China-Ghana renewable energy technology transfer financing

（task-2）

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Preface

The environmental problems of world highlighted in the energy consumption structure, a large proportion of fossil fuels, carbon dioxide emissions growth to accelerate, causing global warming. Therefore, the development and utilization of renewable energy sources has become a protected environment, reduce greenhouse gases, an important measure to address climate change. Renewable energy is one that can be recycled in nature, and can continue to make use of primary energy. Currently popular renewable energy sources are solar (solar thermal, solar light use), hydro (small hydropower station construction), wind energy (onshore wind, offshore wind), biomass (biogas, solid fuel), geothermal energy (power generation and heat using two ways), ocean energy (tidal energy, thermal energy and salinity gradient energy) and the like.

With the signing of "the United Nations Framework Convention on Climate Change", the global international cooperation on renewable energy technologies is also increasing. China and African countries has always been a good basis for cooperation, participation in the infrastructure in many African countries, in order to promote economic development in Africa has made tremendous contributions. At the same time, Africa tremendous amount of renewable energy resources to help Africa's development of renewable energy technologies, not only to promote the African countries out of poverty, economic development and construction, but also help solve the problem of global climate change. China in recent years, increased investment in new energy and renewable energy technology is developing rapidly, the development and utilization technology of solar, wind, hydro, tidal, biomass and geothermal energy has greatly increased number of technical leading position. Development cooperation between China and African countries, renewable energy, primarily through the transfer of renewable energy technologies, so that African countries can have the right to use technology to create local jobs, increase economic output.

However, in the transfer of renewable energy technology cooperation, there are many restrictions subjective, including lack of information, lack of financing, industrial policy support weak. Since renewable energy projects with a long period, a large initial investment, high risk, the effect of slow characteristics, making financing has become the main obstacle to the development of renewable energy.

1. Detailed cost items

1.1 Cost analysis of renewable energy technology transfer

Cost of the project is expected to be able to understand the competitive analysis of the project, will help governments, policy makers, private investors and public utilities to make renewable energy development a wise decision. Cost analysis including cost and performance improvements of change predict the future, so that the government could be the possible development of renewable energy future, in formulating its policies.

At present analysis focuses on the cost of equipment, the total installed cost and renewable energy generation weights levelized cost of electricity (balancing electricity costs). Wherein the equalizer generation cost analysis requires additional data or other assumptions, including economic life, capital cost and efficiency impact of technology and operation and maintenance.

Capital operating costs of renewable energy projects is determined by the market, government policies and technological maturity determined factors. Cheap loans, manage costs and stable economic policies tend to reduce project costs. But in fact, due to the cost of debt required return on equity and debt to equity ratio and other financial reasons, the actual cost of individual country programs remains high.

The key factor in determining the cost of capital is the risk. The risks (such as sales of electricity arrears, currency risk, inflation risk or political risk of a few countries) also makes the project requires a higher rate of return. The risk of each project and not the same, the survey showed that 7% of respondents believe that the profitability of the project is the biggest obstacle to the project, only 12% said no major obstacle; 13% of respondents believe that funding project is the biggest obstacle, along with 12 percent higher than the difficulty of looking for equity investment. Another 12 percent of respondents to seek higher credibility PPA (PPA) as the biggest obstacle to the successful bidder. Therefore, lower equipment costs, a clear government policies and strong regulatory you can minimize the potential risks of renewable energy power generation projects.

In developing countries, the project development cost is relatively high, one of the major problems is that of project development for developing countries. For example, a reasonable operating cost of capital projects in Africa is 15% -20% more than in the OECD countries, the average cost of funds for renewable energy projects up 6% and 12%. Reduce these costs will be greatly enhanced by the African Development profitable renewable energy projects, which would release huge untapped potential of renewable energy in developing countries. And renewable energy projects to meet growing electricity demand of African countries. And onshore wind power, the installation cost of solar energy and hydropower technologies technology has

continued to drop, reducing the renewable energy projects. Biomass, geothermal and hydropower has a mature technology, there are a lot of resources available for Africa's untapped, and can provide lower-cost electricity.

1.2 The cost of renewable energy productions

Renewable energy products are mainly introduced here that some products can be used directly.For example, solar lights, solar water heater, solar oven, wind + solarstreet lamps, etc.Then it mainly includes the cost of the product:the cost of production, transportation cost, customs duties,management andsalesexpenses, installation expenses,etc.

Now such as a solar street lamp that composed of 30w LED light source,the solar panels for 90 wp,80 ah battery and 6m height of light pole.The factory cost price is between $234.61 and $372.24;Due to the port and hub in different selection,single lamp the shipping cost are around$ 45.9 to $64.4, the charges of the port is about $7.27 for one piece;According to the tax policy of Ghana, do not charge for solar photovoltaic products import and export tariff and value-added tax,but 30% of the comprehensive tax must be paid,so the cost of unit piecesolar street light in the range of $374.14 to $577.08 in Ghana. So for Ghana's renewable energy product cost is the sumtotal of Chinese production costs, transportation costs, tariffs.

1.3 The cost of renewable energy projects

For evaluation of renewable energy project cost, generally adopt a balanced power generation costs (LOCE) is a renewable energy project unit cost of power generation.Renewable energy project investment cost includes two aspects:One is thecost of project construction (C_c);the other is Operation and maintenance (O&M) costs of the project(C_s).From the perspective of the cost per unit, unit capacity cost (C_p). This could be defined as function (1).

$$c_p = \frac{C_c}{P_r} = \frac{P_e + E_i + C_d + E_n}{P_r} \tag{1}$$

Where $P_e$isspecific project purchase cost of the equipment(the price reaches the installation site) ,$E_i$is the cost of civil work,C_d is installation costs, $E_n$is the cost of grid connection,and P_r is installed capacity.

If you don't consider the time value of the project investment, regardless of the tax, the unit can be If you don't consider the time value of the project investment, regardless of the tax, the unit cost can be estimated using the following equation(2):

$$c_q = \frac{C_c}{n8760U_eP_r} \tag{2}$$

Where $U_e$is the capacity coefficient of electric field,in a general way use the ratio of actual output power $P_a$and the rated power$P_r$to define.

In the process of project operation, operation and maintenance is necessary ,of course can produce O&Mcosts (C_s).And in renewable energy projects completed and put into operation, its operation maintenance cost is relatively stable(C_i),So the cost of renewable energy projects unit power generation investment can be represented asequation(3):

$$c_i = \frac{C_c + C_s}{n8760U_eP_r} \tag{3}$$

In fact, renewable energy project usually has a long investment horizon (generally 20-40 years).So much so that we cannot ignore the time value,we use equation(4) to estimate the depreciation expense(D_v):

$$D_v = \frac{r(1+r)^n}{(1+r)^n - 1}C_c = \frac{r}{1-(1+r)^{-n}}C_c \tag{4}$$

Where r is discount rate,n is the useful of project lifetime.

If the tax factors was beenignored (usually renewable energy projects taxes are favorable),the LOCE(C_i) could be defined as function (5).

$$c_i = \frac{r}{1-(1+r)^{-n}}\frac{P}{8760kU_e} + \frac{C_s}{n8760U_eP_r} \tag{5}$$

Where P is the installed costs for produce one KW,k is the ratio of specific project purchase cost of the equipment(P_e) and total investment(C_c).

1.3.1 The cost of wind power technology

The main factors affecting the balance cost of electricity (LCOE) of wind power systems are capital costs, financing costs, operation and maintenance (O&M) costs and estimated annual generation capacity.

(1)The installed cost of on-shore

Onshore wind power is currently the lowest cost source of electricity, with $ 0.06 to $ 0.09 / kWh area average balance of the cost of electricity (LCOE). The best wind power projects can always provide $ 0.05 / kWh (not including financial support) of electricity. Due to the improvement of power generation, lower raw material costs, commodity prices and other factors driving the small pressure to reduce costs, but also increased competition in the wind power market. For example the price of China's wind turbine was originally $ 1,036 / kW, experienced a sharp decline in 2007 to $ 628 / kW, in 2011, only to rebound to $ 676 / kW. Compared to the peak of prices, the price of China's wind turbine has fallen by 35%.

The average total installed cost Europe in 2013 was $ 1,710 / kW in 2014 to $ 2,200 / kW. In South America, Chile and Argentina, the average total installed cost an estimated average of $ 2,010 / kW and $ 2,340 / kW. The average installation cost in Brazil is rapidly decreased from 2014's $ 2,650 / kW, is expected by the end of 2015 will fall to $ 1,840 / kW to 2017, it could be as low as $ 1,600 / kW. The average cost in many Asian region remains relatively high. Asian countries, the average cost to install a wind farm of about $ 2,560 / kW. Australia's average cost of $ 2,110 / kW. The average installation cost of the wind farm in Africa is about $ 2,210 / kW.

Compared to 2010, the installation costs for all countries and regions in, in 2011 and 2014 China's average installation cost is lowest in the world, in 2013 an average of $ 1,310 / kW.

In addition to Africa and India, we have experienced a decline in costs. Installation costs of wind farms has been declining, reducing machine costs by wind turbines in the renewable energy market, onshore wind power technology has become more competitive. Other developing countries may get spillover effects of technological development and low-cost turbines from India and China is possible, but it will still depend on the characteristics of the local market and decision-making.

Operation and maintenance (O&M) costs are an important part of a balanced generation costs of wind power (LCOE) of. Operation and maintenance costs typically account for 25% of the total cost of wind power generation system balanced. Since 1980, average annual wind power system operation and maintenance costs have dropped significantly, a full-service contract prices between 2008 and 2013 declined by 36%.An average value of around USD 0.02 to USD 0.03/kWh would appear to be the norm, but more systematic data collection is required to confirm.

According to different project cycle, differentinstalled capacity of wind field, and due to the wind farm installation costs, an average of 2015 years in Africa Ghana dollar lending rate of 10-11%, the average land operation and maintenance costs and average annual power generation time that can be calculatedLOCEaround $0.161/KWh to $0.213/KWh in Ghana.

(2)The installed cost of off-shore

The wind turbine is still the largest offshore wind power project cost composition, but its share is usually 30-50% of the total cost. 2014 in OECD countries on average offshore wind power project installation costs were slightly higher than $ 4,700 / kW cost in China is about $ 2,400 / kW. For O&M cost, due to the offshore wind turbine maintenance, cabling and a higher tower, offshore wind farm operation and maintenance costs higher than onshore wind farms. The harsh marine environment and certain components of the expected high failure rates will increase maintenance costs. Overall, the operation and maintenance costs are expected to be in between 0.027 to 0.054 US dollars / kWh.

The LCOE of offshore wind has risen through time as total installed costs increased with greater distances from shore, increased water depths and increasingly complex projects， However,some reasons as different project cycle, installed capacity of different sea wind field, otherwise Ghana's unique geographical environment and the management policy are all effect on LOCE.the LCOE of recent projects has stabilized in the USD 0.190 to USD 0.305/kWh range for most projects.

1.3.2 Solar PV technology costs

Solar photovoltaic (PV), also known as solar cells, convert sunlight directly into electricity electronic equipment. In 1977, global PV production capacity more than 500 kilowatts. In 2002, the total installed capacity of solar photovoltaic capacity more than 20,000 kilowatts, in 2012, over one million kilowatts. In short, the solar photovoltaic power generation has come of age business solution, the future is even possible to use solar energy from outer space.

Solar photovoltaic power generation is the mainstream, mature technology. However, most mature technology, its costs continue to decline, more and more to attract commercial solar photovoltaic project developers and small-scale residential or commercial customers.

Investment cost of PV system include cost of PV modules and peripheral system cost. PV system costs include the cost of the surrounding structure system, electrical system and soft costs system development. In the case of off-grid applications, if there is a battery or other storage systems, the cost needs to be added.

Reduce the cost of photovoltaic projects of the main reasons for the decline in prices of polysilicon material (45%), followed by other material costs (19%), the module manufacturing (11%) and technological progress (10%), greater economies of scale accounting for all other factors decreased by 16% of the total.

The total installed cost of solar PV systems since 2008, declined rapidly after experiencing exponential growth, the total installed cost of residential systems continued to decline until 2014. From a global point of view, in Germany and China, residential PV systems is the cheapest. The weighted average cost of installation is smaller (1-5 MW) of utility PV systems between 2011 and 2014 declined by 37%, while the weighted more than 5 MW of large-scale PV system installation costs on average decreased by 35%.Range of installation costs in 2011 small-scale utility projects is between $ 3200 and $ 7600 / kW, and the scope of large-scale utility projects is between $ 2,200 and $ 7,050 / kW. By 2014, the project scope smaller utilities has fallen to between $ 1,300 and $ 6,800 / kW, larger projects it has fallen to between $ 1,300 and $ 5,400 / kW. In Africa between 2013 and 2014, the total installed cost of utility projects between $ 1820 to $ 4880 / kW.

As we all know solar power plants can't continuous production.The seasons, day and night, and the meteorological conditionssuch as rain or shine are all effect on generation efficiency.So the PV has a low efficiency,average annual power generation hours 1300 hours.According to the installation costs in Africa, and the years and mortgage rates available at full power, The LCOE of PV projects around $0.176/KWh to $0.387/KWh in Ghana.

1.3.3 Hydropower technology costs

Hydropower technology in a variety of renewable energy technologies, there are many advantages unmatched by other technologies: low-cost hydropower. LCOE large hydropower projects as low as $ 0.02 / kWh; small hydropower projects average LCOE 0.05 / kWh, can provide low-cost electricity to remote communities or grid; Hydropower is a mature technology, there is potential for cost reduction.

It is the most mature, reliable and cost-effective renewable energy generation technology, is today the only large-scale and cost-effective storage technologies. Hydropower projects with design flexibility, can have a variety of sizes and flexible structure based on hydroelectric plants with different characteristics. It’s roughly divided into the following categories: run-of hydropower projects, poor storage capacity designed by seasonal river flows and the decision has now been eliminated. Reservoir (storage) hydroelectric projects, water storage capacity vary, depending on the characteristics of the power grid and dam construction economy. Pumped-storage

hydropower scheme using off-peak electricity, pumping water from a reservoir to a higher reservoir, so that the pumped storage can be used for peak time, provide grid stability and flexibility of services.

The two main components of the cost of hydropower projects: the construction of civil engineering station, including access to the site and any infrastructure required for project development costs; costs associated electrical and mechanical equipment. Project development costs including planning, feasibility assessment, environmental impact analysis, licensing, fish and wildlife/biodiversity biological mitigation measures, developed recreation facilities, historical and archaeological mitigation, water quality monitoring and mitigation. The cost of large-scale hydropower projects mainly in civil works and equipment costs. Therefore, proper siting and design of hydropower projects is a key challenge, and concrete work at the design stage can avoid costly mistakes.

In 2014, the African small-scale hydropower installed cost were between $2500 to $5500/KW, an average cost was about $3750/KW;Because of the difference of the project's location and environment, the installed cost of large-scale had big span .The installed cost werebetween $500 to $6700/KW.And 90% project of installed cost were around $500 to $3500/KW, an average cost was about $1450/KW.The lowest total installed cost in China and India, such as the average installed costof small-scalewas about $1100/KW,and the installed of lager-scale hydropower was about $1000/KW;The highest in Central America and the Caribbean , the average installed cost in the both cases were about $2700/KW and $2900/KW.

Hydropower plants typically have low operations and maintenance (O&M) costs over their lifetimes and large-scale hydropower plants have O&M costs similar to those for wind, but not as low as for solar PV.Annual O&M costs are often quoted as apercentage of the investment cost per kW per year, or as USD/kW/year. Typical values range from 1% to 4%. The International Energy Agency (IEA) assumes 2.2% for large and 2.2% to 3% for smaller hydropowerprojects, with a global average of around 2.5%(IEA, 2010). Other studies (EREC/Greenpeace,2010) indicate that fixed O&M costs represent 4% of the total capital cost. This figure may be appropriate for small-scale hydropower plants but large hydropower plants will have significantly lower values. An average value for O&M costs of 2% to 2.5% is considered the norm for large-scale projects (IPCC, 2011), which is equivalent to average costs of between USD 20 and USD 60/ kW/year for the average project by region in the IRENA Renewable Cost Database.

The LCOE of hydro is very competitive and can provide the cheapest electricity available in the world today. Although the range of estimated costs is wide, the weighted average LCOE of projects is very low, suggesting that the smaller-scale projects with higher LCOE are typically being built because they are the least costly supply solution in remote areas or are providing valuable grid services.In Ghana the LCOE ranged from a low of around USD 0.091/kWh to USD 0.193/kWh forsmall-scale hydropower. However, the LCOE ranged from USD 0.057/kWh to USD 0.125/kWh for lager-scale hydropower.

2. Estimation of financial gap

2.1 Causeof financial gap

Cause of renewable energy generated by the project funding gap for many reasons, summarized through the following areas:

(1) reduction of government funds available

Renewable energy projects having a long period, a large initial investment, high risk, the effect of the characteristics of slow, so many renewable energy projects are supported by the government or public entities. But for most developing countries, governments often cannot afford large items of non-administrative expenses, and because of instability, corruption and bloated political establishment, often leading to the budget deficit. Many expected financial allocations should not be credited to such funding gap, and even lead to disruption of the project.

(2)Outflows of capacity from financial institutions

Partly because of the recession since 2008 is not over, Western financial markets environment is more conservative, the flow of investments in renewable energy projects will continue to be reduced. On the other hand, in the course of the project, due to various reasons, the subsequent investments in financial institutions cannot continue, will lead to a funding gap.

(2) less profitability of the project

In the project operation, the incomes generated is an important part of the project funding, it is not only able to repay the loan, but also to attract more investment, increasing the total amount of funds. If the low profitability of the project itself, or did not reach the expected earnings late will lead to a funding gap.

(3) low usage of capacity

Sometimes investment or loan account has been head of the project, poor cash flow, cycle time is too long, will lead to a funding gap. Typically, funding for renewable energy projects are relatively tight, so the use of funds once the situation it is easy to trigger a series of low budget shortfalls, leading to the final project cannot proceed.

2.2 Estimation of financing gap

Renewable energy project financing consists of government fiscal funds, non-profit organizations to donate, the project itself predictable income. Financial resources which the government is not limited to the government's public utilities or by the relevant departments involved in renewable energy projects, in many cases, most renewable energy projects can get the local government, or even technical outflows of subsidies, which can alleviate some financial pressure. And with the awareness of

environmental protection, a lot of non-profit organizations continue to emerge, many organizations have been able to provide a portion of the donations, generally can apply a certain amount of interest-free or low-interest loans. The project itself is expected to provide significant revenue to give the project financial security, not only can get large loans, and high rates of return can greatly increase the interest investments.

Cost of renewable energy projects are many, including all of the original cost of the investment in human, material and financial resources, machinery and equipment (acquisition cost), plant or infrastructure costs. In addition to the need to repay the loan, which is accompanied by a large part of the project began to run out of funds last independent. In addition, the emergence of various tax items during the operation will bring some capital outflows. Of course, in most cases is governments often formulate policies on tax exemption for renewable energy projects, which can greatly slow down the financial pressure of the project.

To estimate the above two parts, you can get the funding gap of the project, which will help the project promoters to develop more effective financing strategies.

According to the second part of the renewable energy technologies balanced cost estimates, Ghana's renewable energy projects will has certain gap.This is due to the balanced power generation cost of renewable energy technologies (see table 1) is higher than Ghana domestic electricity generated.In 2015, for example, price is to adopt a progressive price mechanism of Ghana, 0-300 KWh, electricity price is $0.16 /KWh.301-600KWh, electricity price is $0.1702 / KWh, 600 KWh and above, the price is $0.2686 / KWh.

Table1:Weighted average LOCE range of different renewable energy technologies

Renewable energy technologies	weighted average LOCE range (USD/KWh)
onshore wind power technology	0.161-0.213
offshore wind power technology	0.190-0.350
Solar PV technology	0.176-0.378
small-scale Hydropower technology	0.091-0.193
larg-scale Hydropower technology	0.057-0.125

The Ghana electricity prices and table 1 shows that wind power technology and solar PV power generation is a gap, recovery of electricity isn't enough to cover the project to continue to operate, even if is the lowest cost of water and electricity technology, there are risks of the funding gap also exists.

3. Comprehensive financial mechanism

Financial mechanisms for renewable energy technology transfer refers to the transfer of renewable energy technologies around the financial institutions and related

financial system. The most important is the financing system.

3.1 Project financing source

The main source of financing for the following three areas: government, such as the establishment of government funds, start renewable energy programs and projects; international and local financial institutions such as China Development Bank, the European Investment Bank, the US Agency for International Development and the World Bank Group and so on; other international bodies, such as the GEF, UNDP, UNEP partners and funds.

Currently, developing countries cope with renewable energy technology transfer funding comes mainly from the CDM carbon market financing, foreign direct investment (FDI), the national government finance, private investment, based on the Convention of public funds, including FDI, National Finance and the gradual rise unlimited potential of the private investment has become the main source of funding for renewable energy technology transfer.

3.2 Project finance construction Suggestions

Because of Ghana's ability the lack of government investment, loans, and private enterprise capital with high quality and convenient channel, give the following four Suggestions:

(1)PPP mode

Recommend the PPP mode of investment in financing, the PPP mode is Public-Private-Partnership acronym, is refers to between the government and Private organizations, in order to build urban infrastructure projects.Its advantages are: one side, the government and the social main body to build "benefit-sharing, risk-sharing and full cooperation" of the community relations, the government's financial burden, the social main body of investment risk reduction;the other side, the private capital is more involved in the project, in order to improve the efficiency and reduce risk.

(2)Cooperate with local private enterprises

African local private capital usually has a high quality of capital, the ability of the project is higher, in business communication, etc.And to understand more fully in the local policy, to project management and operation experience, the most important thing is that have a fixed users and sales channels, this is what investment of Chinese enterprises in Africa does not have the advantage.Due to the participation of local private enterprises at the same time, greatly reduce the risk of the project.

(3)The multilateral cooperation mode

Seek multilateral cooperation, with the various departments and agencies can provide funds for cooperation, to achieve the goal of share risks.Such as cooperation with local investment institutions, local Banks have money stored fat, such as high risk preference, loan interest rates moderate, sufficient to ensure the project funds;Power developers, cooperation with Europe and the United States, Europe and the United

States of electric power investment in Africa experienced developers, have the technology, also can get the trust of the local residents, but the disadvantage is that money ability is not strong.In addition, can also with the African development bank, the worldbank and other financial institutions.

(4)ABS model

ABS is asset-backed securitization.It was based on the project assets can bring the expected return of the guarantee, improve credit rating by a set of plans to issue bonds to raise funds in capital market mode of project financing.With high credit ratings, diversification and diversity, and predictable cash flow and the advantages of small investment risk.

3.3 Renewable energy products sales mechanism

All above was discussed financing scale use of renewable energy technology. Here we introduce in house hold renewable energy technologies, including efficient boiler, and household biogas and solar lights etc. However, the application of renewable energy products is slowly. Through the investigation and study, in the promotion of renewable energy technology generally exist the following problems: some renewable energy product price is more expensive, and the farmers' ability to pay is low; the user of the product durability, reliability, security skeptical; Users worry about new product after-sales service.

To solve the above problems, the first thing to solve the problem of potential user lack of money, the second problem is honesty and product after-sales service. Adopt the method of lease is solving the problem of lack of money, the good faith and after-sales service, a new method of the most effective. Lease refers to periodically or a periodically to exclusive possession of property contract. The side of the leased property is the less or, a party to the leased property to the lessee.

Used leasing way to promote renewable energy technology has the following positive roles.

(1) Solve the problem of user lack of money: due to lease the first payment is only about 30% of the cost of machinery or equipment, you can gain the right to the use of machinery or equipment, the user's one-time investment is not big, enables the more users will be able to withstand. Therefore, the use of leasing way is easier to spread to more users, renewable energy technology accelerate the process of renewable energy technologies.

(2) Reduce the risk of users: in the leasing activity, in order to protect the interests of their own, to participate in the activities of leasing transactions between the parties to sign the contract, both in the term of validity of a contract shall not be entitled to cancel the contract unilaterally. During the lease term, the user is always with the leasing company (or manufacturer, or distributor) is tied by the contract. In conclude when mechanical equipment leasing contract, most of the terms and conditions at the time of the conclusion of the contract are a sure, during the lease period, the user does not have to worry about the risks of currency devaluation; Leasing company in order to obtain higher profit and social reputation, have to bear the equipment installation and debugging, technical guidance and after-sales service, the responsibility of the user does not have to worry about mechanical equipment maintenance.

Solar water heaters, gas stoves, renewable energy products such as straw gasifier can

adopt the mode of hire purchase leasing.