lowering household monthly payments. In some cases, the government could also provide (as an additional support for the RPT mechanism) capital subsidies for RET.

Financial Flows

In the RPT financial flow scheme for a village scale mini-grid under regulated energy-service concessions the money flows are represented by the arrows (Figure VII). The RESCO owns the mini-grid producing electricity by hybrid systems. The RESCO charges below the production cost to the end-consumer a predetermined and affordable price for electricity consumed, $€_{user}$. The Local Energy Development Agency provides an additional value ($€_{RPT}$) per kWh produced by RET to the ESCO. The sum of revenues ($€_{RPT}$ + $€_{user}$) drives local utility economy by compensating the costs and additionally allows a benefit.

In the situation where the local government cannot cover the additional value per kWh of renewable electricity delivered by compensating the tariff, then funds might be obtained from a multilateral donor (left reddish in the diagram). The development partners might enhance their support undertaking the necessary reforms for a coherent, transparent, and attractive investment framework.

Figure VI. RPT financial flow scheme for a village scale mini-grid under a regulated energy-service concession.



Money flows are represented by the arrows

Source: M. Moner (JRC), P. Llamas (ARE), X. Vallve (TTA).

Support to renewable electricity produced under energy availability concept

An alternative option in order to simplify the set up of the minigrids reducing the installation of individual counters by paying a fixed amount of energy produced/consumed. In this energy availability concept, the amount of renewable electricity production are based on estimations considering is concrete climatologic conditions (i.e local solar radiation when PV) and taking typical performance ratio, the energy would be already dispatch. There are already several tools allowing precise predictions for solar electricity production (e.g for Europe, Africa and Mediterranean basis: http://re.jrc.ec.europa.eu/pvgis). After few experience the consumption would get averaged**.** The ESCO will be responsible for controlling the quality of the system in order to avoid under-use of the renewable electricity produced.

Further financial instruments

In the case of regulated energy-service concessions, depending on the local political framework additional financial instruments and incentives might be applied:

i) Capital subsidies: the RESCO might receive yearly payments (decreasing annually) to cover a percentage of the capital cost
ii) Production subsidies: the RESCO might receive overheads to cover a percentage of the capital cost depending on production generated
iii) Government guaranteed loans – the government acts as an intermediary between the agency and the financial institutions as a guarantee of the loan

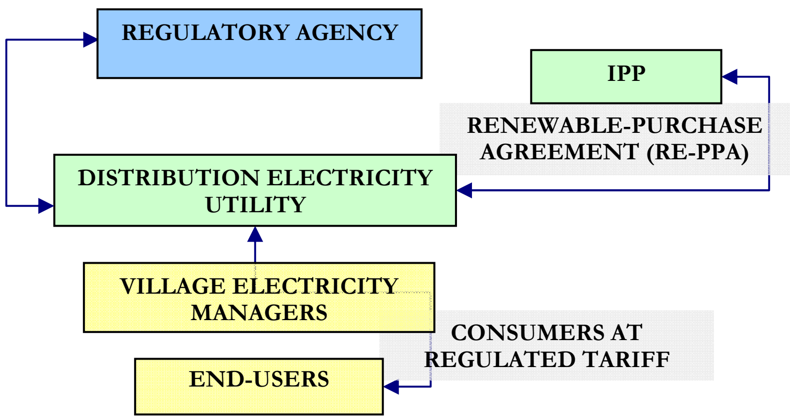
5. RENEWABLE ENERGY PURCHASE AGREEMENT FOR INDEPENDENT POWER PRODUCERS

Legal and regulatory Framework

Under a renewable energy production agreement for independent power producers, IPPs, the local government offers legal and regulatory frameworks for IPPs to assist public and private project developers in installing solar, wind, biomass, small hydropower, and geothermal power generation technologies connected to a minigrid. Under this regime, the IPP sells renewable electricity to the distribution utility under the renewable purchase agreement (RE-PPA), and the distributor sells the electricity to the final users at the nationally/regionally regulated consumer tariffs. The IPP is in charge of collecting the renewable regulated tariffs.

A key factor for the success of the projects under this regulated framework is the assistance to regulators and utility mangers for establishing transparent renewable energy-purchase tariffs and model power-purchase agreements (PPAs) for the small renewable energy producers [28, 29]. The guarantee of a long-term capital reduces the financial risk for potential RET investors by ensuing stability and a favourable rate of return.

Figure VII. Independent power production regulatory framework.

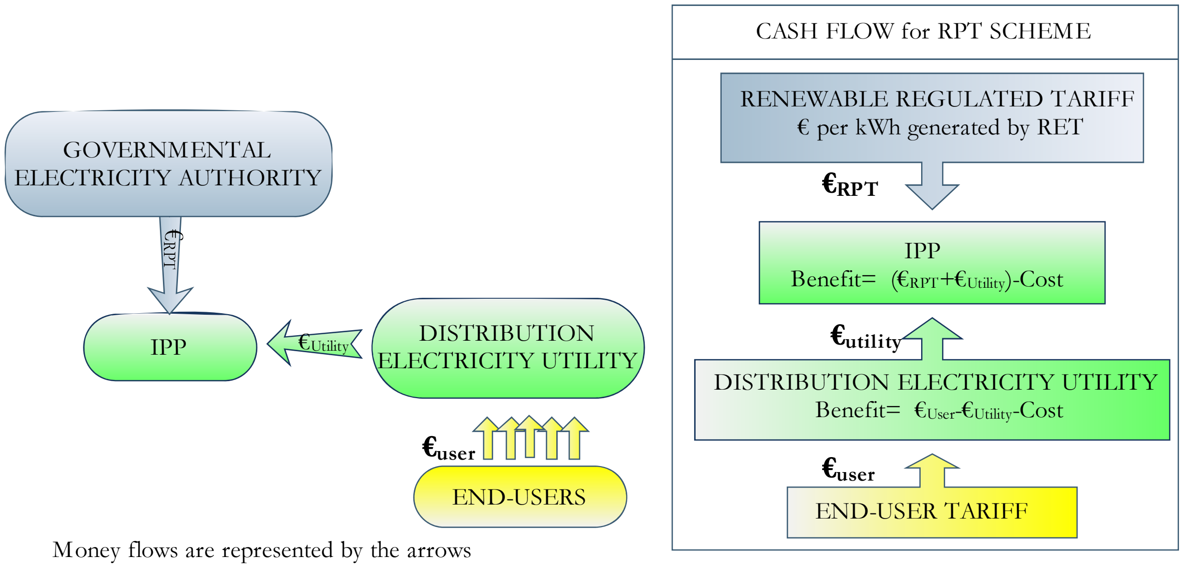


Arrows indicate regulated purchase agreements between the bodies involved

Financial Flows

The Regulatory body creates the policy umbrella to support the RPT. The responsibility for the financial management of the mini-grid will be in the hands of the Electricity Utility (owner of the minigrid) in order to ensure the payment of bills from/to the customers. The Electricity Utility purchases the electricity generated by those renewable energy producers connected to the mini-grid (the IPP, or the co-operative) at a tariff determined by public authorities and guaranteed for a specific period (20 years). The IPPs receive directly the RPT incentives per kWh of renewable electricity delivered to the mini-grid. Moreover, the IPP has the responsibility of installation, operation and maintenance of the connected system.

Figure VIII. Renewable regulated tariff scheme for independent power producer. The local Utility operates the RPT allocations. The IPP sells renewable electricity to the distribution Utility (at the established renewable regulated tariff), then the Utility sells the electricity to the end-users at the nationally regulated consumer tariffs. The IPP is supposed to collect the regulated RPT. Money flows are represented by the arrows.



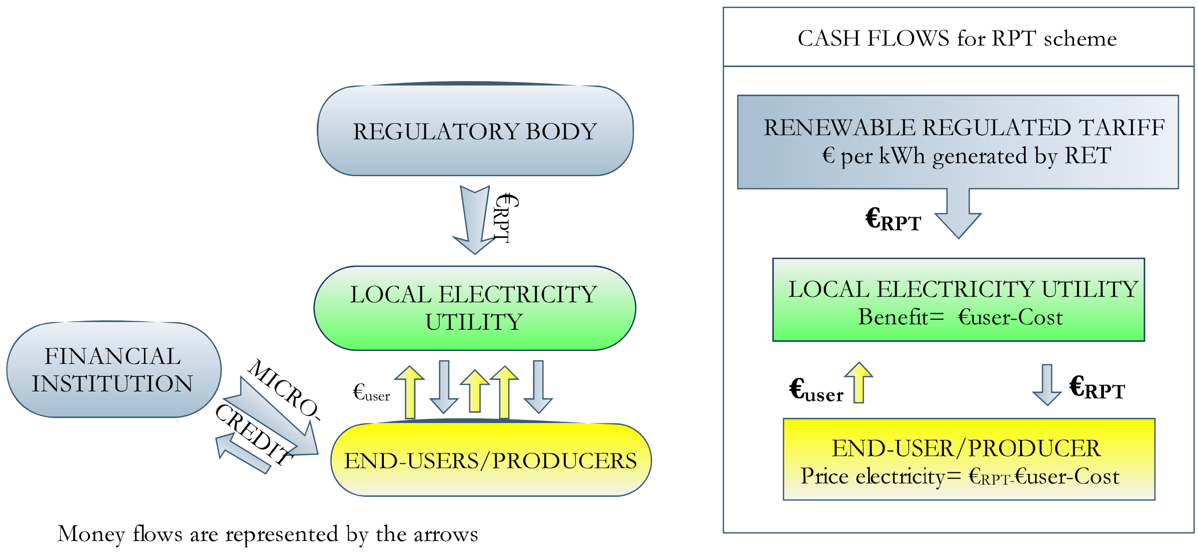
Source: M. Moner (JRC), A. Shanker, D. Rambaud-Méasson (IED).

More than 25 Developing Countries now have regulatory frameworks that allow IPPs to generate and sell power to utilities under power-purchase agreements [20, 30], in those countries the adaptations of the "classical" purchase agreement to a renewable energy purchase agreement where the production of renewable electricity gets a supplementary value can take place in a straightforward process.

6. REGULATED TARIFF FOR RENEWABLE PRODUCER/USER

Under very specific conditions where the end-users might afford the purchase of a PV system, an initial low-interest loan or micro-credit should support the local users to act as independent producers of renewable energy electricity and receive a RPT value for kWh produced. The producer side might receive capital subsidies for up-front costs [31], operation and maintenance costs. An alternative soft way to transfer the ownership of the systems to the user is to begin the installations with private investments and gradually transfer the ownership to the consumers.

Figure IX. RPT tariff for independent renewable producers/users.



Source: M. Moner (JRC), P. Llamas (ARE).

The Local Energy Utility owns the mini-grid and purchases the electricity ($€_{RPT}$) generated by renewable energy producers connected to the mini-grid at a tariff determined by public authorities. The responsibility for the financial management of the mini grid will be in the hands of the local utility in order to ensure the payment of bills from/to the customers. The Electricity Utility (owner of the mini-grid) purchases the electricity generated by those renewable energy producers connected to the mini-grid (the village, cooperative, end-user/small producer) at a tariff determined by public authorities and guaranteed for a specific period (20 years). The degree of ownership will depend on the profile of the producer. The responsibility of installation, operation and maintenance of the connected system will be of the producer. The renewable electricity producers receive the RPT incentives from the Utility. Moreover, this regime would also allow the connexion of IPP under the same RPT tariff.

The fact that the village (or individual users) produce its own electricity will subsequently engage a tighter local participation in the project. Moreover, productive uses of energy should be endorsed enhancing productivity and income generation. For example activities as small industry, agriculture, commercial activities, telecommunications, education and health facilities, clean water, and refrigeration.

7. FINANCIAL ASSESSMENT AND COST ANALYSIS

The RPT financial scheme is designed to achieve different economic purposes such as affordability for local users, to achieve a return of investment, and to generate earnings for energy service companies. An important aspect for the successful implementation of the RPT financial scheme is the determination of the optimal set-up of the business model under the specific local conditions. The objective of this section is to present a consistent approach to economic analysis of RET capital investments under the RPT financial mechanism taking into account the importance of life cycle cost concept. The main method of data analysis utilised in this study is a cost–benefit analysis. Under the current incentive framework in many Developing Countries, the amortization periods of investment on renewable energy are generally longer than the period over which the investment is to be recovered. This presents an unfavourable condition for attracting investments. An increase in remuneration through RPT financial model will actively expand investment in renewable energy.

The attractiveness of the mini-grid under the RPT financial scheme is first determined by a cost analysis to determine under which situation the RPT mini-grid will be cost effective. The technical design of the mini-grid requires data of the renewable energy shares, the fuel consumption of diesel generator set, the fuel costs (including transport-related costs and fuel subsidies), the storage capacity and the amount of electricity generation avoided when using renewables. The design must maximize the total life cycle cost: investment, operation and maintenance, and replacement. In addition to technology cost data, the financial assessment requires data on the regulated tariff rebates for renewable electricity produced and have in account various parameters including interest rate of commercial loan, depreciation cost and pollution costs.

A number of pioneering initiatives needs to be successful for demonstrating the positive effect of RE implementation when following the RPT approach. The final objective of RPT financial scheme is to support the use of renewables in non-electrified areas at a regional and national scale. For this reason, after the accomplishment of the demonstration sites, the final aim of the RPT model is to be used as replicable model for expanding to larger scale users (up to 100 kW range).

Until now, the report has described the RPT financial scheme in a general situation to support providing electricity coverage to rural mini-grids. In the following subsections the model has been limited in geographic scope allowing to concrete description of the regulatory approaches to promote rural off-grid electrification for three different case studies and use them as replicable RPT model for scale.

The three pilot cases are getting underway without the RPT financial scheme as micro-grid projects (see EDA, TTA, ISET for further details on the projects). The following sections will analyse the establishment of the RPT financial model in the already existing or updating mini-grids. To explain the basic financial arrangements in more detail, each one is applied to an electricity management- related case study. For each business model, given the necessary data, quantitative economic analyses have been assessed by modifying the assumptions of the RPT values. Quantitative analysis includes financial indicators such as the simple payback, the Internal Rate of Return (IRR), the Net Present Value (NPV), and the life-cycle cost of the project with and without revenue from regulated renewable electricity tariffs.

Table II. Financial Parameters

Financial Parameter	Characteristics	Value
Payback time	Reasonable time	Less than 15 yrs
Total lifecycle cash flow payback	Gives more than cost over time	
NPV	Used in capital budgeting to analyze the profitability of an investment or project	
Rate of return analysis		7-11 % of returns
Cash flow when financing	Positive cash	
Increase in appraisal valuation	Appraises for more than it cost	

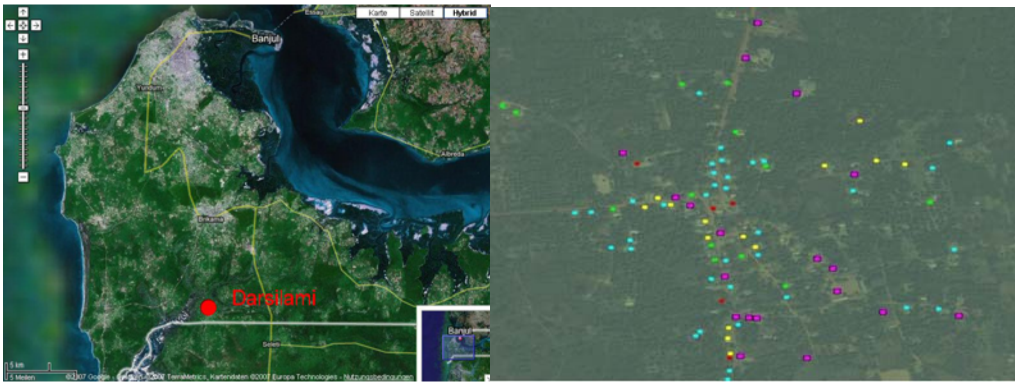
The financial approaches described hereby are based on project designs and expected results. The HOMER tool [32] has been used in the first step of the hybrid mini-grids optimization. Sources of information come from published material, unpublished sources, interviews with project managers and observers and the results of the discussions of the WG4 meetings. Throughout each of the section's case study, figures are represented to illustrate the transactions of each arrangement. Tables are also represented to show how to perform the economic analyses of the different arrangements. The NPV and IRR are calculated for each arrangement. It is important to note that the NPV of a particular arrangement can change significantly if the cost capital, the rate of return, or project life are adjusted. Thus, the examples within the sections are provided only to illustrate how the analyses can be performed. The cash flows and interest rates are estimates, which can vary from project to project. To keep the calculations simple, end-year cash flows are used.

7.1. FINANCIAL ANALYSIS OF PILOT CASE IN THE GAMBIA

Existing hybrid system

The unelectrified village of Darsilami (13°10'39" N, 16°39'28" W) is located in The Gambia close to the border with Senegal. The village has 3,000 inhabitants with two roads of access and does not have any existing grid (the nearest electrical grid is at 20 km).

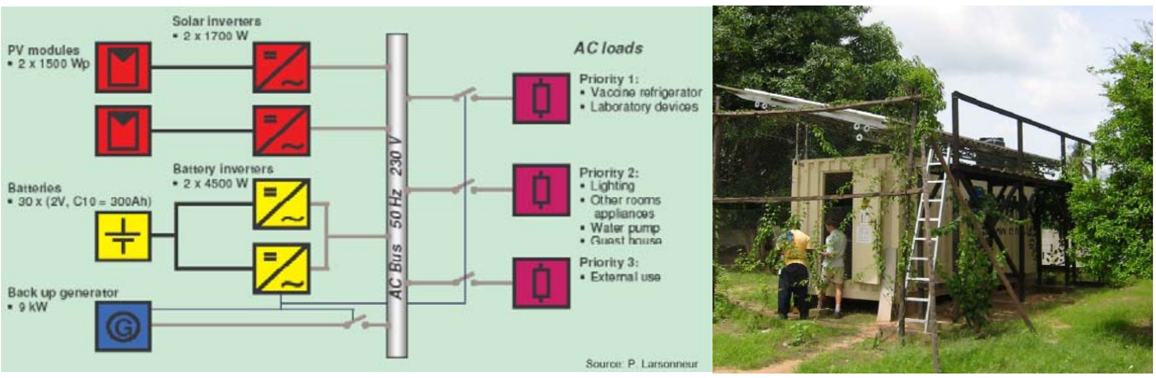
Figure X. Darsilami geographical location , distribution of households and social infrastructure



Source: M. Djuikom (Ferdedsi), M. Vandenbergh (ISET), Google earth

Sources of information come from ISET and the results of the discussions of the WG4 meetings. Currently, Darsilami has a small 3 kW PV-diesel hybrid system that delivers electricity to the local hospital. The hybrid system has the possibility to upgrading in a mini-grid, the capacity of the extension will depend on the consumer profile, their electricity needs, and the potential for productive use of electricity [33]. The hybrid system allows upgrading to 15 kW for bringing electricity to 300 households, HH, with a daily consumption of 200 Wh/HH, and with a total daily primary load of 60 kWh. The hybrid system uses two different power sources: photovoltaic and a gasoline generator, as well as battery bank as storage system.

Figure XI. Existing hospital hybrid PV system (3kW) with diesel generator (9kW) as backup



Source J. Schmid, M. Vandenbergh, and M. Landau (ISET), P.Larsonneur et al 21st European PV Solar Energy Conference, Dresden, 2006.

Up-date of the existing hybrid system to village-scale use

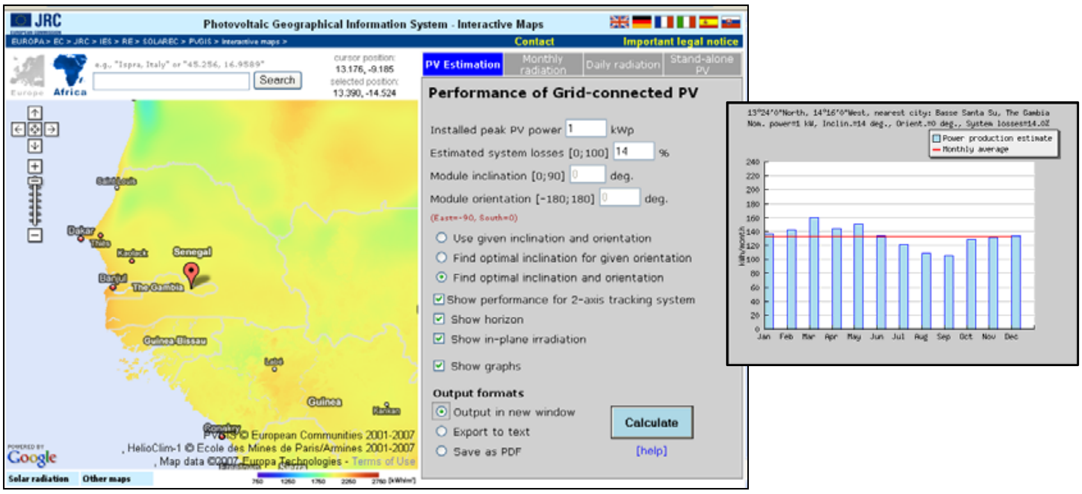
This project proposes a self-organized solar community where the members vote for a board of directors and the board makes the management decisions. The solar community would be a non-profit organization bringing electricity to their members (generally cheaper electricity tariff than by an IPP). The local solar community produces electricity by the 15 kW photovoltaic system, the expansion of the PV system can be acquired either by a private investment (100% of capacity cost), a loan from an International Financing Institution (e.g. 6% interest), or financial support from the local or foreigner governments.

Source: M. Djuikom (Ferdedsi), M. Vandenbergh (ISET)

Optimization

The optimal system recommends photovoltaic with a generator as a backup (slightly used) and the battery bank. That is because the electricity generated by the genset is quite expensive due to short lifetime and fairly low efficiency and because the resource conditions of the site are optimal for applying PV. The yield, 1596 kWh/kWp, and photovoltaic production of the photovoltaic system in Darsilami are calculated using the photovoltaic geographical information system tool (PVGIS) located at http://re.jrc.ec.europa.eu/pvgis.

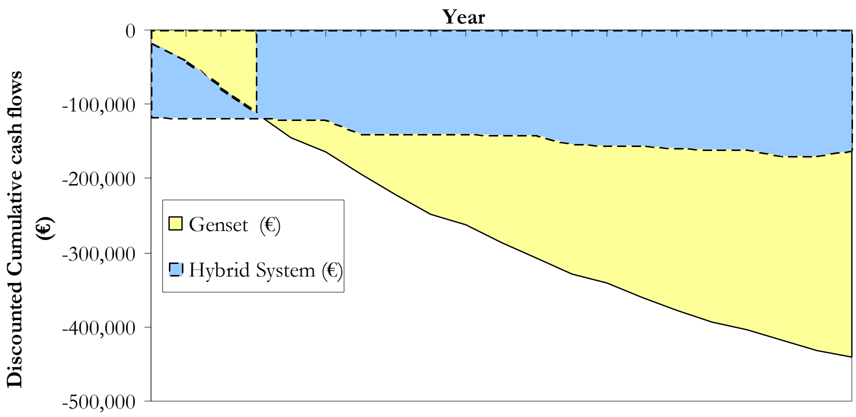
Figure XII. Photovoltaic geographical information System- Interactive Map in Darsilami.



Source: http://re.jrc.ec.europa.eu/pvgis

The calculated costs for a hybrid PV system with a diesel generator as backup have been calculated for a lifetime of 20 years. Diesel generator has a low capital cost but expensive to run, when comparing the a set-up with hybrid system and one running only with an isolated diesel system the simple payback is of three years

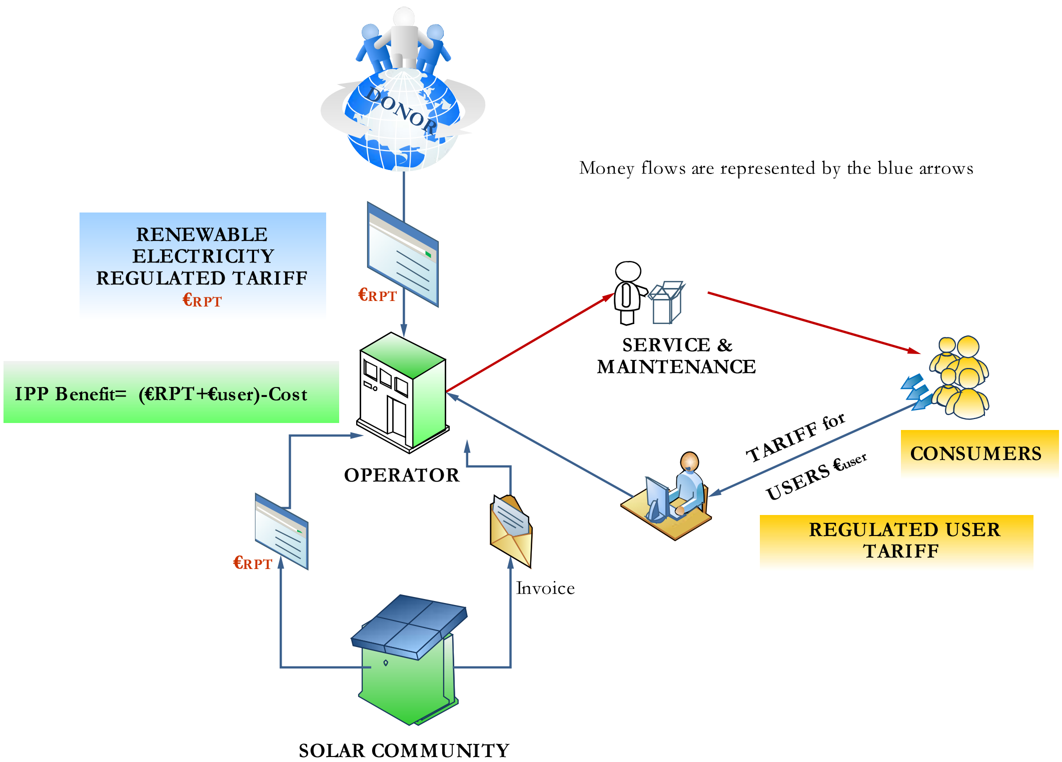
Figure XIII. Comparison of the cumulative cash flows (corresponding to the initial capital, replacement, fuel, and operating cost) between the hybrid system and an isolated diesel system



Financial Flows under RPT supporting scheme

Diesel generators, despite being costly, polluting, and constraining, particularly concerning transportation of fuel, oil, and spares to remote areas, remain often the most common power solution in off-grid areas because of its low capital cost. The RPT scheme it is mechanism to support the use of renewable energy systems in off-grid areas.

Figure XIV. Financial Flow in Darsilami pilot case under the RPT scheme at a village-scale



Source: M. Moner (JRC), J. Schmid, M. Vandenbergh, and M. Landau (ISET)

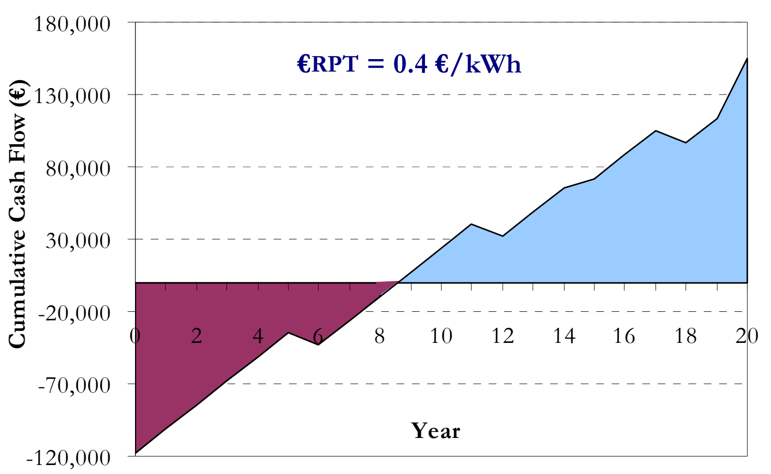
Currently the price for electricity for the city dweller is 0.15 €/kWh and between 0.30 and 0.40 €/kWh when the electricity is produced by diesel gensets. In the project, to make electricity affordable for the village users the grid-operator charges below the production cost to the end-consumer the electricity consumed at a regulated tariff ($€_{USER}$) of 0.20 €/kWh. The local government cannot afford to pay the financial support for the renewable electricity produced in the community. Therefore, the additional value per KWh of electricity produced by renewables, a regulated tariff fixed between 0.40-0.50€/kWh, is partially granted by a donor to the operator. The sum of revenues drives local utility economy by compensating the costs and additionally allows a benefit. In the case that the company is owned by the municipality do not require any specific benefit.

Table III. Evaluation of the hybrid-system under the RPT finance model

Total Investment 196,500€		€/kWh
Annual revenue from RPT (€/yr)	11,500	0,4
Local value of electricity (€/yr)	6,000	0,2
Payback time (years)	8	
NPV of RPT flow (€)	7.6	
NPV (based on WACC 6%)	38,000€	

The capacity investment of the hybrid system is covered for a loan at 6% interest, and the total amount of values for the renewable electricity produced during the 20 years of the guaranteed tariffs, $€_{RPT}$, is covered by a grant. Taking in account the above-considered inputs, the repayment of the capacity investment (payback time) is of 8 years. The payback time give an idea of how quickly the initial investments get back however does not value the savings after "payback" which are much larger; indeed the cumulative cash flows (Figure XV) show the future savings better than the simple payback time.

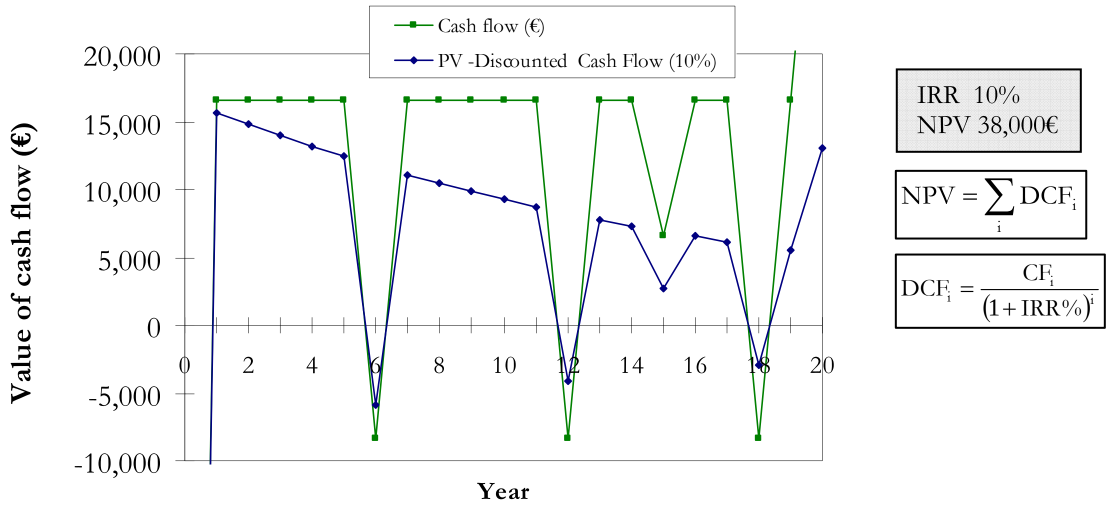
Figure XV. Cumulative Cash Flows under RPT scheme



Source: M. Moner, S. Szabo(JRC)

The total lifecycle payback shows the total amount saved over 20 years life of the system compared to the system net cost, however does not reflect the time value of money (today's € are worth more than future €). To reflect the value of the investment today comparing to the value of that same investment in the future the Net present Value (NPV) is used. NPV compares the values taking inflation and returns into account. If the NPV of a prospective project is positive, it should be accepted. However, if NPV is negative, the project should probably be rejected because cash flows will also be negative. In this pilot case, the sum of all the present values for 20 years is the net present value, which equals 38,000€. Since the NPV is greater than zero, the photovoltaic investment in the project is persuasive.

Figure XVI. Evolution of the future cash flows with or without discount taking in account the time value of money for 20 years (with $€_{RPT}$= 0.4€/kWh).

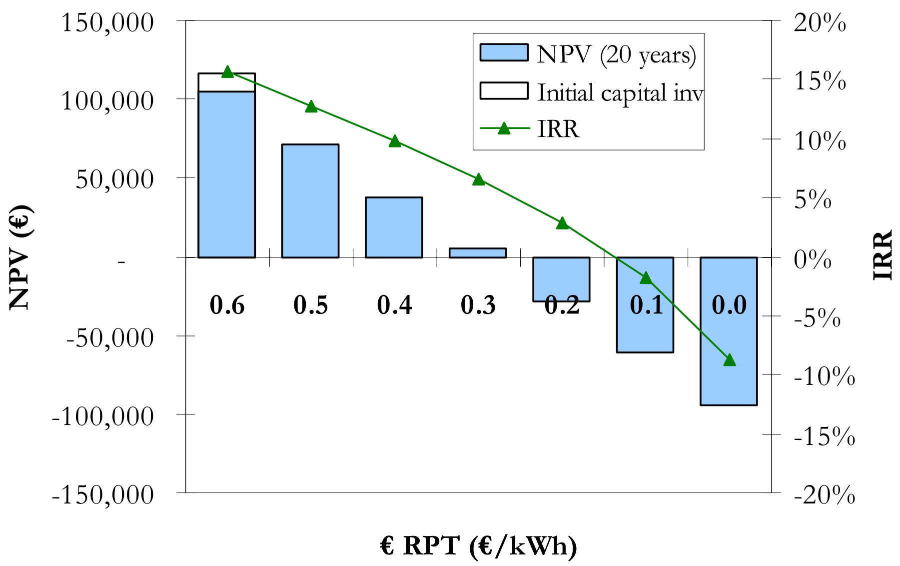


Source: M. Moner, S. Szabo (JRC)

Present value (PV) is widely used in business and economics to provide the value on a given date of a future payment or series of future payments, discounted to reflect the time value of money. The rate of return analysis means to find the effective interest rate yield on the renewable energy investment. This is a useful analysis for comparison with other investment with known rates of return. The IRR analyses include 20-year timeline with the yearly cash flows, the costs and benefit, and O&M. For each year, the sum up of the benefits and costs is calculated with a result of a series of 20 annual net inflows or costs. The IRR analysis tool is gathered in a spreadsheet (see Annex II) giving the equivalent annual yield rate. There are several possibilities for ownership of the mini-grid, as mentioned before could be that the village own the solar system and consequently would get a return on the investments. Depending on the defined parameters, a return of 6 to 7% can be expected in comparison to 3% of the bank.

Moreover, to obtain further private investment there is a strong need to mitigate the financial risks accomplished by ensuring the RPT for a long period of time. As a result of the first investment, a second system can be invested with partial own money resulting in much higher profitability and NPV.

Figure XVII. NPV and IRR versus the RPT value (€$_{RPT}$ from 0 €/kWh to 0.06€/kWh)



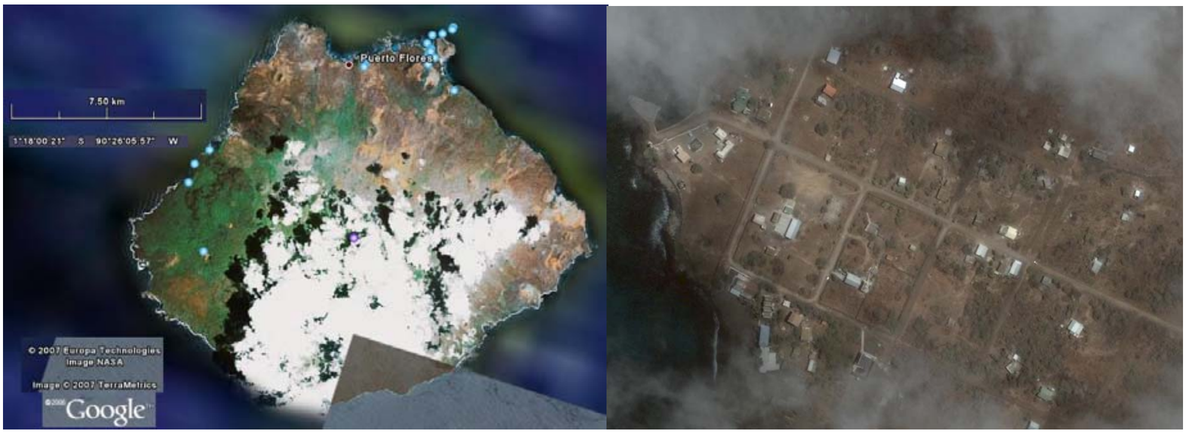
7.2. FINANCIAL ASSESSMENT FOR RPT PROJECT IN ECUADOR

The state-owned electricity monopoly has been unbundled and its assets transferred to the new electricity authority CONELEC (Consejo Nacional de Electricidad). The state-owned monopoly was transformed into several generation companies and a transmission company. The generation-companies have been or are being privatized, as well as the government's share in the different distribution companies [34]. CONELEC grants electricity concessions to the distribution companies and they are the sole providers of electricity for final consumers in their assigned regions. Retail prices are regulated by taking into account the different portions of the rate. The wholesale market is a centralized power pool operated by Centro Nacional de Control de Energía (CENACE) and it is in charge of both system and market operation. The prices to final consumers are regulated. The final price is composed of an addition of the generation costs, the transmission costs, plus the value added of distribution. Distribution company will calculate it annually and send it to CONELEC for its approval. There are various subsidies in Ecuador based on the principle of equal access for all electricity consumers. The high consumption end-users will subsidize low consumption users of the same geographic region. There are also additional direct subsidies, which are used for rural and urban electrification programmes. Following the Electricity Law, distribution companies should present to CONELEC the electrification program for their respective regions. These programmes are financed with the resources of the Fund for the Electrification of the Rural Areas. Based on the amount of funds provided, CONELEC approves those programmes and sends the funds to the distribution companies.

The government of Ecuador launched in 2004 its FiT law considering grid-connected systems, at the end of 2006 published a reviewed FiT regulation also open for autonomous systems, but because the complex regulated power tariff in Ecuador the regulatory agency has been unable to develop a feasible transaction procedure. The FiT values were established at 0.52$/kWh in mainland and at 0.57$/kWh in islands.

The mini-grid used to analyse the application of a renewable RPT financial model based on the Ecuadorian FiT law is based in Floreana. Sources of information come from TTA and the results of the discussions of the WG4 meetings. Floreana is the smallest inhabited island in Galapagos has 173 km^2 and about 200 inhabitants. Until 2003, a diesel genset microgrid was operating 13h per day in Puerto Velasco Ibarra (the single village of the island). Under the genset microgrid scheme the users paid the equivalent to a standard grid tariff, and the electric utility (EEPG) was sustained through a cross-subsidy of 25,000 US$ per year.

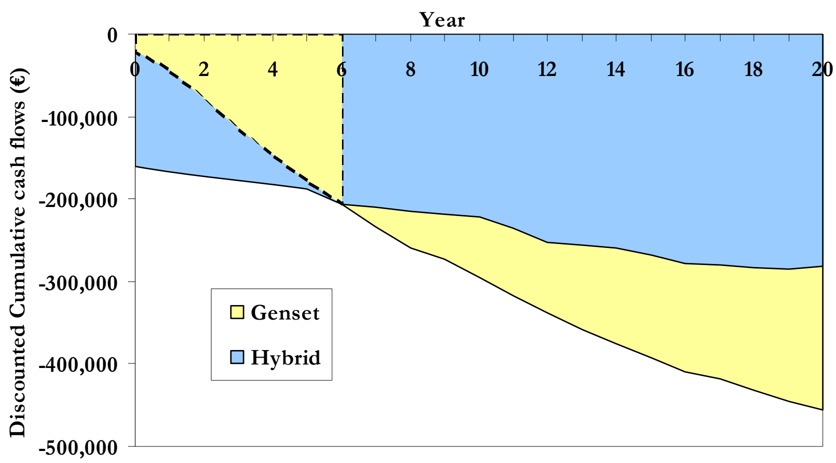
Figure XVIII. Map Floreana Island in Galapagos



Source: Google earth

Currently, the Puerto Velasco Ibarra village has a new service approach using PV hybrid technology that delivers electricity to its 54 users with a total daily load of 16 kWh by a 21 kWp PV generator backed by the previously used diesel genset (60 kWp). A life-cycle analysis comparison between the PV hybrid technology set-up and the genset set-up results in yearly savings of nearly 20,000 US$ (TTA). It must be highlight that the values used are estimates provided only to illustrate how the analyses can be performed, which can vary from project to project.

Figure XIX. Comparison of the cumulative cash flows (corresponding to the initial capital, replacement, fuel, and operating cost) between the hybrid system and an isolated diesel system

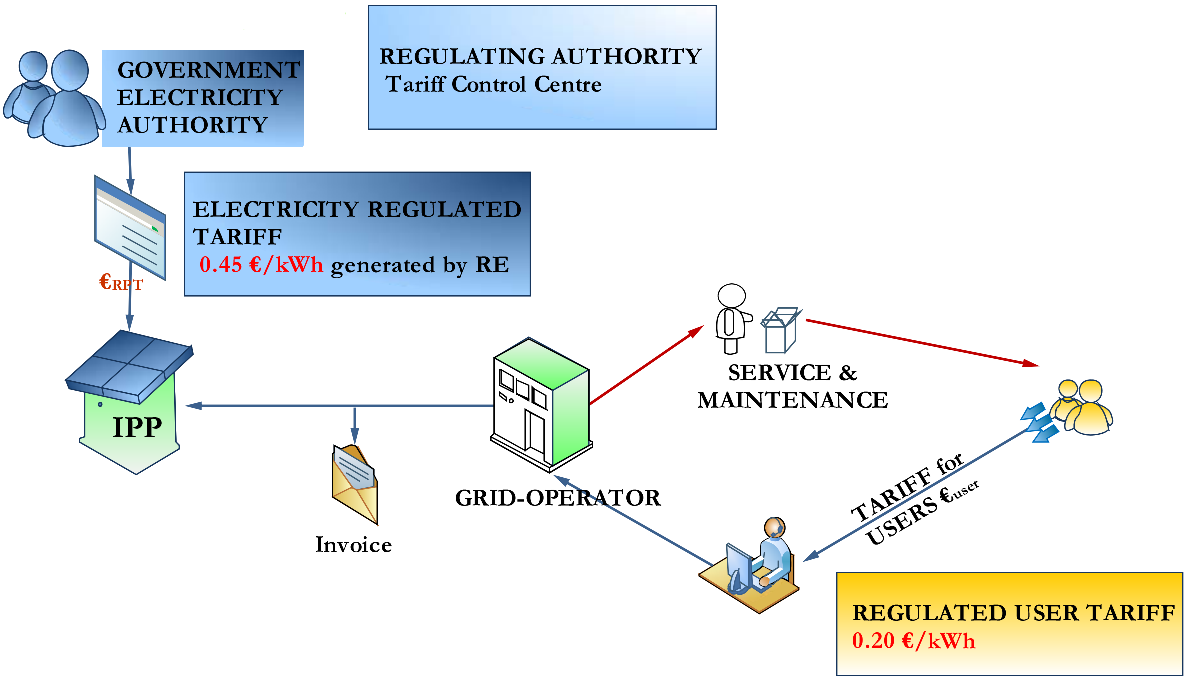


The island council and the electric utility share the IPP that owns the PV hybrid system. The IPP is an independent generator that sells energy deliverability to the distribution company, and at the same time, it is responsible for the operation and maintenance of the system and its management. The national regulating agency monitors and controls the quality of the service to the users.

Currently, a unified tariff scheme with segmented flat rated monthly fees contractually links all users to the energy operator. The standard grid-equivalent electricity service assures electricity 24 hrs per day for everybody and the energy dispenser/meters assuring the demand side management. To make electricity affordable for the village users the grid-operator sells the electricity to the users at 0.2 €/kWh (the willingness for paying few kWh is around 5 to 10 € per month). More detailed information of the inventory in Annex II

Hereby we evaluate the modification of the current financial scheme to a renewable RPT scheme using the same regulated renewable that the Feed-in value fixed by the government for islands (0.45€/kWh). In the evaluation, the Government Electricity authority provides the additional RPT subsidies to the IPP (equally share between the island council and the electric utility), the IPP sells the electricity to a regulated price to the distribution utility, and the end-consumer pay a regulated tariff (0.2 €/kWh) below the production cost to the grid-operator.

Figure XX. Electric service operating scheme in the Floreana island

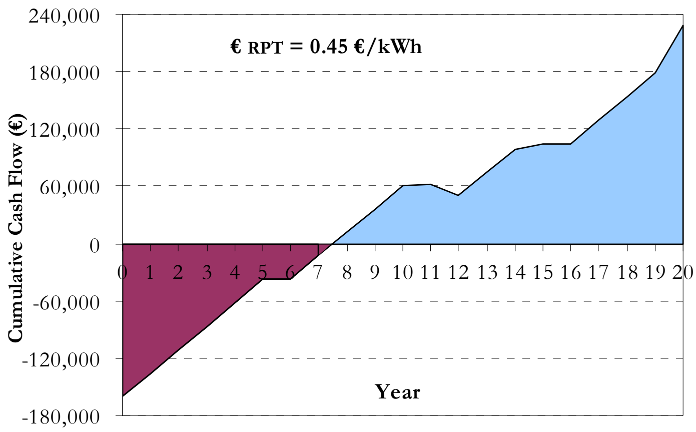


Source: M. Moner (JRC), X. Vallvé (TTA)

The evaluation of the application of the RPT financial in the existing mini-grid in Floreana takes in account a first inversion for 21 kW photovoltaic system and battery storage, with 5 years lifetime for the genset.

Payback time: The payback period of the RET investment is taken to mean the number of years required to recover the initial investment through the net project returns. In the Floreana project, taking in account the above-considered inputs, the payback time of the total PV investment under a RPT of 0.45€/kWh and local electricity of 0.20€/kWh is 8 years. The total lifecycle payback (see figure XX) shows the total amount saved over 20 years life of the system compared to the system net cost, however does not reflect the time value of money.

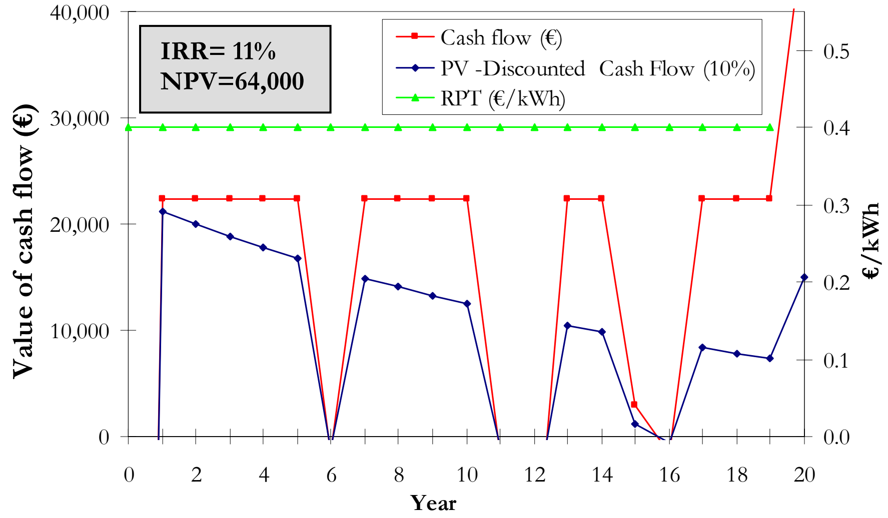
Figure XXI. Cumulative cash flows for PV investment under a RPT financial scheme



Source: M. Moner, S. Szabo (JRC)

NPV: To reflect the value of the investment today comparing to the value of that same investment in the future the NPV analysis is used. In this pilot case, the sum of all these present values is the net present value, which equals 64,000€. Since the NPV is greater than zero, the PV investment in the project is persuasive. Figure XXI compares the value of the cash flows with PV.

Figure XXII. Evolution of the expected future cash flows and present value for the total PV capacity invested under a RPT value of 0.45€/kWh for 20 years.



Source: M. Moner , S. Szabo (JRC)

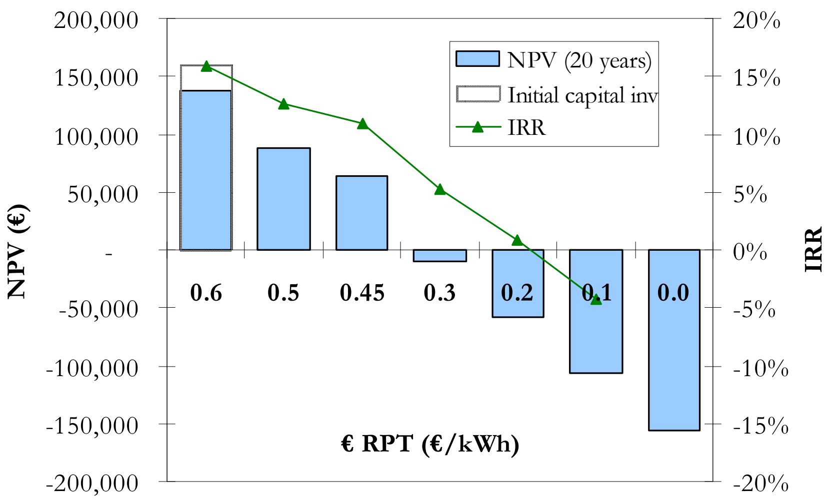
IRR The rate of return analysis means to find the effective interest rate yield on the renewable energy investment. This is a useful analysis for comparison with other investment with known rates of return. The IRR analyses include 20-year timeline with the yearly cash flows, the costs and benefit, and O&M. For each year, the sum up of the benefits and costs is calculated with a result of a series of 20 annual net inflows or costs. The IRR analysis tool is gathered in a spreadsheet (see Annex II) giving the equivalent annual yield rate. Depending on the defined parameters, returns of 8 to 15% are expected. Moreover, to obtain further private investment there is a strong need to mitigate the financial risks accomplished by ensuring the RPT for a long period of time.

Table IV. Evaluation of the hybrid-system under the RPT finance model

Total Investment 315,000€		€/kWh
Annual revenue from RPT (€/yr)	19,000	0,4
Local value of electricity (€/yr)	6,000	0,2
Payback time (years)	8	
NPV of RPT flow (€)	8.6	
NPV (based on WACC 6%)	64,000€	
IRR	11%	

This fact and a positive NPV can attract further private investment for the enlargement of the system under the RPT guarantee for 20 years. As a result of the first investment, a second system can be invested with partial own money resulting in much higher profitability and NPV.

Figure XXIII. NPV and IRR versus the RPT value (€$_{RPT}$ from 0.0€/kWh to 0.06€/kWh)



7.3. DEMONSTRATION PILOT IN MAURITANIA

In Mauritania some of the isolated grids are under the umbrella of the Rural Electrification Agencies (ADER) providing financial and subsidies (60-80% on initial investment, i.e genset), and technical support in management to local and small private operators. Mauritania has 14 isolated grids operating by 2 or 3 diesel generators (250 – 800 kW) managed by the National Utility (SOMELEC). There is no opportunity to be connected to the national grid because the long distance and low demands. Those isolated grids have an average peak demand of 300 KWp and total generation of 1,000 MWh per year. Because they are based on a national tariff (0.10 to 0.20 €/kWh) and the fuel component alone is already higher than 0.2 €/kWh the national utility (at subsidized prices) has permanent losses. In 2007, the local utility launched a new expansion and rehabilitation program (financed by FADES) for the existing mini-grid.

A preliminary study has been conducted to inject solar electricity in the power network supplying the remote town of Mbout in Gorgol province (IED, Oct 2007). The power plant includes two generators of respectively 200 and 80 kW after the planned rehabilitation.

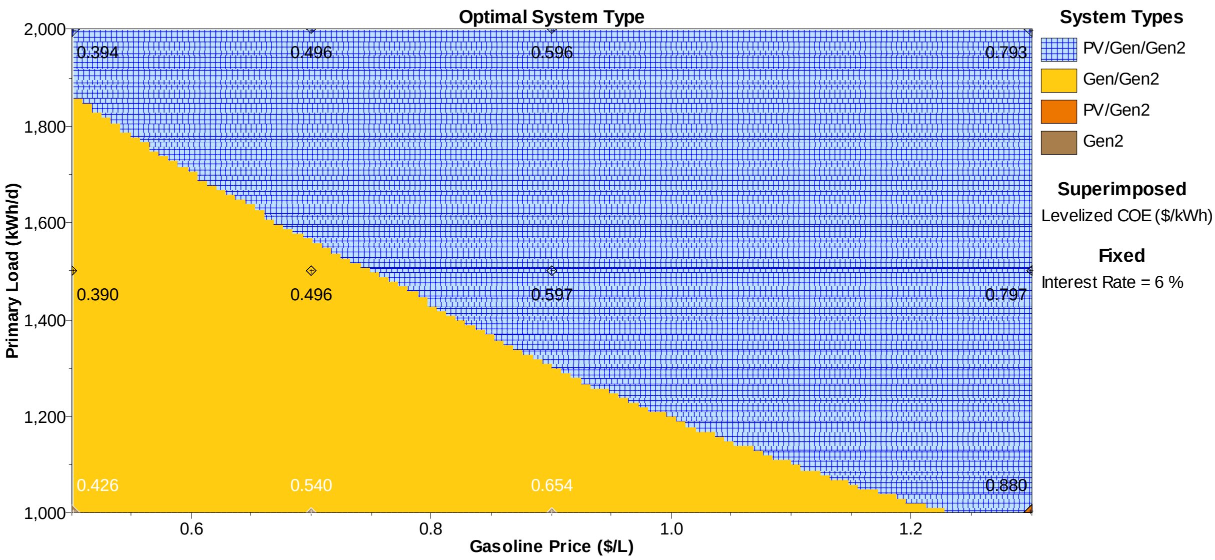
Figure XXIV. Geographical location of Mbout in Mauritania

Source: Google earth

In this section the demonstration pilot case in Mbout, the concept of renewable energy power purchase agreement is applied with a small penetration rate of RETs in the existing isolated grid. Sources of information come from IED and the results of the discussions of the WG4 meetings. The total annual electrical generation by the gensets is 550 MWh. The mini-grid has the possibility to upgrading, the capacity of the extension will depend on the consumer profile, their electricity needs, and the potential for productive use of electricity. A feasibility study has been done when updating the minigrid with a 20 kW PV system delivering less than 6%

of the total electricity produced in the grid. The costs for the hybrid PV system (20kW) with the two diesel generators (280kW) and without battery have been calculated for a lifetime of 20 years using HOMER software [32].

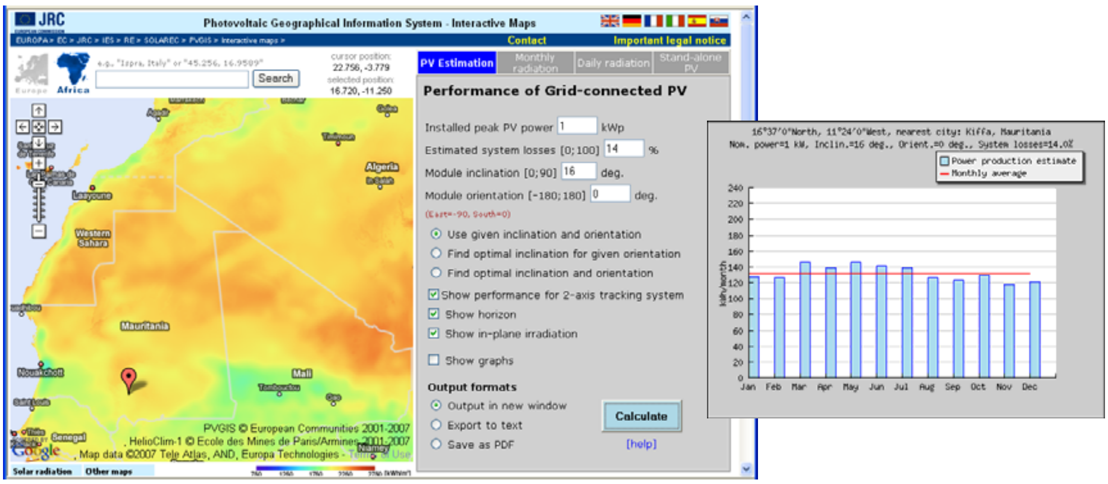
Figure XXV. Optimization of the Mbout system set-up versus fuel prices and primary load



Source: HOMER

The yield and photovoltaic production of the photovoltaic system in Mbout (1800 kWh/kWp) has been calculated using the photovoltaic geographical information system (PVGIS) tool http://re.jrc.ec.europa.eu/pvgis.

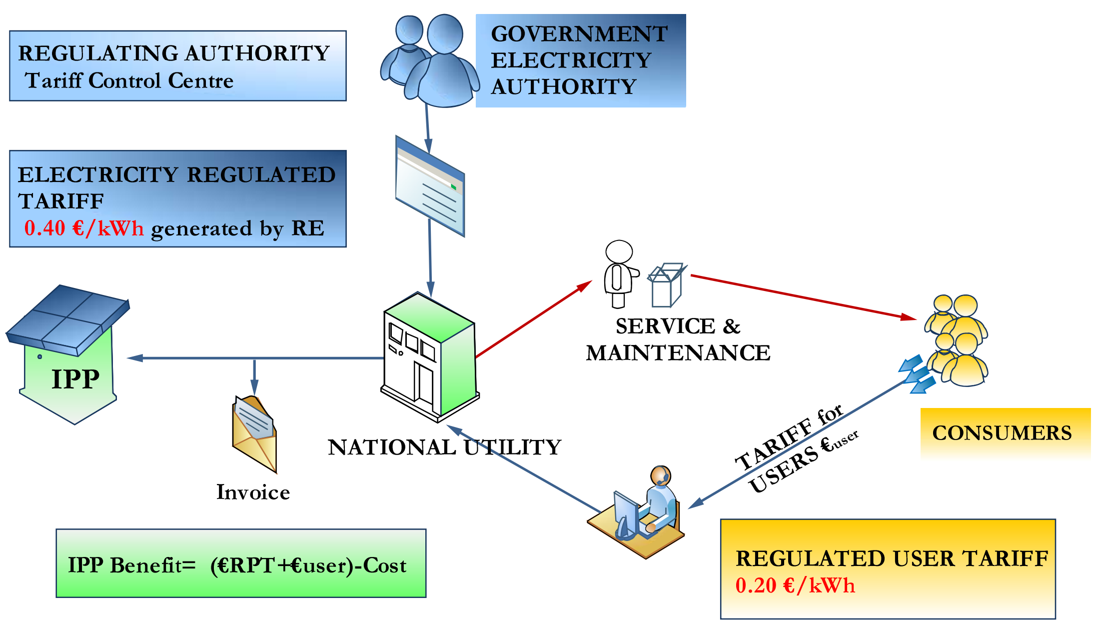
Figure XXVI. Photovoltaic geographical information System- Interactive Map in Mbout



Source: http://re.jrc.ec.europa.eu/pvgis/

Next figure illustrates the basic financial arrangements; the arrows represent the electricity purchase as well as the subsidies cash flows the parties involved. It has been considered a RPT of 0.40€/kWh guaranteed for 20 years. The National Utility manages the isolated mini-grid by charging to the end-users the national tariff (0.20 €/kWh) and delivering to the IPP 0.40€ per kWh generated by RET. The sum of revenues drives local utility economy by compensating the costs and additionally allows a benefit.

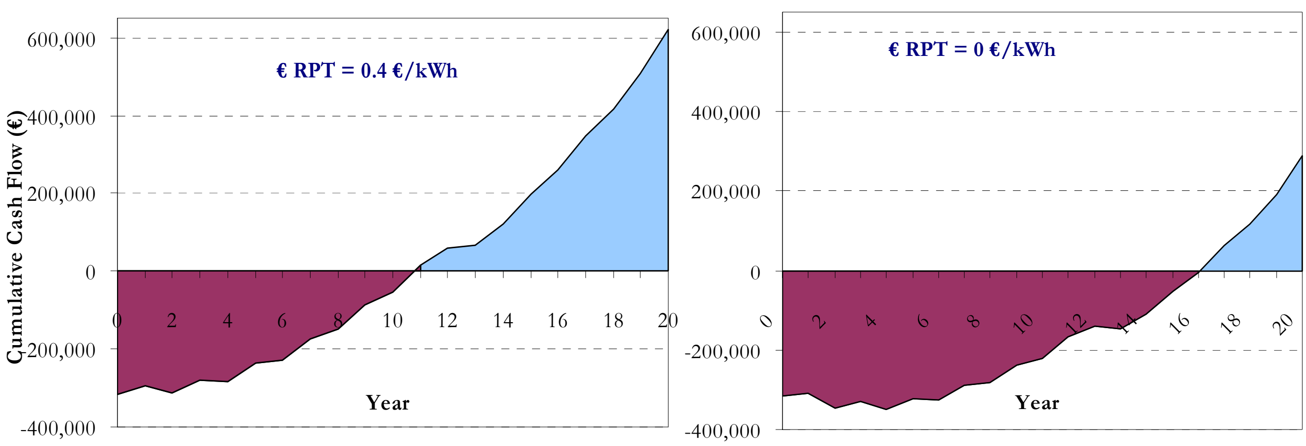
Figure XXVII. Renewable regulated tariff scheme for independent power producer.



Source: A. Shanker, D. Rambaud-Méasson (IED), M. Moner (JRC).

Payback time: Taking in account the a RPT value of 0.40€/kWh the repayment of the capacity investment is of 10 years (16 years without RPT). The payback time give an idea of how quickly the IPP initial investments get back however does not value the benefits after the "payback"; indeed the cumulative cash flows (see next Figure) show the future savings better than the simple payback time.

Figure XXVIII.Comparative Cumulative Cash Flows with or without RPT scheme.

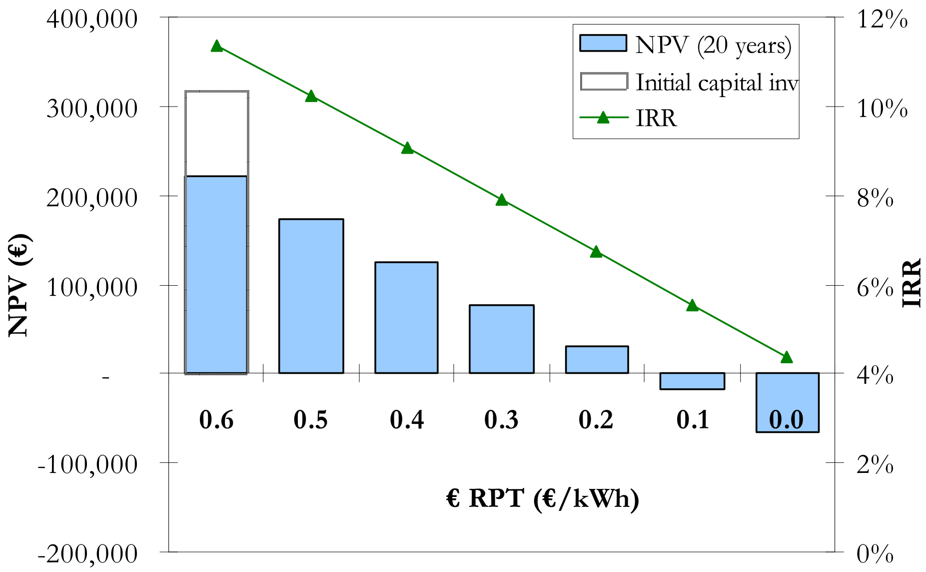


Source: S. Szabo, M. Moner (JRC)

NPV: The total lifecycle payback shows the total amount saved over 20 years life of the system compared to the system net cost, however does not reflect the time value of money. To reflect the value of the investment today comparing to the value of that same investment in the future the NPV compares the values taking inflation and returns into account. In this pilot case, the investment in the hybrid mini-grid under a guaranteed purchase agreement for the renewable electricity produced paid as 0.4€/kWh results with an IRR of 9% and NPV of 125,000€. Since the NPV is greater than zero, the PV investment in the project is persuasive.

IRR: The internal rate of return approach is designed to calculate a rate of return that is internal to the project. Meaning that when IRR is larger than the minimum attractive rate of return (MARR) the project is attractive. The minimum rate of return can be higher than the interest earned from the bank, or other risk-free investment. In this case, only investments with a return greater than 6% should be accepted. The MARR is also used as the discount rate to determine the net present value. Next figure shows the NPV and IRR values for each RPT from 0 to 0.6 €/kWh.

Figure XXIX. NPV and IRR at RPT price from 0.6 to 0 €/kWh.



Source: M. Moner (JRC)

The NPV and IRR of this particular arrangement (with a fixed initial capital cost, MARR, and project life) change significantly with the variation of RPT. NPV is useful because one can convert future saving cash flows back to time zero (present), and then compare to the cost of the project. If the NPV is positive, the investment is acceptable. Under the particular arrangement in Mbout NPV>0 and IRR>6% when RPT>0.2 €/kWh, therefore when RPT>0.2 €/kWh the investment is attractive.

8. CONCLUSIONS

Regulatory frameworks and related financing schemes can be a key success factor for energy projects. Acknowledging the fact that traditional local government policies based on the extension of electricity power grid have achieved a limited success in increasing access to modern energy in the rural areas, this document has described new approaches in promoting decentralized energy generation systems by an innovative financial mechanisms. Financing schemes are a decisive factor to make renewable energy technologies at an affordable cost for users and attractive for private investors.

The renewable RPT concept (based in the classical FiT) is new for autonomous RET although the form of cross-subsidies it is used in several Developing Countries with a regulated tariff system and large number of isolated mini-grids usually supplied by a diesel power plant.

This study attempted to establish a decision support to facilitate the evaluation of investments for private investors and policymakers under the RPT financial scheme. The evaluation comprises the analysis of the returns on investment based on a cash flow analysis and GIS according to the expected energy outputs, energy costs, and RPT incentives. This price support mechanisms will be effective when international donors or private investors are attracted to invest in RET, and when the mini-grids are designed under beneficial climatic and geographical conditions for the performance of RET.

Hopefully, this new approach will increase the implementation rate of renewable energy projects by encouraging mobilization of finance, which would have otherwise been cancelled or postponed due to lack of funds. Ideally, the application of renewable RPT will increase generation capacity and cost reduction as generating economies of scale. As a result, RPT would also generate a favourable impact on the environment (savings in CO_2 emissions), health impact (avoiding indoor air pollution from the traditional fuel), and socio-economic conditions (employment). Solving the continual lack of public funding requires bilateral, multilateral, and private partners. Generally, RPT financial scheme will help to have a low risk/reward ratio. Despite these benefits, the cost-effective renewable energy projects are not implemented due to the financial constrains. This alternative financial arrangement can overcome the initial cost obstacle. It is expected that the application of the RPT financing scheme would attract investors increasing the financial flows towards the energy sector.

If subsidies continue to make diesel or coal cheaper than renewable alternatives, this will create on ongoing barrier to renewable deployment in rural areas. The governments of Developing Countries must draw on growing international experience to create the necessary policy and regulatory changes and attract investment. For Developing Countries, RPTs offer a proven method for speedy growth in the share of renewables in the country's energy mix [4]. The extent to which RPTs can be successful will depend on factors both within and beyond the government's control, but with continued commitment and international assistance it is a policy that could help Developing Countries leapfrog more developed countries, and place them at the forefront of the energy revolution.

The selection of a large-scale demonstration site depends on the financing terms offered by the local and regional government and its policies relating to non-electrified areas, and the regulatory and legal framework for renewable energies and if already existing funding for investment. The large-scale demonstration project might start with a simplified IPP for renewable PPA framework, such as what is being worked upon in Indonesia and exists in the Philippines, India, or Thailand. Other factors are the availability of renewable energy systems and opportunities of local manufacturing of system/components/BOS, experience within the country/region, reliability, experience in the existing ESCOs, energy demand and consumer profile and their electricity needs depending on their economic activity and source of income (farming, livestock, services, and craft) and their potential for productive use of electricity.

The financial mechanism also should include the budget for technical assistance to develop projects and raise awareness, covering, in full or in part, preparation of feasibility studies, business plans, loan documentation for off-grid projects, and national promotion campaign on RPT schemes.

This synthesis can serve as a guide to regulators, companies, and development institutions seeking to promote rural off-grid electrification. Ideally, the application of Renewable Energy Regulated Purchase subsidies will increase the electricity generated by RES and will stimulate a higher investment increasing advocacy and rising the financial flow towards investment in energy projects in developing world.

9. ANNEX I. GLOSSARY OF TERMS AND ACRONYMS

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie
ARE	Alliance for Rural Electrification
CENACE	Centro Nacional de Control de Energía
CONELEC	Consejo Nacional de Electricidad
CONOLEC	Consejo Nacional de Electrificación
DRE	Decentralised Rural Electrification
EDF	European Development Fund
EIB	European Investment Bank
EU	European Union
FiT	Feed-in Tariff
GEEREF	Global Energy Efficiency and Renewable Energy Fund
GEF	Global Environment Facility
HH	Household
HV	High (Transmission) Voltage
IED	Innovation Energie Développement
IPP	Independent Power Producer
IRR	Internal Rate of Return
JRC	Joint Research Centre
kV	kilovolt
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt hour
LV	Low Voltage -generally based on 120- or 240-volt single-phase supply
m	meter
MARR	minimum attractive rate of return
mm	millimetre
MV	Medium Voltage -also called *primary voltage*; usually 1 to 35 kV
NGOs	Non-Governmental Organization
NPV	Net Present Value
NRECA	National Rural Electric Cooperative Association
O&M	Operations & Maintenance
PPA	Power Purchase Agreement
PV	Photovoltaics
GIS	Geographical Information System

RESCO	Rural Energy Service Company
RETs	Renewable Energy Technologies
RPT	Renewable Energy Regulated Purchase Tariff
SHS	Solar Home System: PV-based system typically 10 to 100 peak watts
TTA	Trama Tecno Ambiental
UNDP	United Nations Development Programme
VAT	Value Added Tax
W	Watt
Wp	Peak Watt
WACC	Weighted Average Cost Of Capital (WACC)
WG4	Working Group 4

10. ANNEX II COSTS INVENTORY

Table V. Calculated costs for the hybrid PV system with diesel generator backup in Darsilami pilot project

EQUIPMENT	
PV Array	15 kW
Generator	15 kW
COST SUMMARY	
Total net present cost	78,450 €
Levelized cost of energy	0.44 €/kWh
COST BREAKDOWN	
Totals Equipment	68,497€
Annual O&M + Fuel	600€
Other costs	45%
TOTALS (€)	€106,400

Annual average of primary load per day: 60 kWh

Annual electric energy production: 30 MWh

Gasoline Price: 0.5$/l

20 yrs RPT guarantee

Expected rate of return from investor: 10%

Other costs: Installation, capacity building, transport, feasibility studies, tax on import of technology

Table VI. Calculated cost for the mini-grid in Floreana with a PV hybrid system with a diesel generator as backup

EQUIPMENT	
PV Array:	18 kW
Generator:	60 kW
COST SUMMARY	
Total net present cost:	€365,000
Levelized cost of energy:	0.7€/kWh
COST BREAKDOWN	
Totals Equipment	€160,000
Annual O&M + Fuel	€75,000

Project life time 20 years (20 yrs RPT guarantee)

interest 6% Discount Rate

Yield 6.17 kWh/m² (daily)

Gasoline Price: 0.7$/L (include transport).

Specific fuel cons 0.37 l/kWh

11. CONTRIBUTORS AND ACKNOWLEDGMENTS

CONTRIBUTORS

- Magda Moner and Sandor Szabo (Joint Research Centre European Commission-JRC-EC)
- Paula Llamas (Alliance for Rural Electrification)
- Xavier Vallvé (Trama Tecno Ambiental-TTA)
- Jürgen Schmid, Michel Vandenbergh and Markus Landau (Institut für Solare Energieversorgungstechnik-ISET)
- Martin Staffhorst (Top50-Solar®)
- Anjali Shanker and Denis Rambaud Méasson (Innovation Energie Développement-IED)
- Wilfried van Sark, Mauricio Solano (Utrecht University)
- Aulich Hubert (PV Silicon Forschungs und Produktions AG)
- Gert Jan Jongerden (Solar cells Nuon)
- Arvind Shah (Université of Neuchâtel)

ACKNOWLEDGMENTS

The authors would like to acknowledge:

- The members of WG4 of the European PV Platform for their contribution to the discussions gathered in this report
- TTA, ISET, Ferdedsi and IED for their contributions on the three pilot cases studies
- Gabriella Zsotér and Greg Nemet for their valuable comments and suggestions
- The JRC IEC graphics and audiovisuals services (Nadine Bähr and Manuel Florensa)
- Jennifer Rundle for her contributions on the linguistic correction

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[8] FACT

[9] The bulk of private investment in electricity was in Latin America and the Caribbean almost 40% of the total.

[10] The World Bank database contains more than 3,300 projects dating from 1984 to 2005 and tracks total financial flows to projects in emerging markets. http://ppi.worldbank.org

[11] ECA Economic Report for Africa (ERA), Unlocking Africa's Trade Potential, www.uneca.org, 2004

[12] If environmental externalities are factored into the market prices of competing fuels, a process which is still infrequent, then minigrid-based renewable energy becomes even more competitive. China's roughly 80 PV/wind/diesel mini-grids (about half of which are PV-only systems), sized 10–200kW, are installed mostly on islands along the coast and in the northern and western remote regions. In India, nine PV mini-grids (most 25 kW) and two biomass mini-grids serve 35 villages in West Bengal

[13] Reiche et al. 2000; Kaufman 2000 Reiche, Kilian, Alvaro Covarrubias, and Eric Martinot (2000) Expanding Electricity Access to Remote Areas: Off-Grid Rural Electrification in Developing Countries. In World Power 2000, Guy Isherwood, ed. (London: Isherwood Production Ltd.), pp. 52-60.

[13] R. Peter et al. Renewable Energy 25 (2002) 511–524 519

[14] "Classic FiT" applied in Germany, Spain, Italy, France, Greece, Switzerland, Austria…

[15] Unattractive policies, laws and non-transparent regulatory measures and bodies, and unstable institutional frameworks hinder bilateral, multilateral and private sector participation in any development sector.

[16] Noteworthy cases include a public energy-service company on the outer islands of Kiribati, a public-private energy-service company in the Comoros Islands, and a purely private-sector effort in the Dominican Republic (Hansen 1998; Gillet and Wilkins 1999)

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[25] In some countries, these plants are regulated under the same law that governs grid-connected IPPs . In Mexico, for example, the same IPP law is used for all privately built power plants whether or not the plant is designed principally to supply bulk power to customers via the grid.

[26] Notion of the "parent body": especially in Africa where there has been in the recent past a lot of deregulation, the institutional schemes are well advanced with different models: Rural Electrification Funds exist in a large number of countries, sometimes with financial only, otherwise with technical also responsibilities; often, there is a regulator; and sometimes a "multisector rural infrastructure service agency": the model would need to be grounded in reality

[27] South Africa and eight Argentinean provinces (a utility company in Argentina) cases are a variation of the rental model called "concessions"

[28] Notable project examples are currently taking place in Sri Lanka, China, India, Cape Verde, and Mauritius

[29] R. D. Bandaranaike, "Grid Connected Small Hydro Power in Sri Lanka: the Experience of Private Developers," Ecopower Limited, Colombo, Sri Lanka).

[30] These include Argentina, Brazil, Chile, Columbia, Costa Rica, Dominican Republic, Guatemala, India, Indonesia, Jamaica, Kenya, Malaysia, Mauritius, Mexico, Morocco, Pakistan, Philippines, Sri Lanka, Tanzania, Thailand, Turkey, Uganda, Zambia, and Zimbabwe

[31] A typical financing arrangement for a local user with an individual system would be an investment of €500, consisting of user cash payment of €100, a grant payment of €100, and a loan of €300 with an annual payment on the loan of €75 (25% of original loan)

[32] https://analysis.nrel.gov/homer

[33] J. Schmid, M. Vandenbergh, and M. Landau (ISET)

[34] http://www.conelec.gov.ec