

**Feasibility Study of Renewable Energy Options for Rural Electrification in Cambodia (REOREC)**



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**PRICING OPTIONS FOR RENEWABLE ENERGY BASED  
ELECTRICITY GENERATION**

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### **PRICING OPTIONS FOR RENEWABLE ENERGY BASED ELECTRICITY GENERATION**

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## 1. INTRODUCTION

The Royal Government of Cambodia objective, through its Rural Electrification and Transmission Project (RE&T), in co-operation particularly with the World Bank (WB) and the Asian Development Bank (ADB) and other International Institutions, is that by the year 2030, over 70% of this rural population will have access to *grid-quality electricity*. These are ambitious goals which can be achieved only through the continued support of the international community.

Cambodia has no national grid and the country's electricity supply consists of 24 isolated grids centered at major cities, provincial and small towns, with the exception of the electricity supply system of Kampong Speu which has been connected to the Phnom Penh system through a 115 kV single circuit transmission line since 2002. Electricity service providers in small towns and communes near the borders of Thailand and Vietnam also sourced some of their power from electricity suppliers from these countries. The three main electricity suppliers in Cambodia are: i) Electricité du Cambodge (EDC); ii) licensed electricity providers, and; iii) rural electricity enterprises (REE).

The Cambodian Research Centre for Development (CRCD), together with its partners Centre Wallon de Recherches Agronomiques (CRA-W) of Belgium, Risø National Laboratory of Denmark and Emerging Power Partners Limited of Finland, was provided a co-financing grant by the European Commission to implement a project entitled "Feasibility Study of Renewable Energy Options for Rural Electrification in Cambodia (REOREC). The principal objective of this project is to evaluate and develop the potential renewable energy options for the electrification of rural Cambodia.

A number of feasibility studies was carried out to identify and evaluate actual renewable energy projects. These included both on-grid and off grid projects which raises different questions regarding the possible end-user tariffs or buy back tariffs. These issues are discussed in relation to overall energy pricing policies in this report.

## 2. PRICING POLICIES AND IMPLICATIONS FOR RE IN RURAL AREAS

### 2.1. Fairness and equity concerns

Electricity access is generally accepted as vital for improving living conditions of poor households. Whether the price of electricity supplied or the access in the first place is the most important is unclear. It is probable that access should be prioritised even if it involves very high consumer prices.

With the isolated structure of distribution networks in Cambodia, this involves having very large differences in actual electricity prices at the moment. In a long-term perspective this must be considered unfair and in direct contrast to distributional objectives of supplying electricity to poor households at affordable rates. This priority should be included in the long-term objectives and also be implemented in the renewable energy projects. However, this objective should not be a barrier to rural electrification and the implementation of renewable energy projects. The possibility of charging higher tariffs in isolated rural areas is one of the characteristics that would make the renewable energy projects viable (profitable).

From the renewable energy point of view, it is therefore possible that higher energy tariffs should be approved under the condition that renewable energy solutions are chosen. As they have generally higher capital costs than conventional technologies, the possibility of charging higher electricity tariffs, which are gradually reduced, would be a competitive advantage to renewable energy technologies.

The prospect of falling tariffs would contribute to the fairness objective by narrowing the gap between consumer prices in urban and rural areas without compromising the possibility for electrification in the first place. The degree of uncertainty over future tariffs will be less for the renewable technologies as the variable costs (fuel) are much less than for the conventional technologies. This property would also contribute to the fairness objective, by reducing the price risk for poor households.

It is probably just as important to secure long-term availability of reasonably priced electricity locally than to have just as low tariffs as in the urban areas from the first day of operation. The access to electricity will be seen as a progress and the following gradual reduction of tariffs will be seen as continued progress. Access to electricity will be much more important than the actual price consumers have to pay for a low consumption of electricity as an incentive for people to stay in the rural areas.

More radical equity objectives will have to involve subsidy elements and in the case of renewable energy these could target the investment cost and thereby lowering the initial tariff requirements.

### 2.2. Development objectives

The pricing policy of promoting development in rural areas by supplying electricity to small-scale industry at affordable rates is an indirect measure to support working opportunities in rural areas.

For the agricultural sector access to electricity could improve revenues from products by allowing local initial processing and storage, pumping of water etc. The actual cost of electricity is again less important than just having the access. For larger processing facilities the question of competitiveness relative to other producers in areas with access to cheaper electricity becomes more important.

For the larger agricultural processing activities and for industrial activity a policy of supporting these also in remote rural areas by subsidising their electricity tariff will not be sustainable in the long run.

The question of tariff differences between consumer categories is also an important issue for the renewable energy projects. Equity concerns would tend to favour low tariffs for poor households with low electricity consumption. If cross-subsidising from commercial and industrial use to residential use is requested, then the development objective could be compromised in the way that less commercial/industrial activity will be developed and in the end this would produce less employment opportunities for the population in these areas. Cross subsidising the commercial and industrial use at the expense of households would on the other hand be difficult to implement and would also be unfair to the very small-scale production activities taking place in the household.

An existing processing/industrial facility becoming an electricity producer will probably have a major part of the profitability of the project from its own savings. It is not possible to assign a specific price to this electricity consumer that differs from the price offered to others. However, if the project is profitable by assigning the same price to its own electricity consumption (or the reduction in purchased electricity/fuel)) then the renewable project will contribute to the overall profitability of the company. The power production involvement can thus cross-subsidise the other activities of the company. The arrangement wont create an inefficiency problem because the alternative option of selling the electricity in the market would be balanced against the revenue generated by using the electricity in its own production.

Actually the investment in a renewable energy project would make the existing production more competitive and could contribute to the local development goal.

The importance for health and education of having access to electricity should also be considered as a possible development gain.

### **2.3. Regulation and approval of tariffs**

The Cambodian system of licensing and approving the tariffs of new licensees involves the opportunity to allow different tariffs for specific technologies such as renewable energy based. In principle, the cost-recovery option is securing that the technology with lowest costs is the most competitive if there are competitors in the market to supply electricity. If there is only one supplier actively seeking a license to put up new electricity producing capacity, then he might just as well choose a technology that has higher costs on average but lower marginal costs in the longer term where it is more likely that he might be exposed to competition. From an efficiency point of view this does not ensure that the cheapest production technology is implemented.

Renewable energy can be favored in this system of regulating licenses and tariffs if the authorities are initiating or supporting the new applications for licenses involving renewable technologies. It is possible to approve tariffs for renewable projects with higher costs than electricity production based on fossil fuels.

#### **2.3.1. Cost covering**

In the EAC regulation of tariffs, the basic principle is the right to fully cover production and distribution costs. With isolated grids this involves large variation in production and distribution costs within the country and thus in the tariffs the population have to pay. This is however necessary to have any incentive to private participation in the extension of grids and electricity supply in remote areas. Otherwise, the population and businesses located in areas with low costs of production and supply would have to subsidise electricity consumers in more remote areas.

Cost covering in local grid-systems without competition would allow favoring more expensive renewable energy production backed by other favourable characteristics. This could however be combined with, obligations to reduce tariffs in the longer term. This would secure that tariffs in the longer term does not exceed the expected tariff levels of fossil fuel based electricity. This option is further explored below.

#### **2.3.2. Cross-subsidy allowed**

Cross subsidies among consumer groups are allowed and there is no restriction on the costs of supplying relative to the tariff for consumer categories. As there are examples of cross-subsidising towards low-income consumer groups in the Phnom Penh there does not seem to be any obstacles to having a cross-subsidy in the other direction. For specific projects it is possible to allow the project developer to benefit from indirectly paying a much lower price for self electricity consumption than the customers in a mini-grid that it is supplying.

This possible element of cross-subsidy should be limited, but to have the incentive to undertake the renewable project in the first place there needs to be some profit (or reduced implicit electricity price) for

the project developer.

The REF support in the form of grants seem to be unrelated to the tariff structure of the electricity sales from the new licensee. It should be secured, that the project is not cross-subsidising the project developer in excess of the necessary saving (profit) to make the project worthwhile to undertake in the first place. Therefore any possible difference in tariffs should not exceed the corresponding difference in the cost of supplying the different customers.

## **2.4. Specific elements of tariff structure in relation to RE projects**

Tariff structure can be simple or it can include several fixed and variable elements as well as time of use based, peak based or location based elements. Some of these are less relevant for low-income rural areas but others should be considered to be allowed in these areas as they could reduce the uncertainty of future demand or reduce the investment costs relative to the supplied electricity. The more complex tariff structure the larger is however, the higher the possibility of distorting the use from the most efficient use of a given supply of electricity. Massive subsidy of residential consumption (the variable part) should be avoided relative to the industrial use. If residential consumption is to be subsidised it should be by subsidising part of the fixed tariff element or the initial connection costs.

### **Fixed tariff elements**

A fixed tariff element is intended to capture the costs of maintaining the connection and the registration of the individual consumer. The fixed element can also be set to cover the initial connection costs and a part of the grid costs.

As the rural areas to a large extent will be dominated by low-income low-volume customers a fixed tariff element would result in very high price level per kWh actually consumed. The fixed tariff would also be a disincentive to consume in the first place, and could thus be an obstacle to the rural electrification itself. The fixed tariff element will therefore often be transferred to higher tariffs on the electricity consumed. This would disfavour the larger consumers that have lower costs of supply than the smaller customers and is one argument for the lower tariffs for the larger consumers.

Fixed tariff elements on the other hand can be a way of financing the connection costs of households. If connection/rural electrification is part of a project then the fixed tariff can allow households the financing for connection that they are possibly not able to obtain from other sources.

### **Metering costs and time of use tariffs**

Real time pricing seems irrelevant for a rural electrification project as this market oriented facility is most efficient if there are many adjustment options on the supply side and very different values assigned to consumption at specific time for different consumers.

Time of use tariffs is probably also irrelevant as the higher metering costs are exceeding the gains from shifting consumption from one time period to another. The majority of residential consumption in rural areas is probably at times where industrial (agricultural) related consumption is low and the major part cannot be shifted to other hours. A possible gain could be achieved if there is industrial consumption at peak times of residential demand. This could be relevant if the industrial demand is mainly drying/cooling or pumping, which to a large extent can be shifted from the peak hour. In this case it could be relevant to charge a large customer less in the off-peak hours and more than the residential customers in the peak hours. Time of use tariffs does not seem relevant for residential demand until this has a large proportion of air-conditioning, which will not be the case in the low-income rural areas.

### **Advance payments**

The use of advance payments either as a way to reduce losses or as a way to increase predictability of consumption is especially relevant where there is less control with collecting revenues or the costs of collecting would also be high. In rural low-income areas the ability to pay electricity consumed during a longer period will experience high fluctuations. The households will very seldom have savings to eliminate the effect of fluctuations in income and the risk of defaulting on electricity bills will therefore be high. Instead of the initial requirement of advance payment, which will certainly reduce demand and make the whole project less viable the advance payment requirement could be replaced by some pool of funds guarantying the payment of the first year bills. If this is brought about as a subsidy or grant rather than from ordinary tariffs this would reduce the vital uncertainty of collected revenues from the initial year of operation. This subsidy should only be at a size giving partial protection from expected losses from non-collection. Interruption of supply by non-ability to pay will have to be in place.

With interruptible connection and metering equipment the funds to buy the electricity at the time of requested use will be made available and this does not imply having to pay a large amount to secure the supply for a longer period (a year). This way of advance payment is not reducing the expected demand as much as the up front payment of one year of electricity consumption, but it is rather costly in respect of the equipment and also involves collecting costs.

### **Volume dependent tariffs**

Higher volumes of electricity have lower supply costs as there are fixed cost elements of supplying. Reflecting cost differences in the tariff is the optimal solution from an efficiency point of view, but can be in conflict with distributional concerns. Both elements seem to be incorporated in the tariff structure in place for the Phnom Penh region (see next section)

A secondary reason for the existence of this difference is the degree of competition in market segments. For the larger consumers there is a tendency that frequent review of possible supply options and prices will force the suppliers to reduce their tariffs to match their competitors.

This would result in the lower tariffs for larger customers and even lower than the cost differences could justify. In rural areas this could be just as pronounced as there is probably not as much competition as some other places, but the larger consumers will have other elements of bargaining power/local influence. The residential consumers possibly do not have this kind of bargaining power and will have to take the offered tariff. Therefore there has to be a review securing that the larger customers are not offered too large a discount relative to the residential consumers. Some variation in tariff based on level of consumption should be allowed in the review of proposed tariff for the rural electrification projects.

### **Long term supply contracts**

In the rural areas with new electrification projects it is very difficult to forecast electricity demand and this induces a major risk to the profitability to all electricity projects. The larger the dependence of electricity supplied to a new grid relative to the possible own use, the larger is the uncertainty of total revenues within the project. One way to overcome this problem or reduce the risk on the demand side is to make long term contracts with take or pay elements (minimum consumption) with a few larger potential customers. This would involve contracts with some discount, but it might be combined with giving higher degree of security of supply guaranties than to other (residential customers). In some cases local authorities or institutions would be large enough customers to enter these types of agreement. In the case of renewable production with relatively stable production costs in the long term the price risk for the consumer (local small scale industry) this could involve quite a reduction in cost risk for its electricity supply if the uncertainty is biased in the direction of future demand exceeding the production capacity of the given (or possible) renewable project. Thus there could be possible benefits from these types of contract for both consumer and supplier. The problem with these are that the competition for the most productive use of the electricity generated is reduced (some proportion of production is taken of the market).



## Connection tariffs

Rural area electrification projects will in most cases involve the construction of entire new mini-grids or replacement of smaller grids. Households in these areas are often incapable of paying/financing their connection costs. Therefore the initial grid including connections will have to be seen as one package that need to be financed by the producer/distribution entity. This part of the investment is the most relevant part to subsidise relative to the investment in generation equipment or the actual electricity consumption. Subsidising investment in generation could lead to overinvestment and subsidising consumption could lead to consumption levels where the marginal utility of use is exceeding the marginal costs of production.

Because of the lack of funds in households the connection tariffs will largely have to be covered by the electrification project itself or by a subsidy. If not subsidised it must be recovered through the tariff for the electricity consumption. If the project involves subsidies/grants it is relevant to subsidise connection costs, but a fraction of these costs should be borne by the consumer to secure that only consumers with a minimum of expected consumption are being connected.

## 2.5. Off grid renewable generation

Off grid renewable generation involves comparing with much more expensive alternative options from conventional production/existing facilities. This makes it easier for the renewable technologies to compete and in many cases the renewable technologies should be able to generate and supply at lower tariffs than are used in the isolated areas already as they are supplied by very inefficient diesel based systems.

The two main problems for the RE projects are the high investment costs and the relative unknown technology to the people in these areas. Support to promote the renewable technologies could include a number of tariff related options of which the majority are mentioned in the previous section:

- High initially allowed tariffs with following tariff reduction
- Support as grants to the grid investment/connection costs
- Partial grants to the investment in the RE technology
- Guarantees for minimum revenue from electricity sales (or buffer fund to allow sales without advance payments) when sales and/or revenue collection is uncertain
- Allowing long term contract with larger customers at lower prices than what households pay
- Allowing priority to larger customers with regard to security of supply and transforming this difference to reduced difference in the tariff paid by the residential and large consumers
- Support to handling procedures to secure the financing from CDM

If the case is entirely a generation project then the viability of the project could be assured by some PPA securing a long term profitability of the RE project. At the current diesel prices and diesel based generation costs in remote areas, the RE projects will often be competitive at the average production costs but it is vital for the project to secure the long term rates. A PPA with a tariff for the next 15 years will be more important than a subsidy as a higher feed in tariff than diesel based generation. It is important to guaranty that the price can be obtained also in the case where the local grid is becoming connected to a larger grid.

One of the uncertainties regarding the competition from other generation in isolated grids is probably the long term prospects for having these grids connected with national grids or larger regional grids. Such a

development would pose a threat to the otherwise high feed in tariffs that can be obtained in the isolated grids.

For efficiency reasons the investment costs should not have too high a share of subsidy/grant element as this would tend to lead to overinvestment and investments in projects that are not the most efficient given the size of potential demand.

## **2.6. On grid renewable generation**

For RE connected to larger grids the price level for generation is much lower because of the larger generation units in the system and the inclusion of cheaper technologies than the diesel based generators in the remote grids. Therefore RE projects of comparable size as those in the remote areas will be more exposed to competition. One of the major question in this respect is the competition relative to the larger hydroprojects already underway and planned. The subsidy element must therefore be expected to be more pronounced here unless CDM is making it favourable anyway.

On grid renewable generation will have to be compared to EDC marginal generation costs. This result in comparing the renewable projects with the proposed hydro projects of EDC and IPP's long term marginal costs. This would result in rather unfavourable tariffs for buy back rates from renewable projects compared to the off grid projects. With this in mind it should be considered to which extent a premium from the small renewable projects relative to the large hydro projects should be given. It will be difficult to argue that the premium should be based on these small scale facilities being available at peak load. Also the alternative option of importing hydro based generation from e.e. Laos should put a limit on the level of subsidy for these small RE generator. PPA's with a fixed price could be compared relative to a agreements that include some demand dependent fluctuation in the price to allow for efficient dispatch also in a future generation setup with more independent generators.

For efficiency reasons the subsidy element should be rather limited as the competing technology seems to be the larger hydro projects that are characterised by the same degree of substituting imported fossil fuel and reducing the energy related emissions.

### 3. EXISTING TARIFF STRUCTURE

The existing tariff structure in Cambodia is mainly represented by the structure of tariffs in the area supplied by EDC. Tariffs in other areas are in general at higher levels and it is not possible to transfer the tariff structure of the EDC area to all areas of Cambodia. For many reasons a simpler tariff structure would often be chosen for the smaller supply areas.

#### 3.1 Tariff structure in EDC supply area

The EDC tariff structure reflects cross-subsidies among consumer groups. Contrary to many countries that favour industrial users competing in export markets, there is a cross subsidy towards the low-income households. There are other countries in the SE Asian region exhibiting the same tendency as seen in the next section. The following details in this section are based on Chapter 4 in “Markets, Policies and Institutions”.

**Table 1: Tariff variation: EDC’s Electricity Tariff in Phnom Penh and Kandal Province**

Category of Customer	Description	Riels/kWh	Relative to average	Rural tariff with EDC structure (US cent)
Domestic	0 - 50 kWh/month	350	55%	16.4
	51 – 100 kWh/month	550	86%	25.8
	More than 100 kWh/month	650	102%	30.5
Government institutions		700	109%	32.8
Embassy, NGO, Foreigner's residence		800	125%	37.5
Commercial and service sector	Small	650	102%	30.5
	Medium	600	94%	28.1
	Big	700	109%	32.8
	Medium voltage	800	125%	37.5
Industrial	Small	600	94%	28.1
	Medium	550	86%	25.8
	Big	500	78%	23.4
	Medium voltage	480	75%	22.5
Average (16 US cents/kWh )		640	100%	
Rural projects tariff (US cent)		30	188%	

Calculated from *Table 4-7 in* : “Markets, Policies and Institutions”.  
Original Source: Electricity Authority of Cambodia, 2004.

Based on the tariff structure reported in table 1, the bottom residential tariff is only 44% of the highest commercial tariff. This is a massive subsidy of low-income households in the urban areas. As their consumption does not constitute such a large fraction of total demand this is possible in the EDC supply area. Some of the differences in the tariff structure seems less well justified by distributional concerns as there does not seem to be any reason for the high rate for commercial at medium voltage.

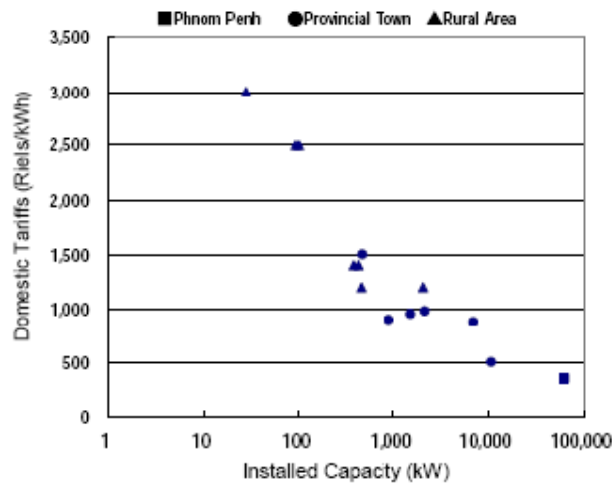
A revision of the tariff structure has been undertaken recently to pass on the variation of the purchase price of EDC in the tariffs charged for medium to large commercial and industrial customers. They will be charged at a flat rate, which is however adjusted a number of times annually (monthly). This simplification seems reasonable with regard to reducing the difference among the different size commercial and industrial customers.

The problem about extending this tariff structure to the rural areas is that a majority of the possible customers will belong to the group of residential customers with low consumption and therefore entitled to the lowest tariff level (45% discount). In the urban areas this customer group will only constitute a minor share of sales, but in some of the rural areas they might constitute more than half of the potential sales. Correspondingly the commercial and industrial tariff levels would even further discourage the location of processing activities requiring electricity input in the rural areas. The competitive situation for processing and therefore employment in rural areas relative to urban areas would be even worse than if the tariff is flat in the rural areas.

Therefore allowing the tariff structure to be less complicated in rural areas and to offer less discount to the residential sector must be considered. Subsidies for these low-income groups should instead be targeted at providing the access to electricity for the population or reducing the overall cost of supplying electricity.

As the present tariffs in rural areas range from high to extremely high (up to 4000 Riels/kWh) setting up new projects including RE would in the longer term always lead to reduced tariffs and be an improvement to the rural households. On the other hand residential customers should not be discriminated against by being charged much higher tariffs than the commercial and industrial customers. A flat rate for all customers is therefore to be preferred.

Figure 1 shows the correlation between tariff rates and installed capacity. Rural tariff variation is very high. This leaves room for a lot of tariff reduction potential by retrofitting, conventional technologies and even RE. The problem is what the benchmark should be for comparing the proposed tariffs in new projects. Should RE projects be favoured by comparing to the highest levels of tariff in rural areas or should they only be compared to the existing tariff in the nearest area where there is existing supply? If tariff rates of above 3000 Riels /kWh are used nearly all possible technologies will be very profitable if the uncertainties regarding collection/payment of bills and technical production conditions are eliminated.



**Figure 1 Tariffs and Installed Capacities (reproduced from Figure 4-3 in Markets, Policies and Institutions ):**

However it is reasonable to expect considerable reduction in the rural tariffs compared to the highest levels. Tariffs above 1500 Riels/ kWh should be ruled out even if the cost calculations of projects seem to back such rates. At levels of 1500 riels/kwh approval of projects should be dependent on including a specified future reduction of tariffs. The efficiency problem about too high rates are that they are creating

incentives to use alternative sources (other fuel, own generators) that again might tend to undermine the project viability by reducing effective demand.

### 3.2 Tariffs in international comparison

As already mentioned the Cambodian tariffs are very high in international comparison. The following **Table 2** shows the large variation among neighbouring countries as well as the high tariffs for Cambodia.

Country	Residential	Commercial	Industry
Brunei Darussalam	2.96 - 14.88	3.03 - 11.91	2.972 - 11.91
Cambodia	8.41 - 15.62	14.41-15.62	11.53 - 14.42
Indonesia	1.50 - 4.11	2.47 - 5.05	1.52 - 3.91
Lao PDR	0.39 - 2.73	3.0 - 3.74	2.52
Malaysia	5.40 - 8.73	2.57 - 10.27	2.57 - 10.27
Myanmar	7.32	7.32	7.32
Philippines	3.29 - 11.20	3.84 - 10.31	3.50 - 11.34
Singapore	9.82	4.71 - 7.64	4.44 - 7.12
Thailand	3.45 - 7.56	2.97 - 7.56	2.97 - 7.21
Vietnam	2.73 - 7.65	3.97 - 13.08	2.65 - 13.08

Source: [www.aseanenergy.org/publication/electricity\\_prices.htm](http://www.aseanenergy.org/publication/electricity_prices.htm)

**Table 2 Regional comparison of electricity tariffs** (Countries 2005 (in US\$))

The tariff comparison does only include the interval for each consumer category. The comparison shows that the Cambodian tariffs are the highest in the region for industry and commercial sectors. For the neighbours Thailand and Laos the corresponding tariffs are considerably lower. For the residential sector the tariff is also above other countries in the region, but it is unclear to which extent as the lower bound of the interval is below the upper bound in a few of the other countries.

The comparison shows that the appropriate tariff to compare against in new projects might just as well be competing imports from neighbours than the existing tariff in Cambodia or even the costs of new hydroprojects within Cambodia.

### 3.3 Generation and PPA tariffs

As a large fraction of the electricity sales in the EDC area (Phnom Penh) is based on IPP generation and PPAs this would constitute an important tariff to compare against in the evaluation of new RE projects that are to supply power to the larger grids either in regional towns or in Phnom Penh. So far no information on the exact tariffs in these PPA are available but they should be used in the EAC evaluation of new generation licensees and possible funding. As these are of relative large size and in the large grid these rates will probably be lower than what is necessary for the RE projects. The possible tariffs to be used by RE projects as the IMW facility in the feasibility studies should be compared to the agreements regarding the new hydro projects as well. Therefore the RE projects should be entitled to at least the rates in the existing PPAs and that should be without deductions for lower availability of the small-scale RE projects.

### **3.4 Tariff structure in Cambodia and incentives for investment in RE in rural areas**

The tariff structure in place involves cross-subsidies favouring low-income urban households as described above. The higher tariffs allowed in rural areas without the restriction of having to cross-subsidise towards low-income households in these areas results in a better incentive structure here.

The high tariff levels in rural areas is an incentive for investors, but on the other hand this is a disincentive in the form of reducing the potential demand from the poor rural households. Therefore it is difficult to establish grids that are efficient in the way of distributing enough electricity to actually finance the grid investment. If totally privately financed the grid and connection costs would not be profitable and the risk is that the project is entirely scaled to match the consumption of the investor himself or a few larger consumers.

Therefore the subsidies would be better allocated to the grid and connection costs than to subsidise the generation investment as the RE projects in many cases are profitable by itself at facilities having some existing electricity demand.

The advantage of having high tariffs on the other hand increases the incentive for efficient generation and for the collection of actual consumption payments. If the subsidy is instead given to reduce generation equipment costs there is less incentive to make the generation and sales as large as possible. A subsidy to the feed-in tariff would relate subsidy to actual output, but no incentives would then be in place to secure that distribution and grid maintenance were working properly. This is just as important for the local residents to benefit as having lower tariffs.

An arrangement with high initially allowed tariffs and a sliding scheme has the additional advantage that the investor has an additional incentive to ensure that grid and distribution operate efficiently from the beginning and that potential consumers have immediate access.

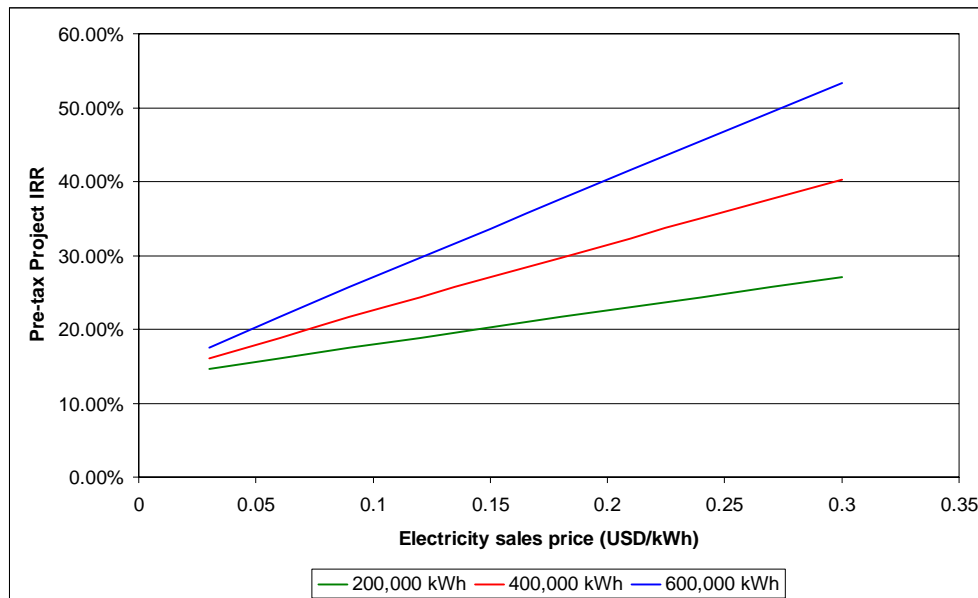
## 4. FEASIBILITY STUDIES AND REVENUE SIMULATIONS

The feasibility studies have identified a number of RE based cases with promising characteristics and with attractive financial results for potential investors. This chapter is examining different assumptions and options regarding tariff levels, structure and output distribution.

For this, two of the feasibility cases have been further explored which include one off grid facility with own consumption and own on grid facility primarily producing for feed-in to a larger grid.

### 4.1 Off grid generation with own consumption

This case is based on the feasibility study of a 200 kW methane-fired power generation plant and explores further the volume of sales to the mini-grid and assumptions on the end-user tariff.



**Figure 2 Feasibility study 200 kW methane-fired power generation plant**

Figure 2 reflects the base case for the assumptions and only shows sensitivity to price and volume of electricity sales. This shows that the project profitability is robust against much lower sales prices and also lower sales volume. For the high volume case which is the base case the sensitivity to electricity price for the entire project is relatively high, but the project would be profitable even without the electricity sales at all. In this case the fuel savings associated with own electricity production and consumption is substantial enough to secure profitability.

The investment in the mini grid and the expansion from 100 kW to 200kW will in this case have to be weighed against the chance of having either the CER revenues or the electricity sales revenue.

### 4.2 Off grid generation and a sliding tariff

Another option than just reducing the allowed maximum end-user tariff to 0.15 USD/kWh is to approve a sliding tariff as mentioned as an option in the sections above. To illustrate this point, a sliding tariff starting

from the 0.3 USD/kWh used as the base case in this feasibility study and reduced by 5% annually.

This would result in a much more favourable profitability response to the lower prices. The IRR is only reduced around 5% points in the base case for sale of 400,000 kWh even though the price after 15 years drop as low as 0.07 USD kWh. For a more realistic reduction from 0.30 to 0.15 USD/kWh the effect is barely seen. This is partly a result of the high discount rates used in the calculation that gives much less weight to the revenue generated 15 years from the investment. High initial tariffs could thus help finance the investment and at the same time a gradual improvement for households is given in reducing their electricity bill or allowing them to increase their consumption. The effect to the IRR of requiring a constant price of 0.15 USD/kWh would be to reduce IRR from 53% to 33% much more drastic than with the sliding tariff.

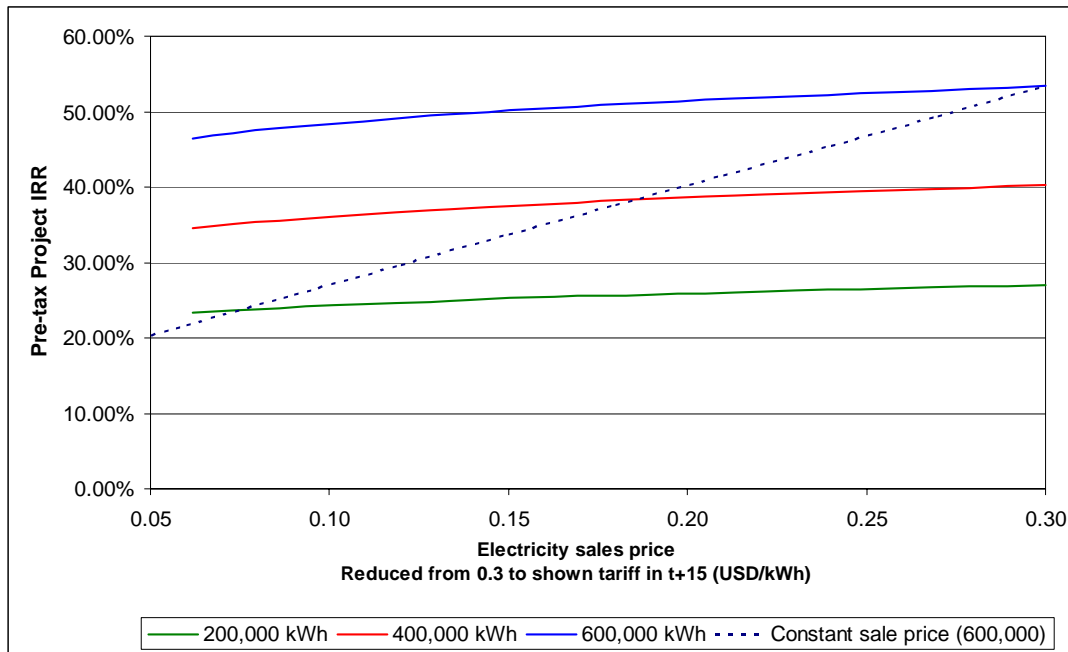


Figure 3 Using a sliding scale for electricity sales prices

The idea of using a sliding scale for the allowed electricity sales price includes important incentive and financing properties. First the project IRR is not very much affected if it is only in the longer term that the lower prices will be effective compared to restricting the sales prices at lower level already at the initiation point. In this way, the objective of more equal price setting between rural and urban areas in the longer term can be achieved, without compromising the profitability of the project. With the high estimate for sales the IRR will only be reduced from 53.4% to 50.1% with a reduction of the sales tariff off 50% to 0.15 USD per kWh. The advantage is based on the private high discount rate and the high initial allowed sales price would benefit the project. Also the incentives for having an efficient construction and implementation phase to exploit the high initial allowed sales price is important. The prospect of falling electricity prices will also allow households and small-scale businesses to plan for future activities based on utilising electrical equipment.

However it is quite unrealistic that the price changes should not influence the sales volumes – just as the sensitivity figures giving IRR as a function of sales and sales prices exclude the effect of prices on volume.

The high initial price could alternatively be justified by allowing to finance the mini-grid and connection of households.

### 4.3 On grid generation example

Buy back rates, small IPPs and renewables are important issues to address and can be crucial to the investment decisions of relatively small consumers that would engage in small-scale generation mainly

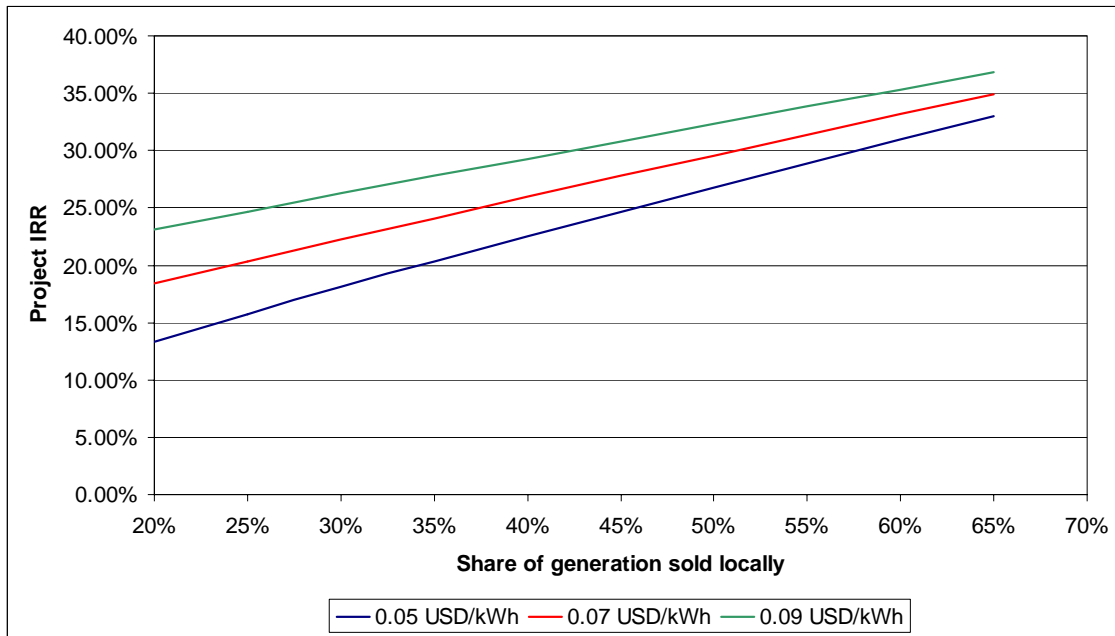


with the purpose of securing their affordable electricity consumption but with a high degree of variation in their load or production.

One option that would favour such small renewable producers is the principle of exchanging power at equal rates with a large distributor on a larger grid. That is the power production from the small plant is paid the same, whatever the time of use and supply pattern for this customer is. Net metering would be one option but this could be combined with restrictions on the duration and timing of the net flows to result in equal pricing.

The larger the production to demand of this customer and the more production is out of phase with demand the more problematic will this equal pricing principle be. For small generators on large grid with flexible resources as hydropower this is a possible option without harming the entire grid and generation system.

Based on the feasibility study of a 1MW husk fired facility some additional sensitivity assumptions can be carried out to illustrate the different tariff assumptions regarding this buy back tariff or in this case more like a feed-in tariff. In this case, that is, adding a new rice husk fired facility it is important to address the potential of allowing supply to the area at tariffs different from the EDC tariffs even though the cogeneration facility is connected to the EDC grid. An agreement with EDC to take all excess production from the plant at low tariffs e.g. 7 US cent/kWh, could be combined with allowing the supply in the local area at tariffs as high as 20 US cent/kWh at end user level. This is at the low end of the assumptions in the case study above. It is assumed that this is attractive to consumers in the local area relative to existing alternatives, but this involves discriminating relative to the residential customers on the EDC grid.

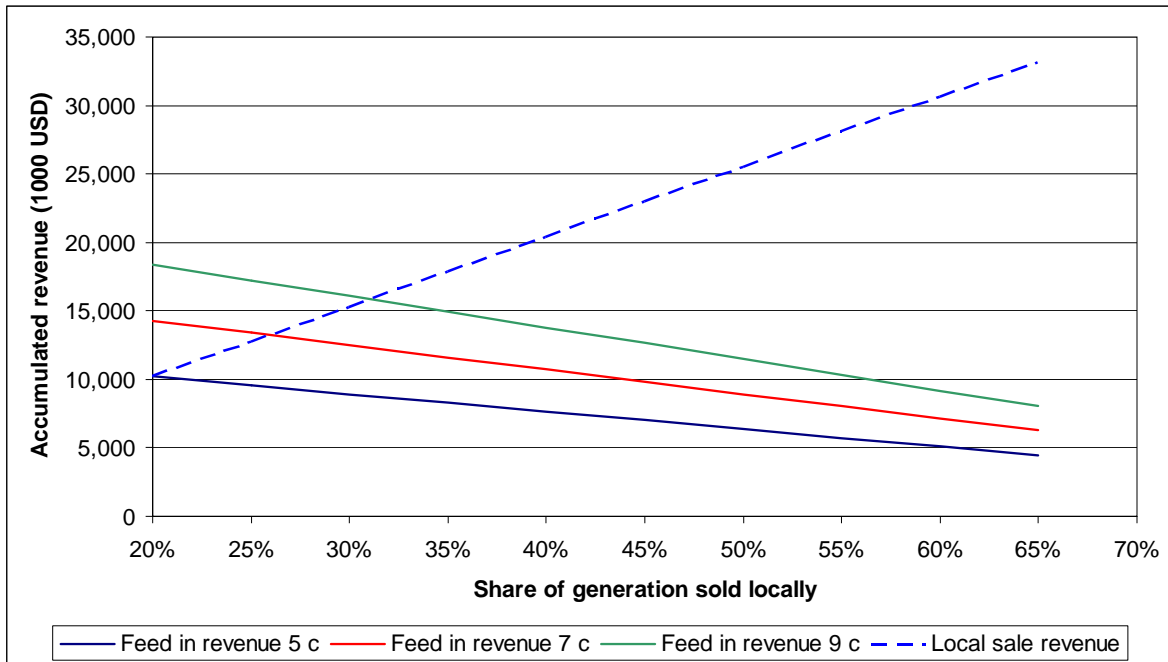


**Figure 4 Sensitivity of varying local sale share of generation at 20 US cent/kWh to end users and feed in tariff to EDC at lower price levels**

This assumption is addressed by the sensitivity analysis assuming that a price of 20 US cent/kWh sold to customers on a local grid can be approved. It is assumed that this involves no additional cost to grid investments. The share of the fixed annual generation assumed to be sold to local customers is then varied between 20% and 65%. At the same time prices obtained from selling the excess production to the overall grid is varied from 5-9 US cent/kWh giving the three lines in Figure 4.

The profitability as measured by the IRR is quite sensitive to this price assumption if the majority of generation is to be fed to the large grid. If it is only the excess production for example 50% that is fed to

the large grid then the sensitivity becomes smaller and IRR is only reduced around 6% points by reducing the feed-in tariff from 0.09 USD/kWh to 0.05 USD/kWh.



**Figure 5 Revenue simulation with local sales**

In Figure 5 the revenue from sales at the two different markets are given under the same assumptions as above. The figure shows that with the high tariff of 0.20 USD/kWh allowed as the end-user tariff this part would be the major source of revenue already with a 35% share of electricity sale even if the feed-in tariff is 0.09 USD/kWh. The total is the sum of the dotted line and the three coloured lines. Local tariff is assumed to be unaffected by the different feed-in tariff levels.

## 5. OTHER FISCAL AND FINANCIAL MEASURES TO PROMOTE RURAL RE AND THE IMPLICATIONS FOR FEASIBILITY STUDIES

The previous chapter examined different changes in assumptions regarding end-user sales tariffs, volumes and feed-in tariffs. In the report “Markets, Policies and Institutions” a number of other incentives and policies were examined. Subsidies were discussed in relation to tariff subsidies and alternatives but there are broader fiscal and financial measures not touched upon above.

Some broad categories are:

### **Investment incentives and subsidies**

- Tax holidays and tax exemption
- Favourable depreciation allowance
- Import duties reduction for RE equipment
- Long term exclusive distribution license with favourable approved tariffs
- Investment subsidies for RE projects – grant for minigrid investment or part of generation equipment
- Soft loans or state guaranteed loans to overcome high financing costs
- Reducing costs of obtaining a license (license fee and professional assistance)

Starting with the tax holiday/exemptions these are not very efficient for RE projects because these projects often have a cash flow profile generating only the profit in the longer term. The depreciation of the large initial investment will postpone the time that a taxable profit is earned and therefore the tax holiday should be very long to be an effective incentive.

Import duties exemption in the RE equipment could be given as this is productive infrastructure investment that at the same time is saving foreign currencies by reducing imports in the form of fossil fuels (diesel, fuel oil, etc.).

The conditions regarding the license can be very important for RE projects as they are generally dependent on a long project cycle and therefore exposed to long term revenue uncertainty. So both high tariff allowed and some exclusive rights to distribution within an area can reduce uncertainty remarkably, but at the costs of increasing competition and reducing tariffs.

### **Production and input subsidies**

- Feed-in tariffs above conventional generation costs
- Output-based subsidy
- Subsidies targeting the input use – labour costs – biomass costs

Feed-in tariffs can be an effective way of promoting RE but this is only targeting the effectiveness of production. If the distribution is just as important as will often be the case with rural electrification, more end-user oriented incentives can prove more effective. Feed-in tariffs are mostly used uniformly so that one technology is given the same subsidy independent of the location. This is not appropriate for Cambodia and the rural electrification where exploitation of local resources are much more valuable where it will generate and replace non-existent or very expensive generation. However, it is generally advisable to secure that connection can be established at low costs if the RE facility is located close to the main

grid and that a fixed feed-in tariff is in place. It is not necessary to have time dependent feed-in tariffs unless the generation share from RE becomes quite high in the main grid.

Subsidising output can also be implemented in local grid with fluctuating demand. Here not the output, but the demand determines the subsidy even though the subsidy is paid to the generator. Other ways of subsidising output can be subsidisation of output at peak hours based on availability performance. Additional to this some premiums can be given for reaching some local target for generation efficiency etc.

In case of uncertainty regarding the biomass resource intended for use in generation, there is the additional option of subsidising the collection and purchase of this resource. The advantage is that it might secure an unreliable biomass resource and it might create local employment and income as well.