Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

TECHNOLOGY TRANSFER PROJECTS AND INSTITUTIONAL DEVELOPMENT IN DEVELOPING STATES: SUCCESS OR FAILURE OF SOLAR HOME SYSTEMS IN RURAL AFRICA

1. Introduction

International environmental law documents call for technology and knowledge transfer from developed States to developing States as one of the measures to mitigate climate change. There are endless possibilities for different technology transfer projects, from building and setting up wind energy centrals to enabling rural electrification with the use of solar power. However, the projects established under these measures all focus extensively on the amount of greenhouse gas emissions reduced. It is obvious that a technology transfer project based on acquiring energy from solar power will be unsuccessful in a developing State where there is little sun. Since the reduction of emissions will be marginal. Nonetheless, it is generally far less clear that such a project might be equally unsuccessful in a developing State where there is an abundance of sun all year round and the greenhouse gas emission reductions from the project would be extensive.

This research paper demonstrates that while the amount of greenhouse gas emissions reduced is the basic element for approval of a project, the success of a project in a developing State lies in the project's conformity with the institutional system in that State. The findings are based on a comparative research of two different models of solar home systems [hereafter SHS] in rural areas of two African States with different institutional development. In part 2 and

3, the research paper illustrates the importance of SHS for the development of rural areas of Africa and presents the two different models of SHS through 5 variables. These are: consumer costs, financing, ownership of materials, operation and maintenance, and reliability. In part 4, the research paper presents the background behind the development of the two different user models of SHS, “fee-for-service model” and “market model”. In part 5, the research paper presents a discussion of the dependence of the SHS user models on the institutional framework in developing States.

2. Importance of electrification for development

Electrification has often been promoted as one of the backbones of economic development in Africa. Namely, electrification brings many benefits to the population of developing States. These benefits include longer operating hours of schools, hospitals and businesses; use of water pumps and irrigation systems; access to information technologies, like radio or TV; operation of small-scale workshops and other commercial establishments; as well as the ability for the villagers, especially women, to work in the evenings and gain some extra income from the trade of homemade products; just to name a few.

Unfortunately, these benefits are reserved for only a small percentage of the population in Africa. This is the population in the urban areas, where the access to electricity is inexpensive. On the contrary, the situation in the rural areas of Africa is quite the opposite. It is estimated

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

that more than 60 per cent of the African population lack access to electricity.[1] The majority of this 60 per cent of the African population live in the rural areas, where the extension of a conventional electricity grid is financially unviable.[2] This is partly attributable to the specific characteristics of these rural areas. These are: large geographical distances from the urban areas, low population density, low levels of economic development, low financial ability and low levels of skills of the population.[3]

Therefore, several insular sources of electricity have been promoted, from solar home systems to wind power, to fuel generators and different hybrids of these. From the literature on rural electrification, the SHS seem to be preferred over the other insular sources of electricity.[4] Today more than 600,000 solar home systems have been installed in the developing world.[5] Wind power can be used only in areas with sufficient wind consistency. The fuel generators have to be regularly filled with fuel and the fuel stations are usually far away from the small rural African villages. Thus, the costs of the fuel transportation are high, as well as

[1] N. Wamukonya, "Solar home system electrification as a viable technology option for Africa's development" (2007) 35 Energy Policy 6 at 6; S. Karakezi and W. Kithyoma, "Renewable Energy Strategies for Rural Africa: Is a PV-led Renewable Energy Strategy the Right Approach for Providing Modern Energy to the Rural Poor of Sub-Saharan Africa?" (2002) 30 Energy Policy 1071 at 1071.

[2] *Ibid*.

[3] R. Westerveld and C. F. Maitland, "Technical and Policy Advances in Rural Telecommunications" (2002) The Southern African Journal of Information and Telecommunication, Issue 3 at 1; C. M. Haanyika, "Rural Electrification in Zambia: A Policy and Institutional Analysis" (2008) 36 Energy Policy 1044 at 1045.

[4] Wamukonya, *supra* note 1 at 8; E. Martinot, A. Cabraal and S. Mathur, "World Bank /GEF solar home system projects: experiences and lessons learned 1993 – 2000" (2001) 5 Renewable and Sustainable Energy Reviews 39 at 40; M. Hankins, "A Case Study on Private Provision of Photovoltaic Systems in Kenya", Chapter 11, in: Energy and Development Report 2000: Energy Service for the World's Poor, Published by the Energy Unit of the World Bank's Infrastructure Group and Energy Sector Management Assistance Program (ESMAP) (2000) at 93.

[5] Hankins, *supra* note 4 at 93.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

there are several difficulties in accessing spare parts and technical support.[6] For example, a study in Kenya found that a household saves around US$10 monthly from kerosene, battery charging at generation stations and trips to these remote locations, by using an SHS.[7]

SHS are also advertised to be one of the cleanest electricity generators. Namely, in the production of electricity from the solar power no greenhouse gases are emitted. However, the level of emission reductions from SHS is relatively small.[8] The amount of electricity generated from the SHS is limited. Therefore, the use of SHS replaces only a small amount of greenhouse gas emitting sources of electricity, like kerosene lights or lead-acid batteries.[9] Moreover, the study in Ghana demonstrated that the high energy use in the production of the SHS makes it a less potential greenhouse gas mitigation option.[10] Nevertheless, though these small decreases in emissions, the SHS are an important addition to improving the health of the rural population. The particle emissions from kerosene and other biofuels used in the household for cooking, lighting and warming are the source of acute respiratory infections among the rural population, especially women and children.[11] While the SHS has yet no impact on cooking, where biofuels still continue to be the main source of energy,[12] the use of SHS for lightning can still alleviate such health problems.

---

[6] Wamukonya, *supra* note 1 at 8.
[7] R.J. van der Plas and M. Hankins, "Solar Electricity in Africa: A Reality" (1998) 26 Energy Policy 295 at 299; Hankins, *supra* note 4 at 96.
[8] Wamukonya, *supra* note 1 at 9.
[9] *Ibid*.
[10] Nässen, Evertsson and Andersson, *supra* note 27 at 509.
[11] Karakezi and Kithyoma, *supra* note 1 at 1074.
[12] *Ibid*. at 1075.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

As SHS are environmentally the most viable option for electricity production in rural areas, they are the object of several technology transfer projects. Namely, climate change mitigation in the developing States can be achieved only with means that alleviate poverty and improve the quality of living.[13] Both the United Nations Framework Convention on Climate Change [hereafter UNFCCC][14] and the Kyoto Protocol to the United Nations Framework Convention on Climate Change [hereafter Kyoto Protocol][15] present commitments of the developed States to facilitate technology transfer to developing countries. Technology transfer can be defined as transfer of systematic knowledge from abroad for the manufacture of a product, for the application of a process, or for the rendering of a service.[16] Both Article 4.5 of the UNFCCC and Article 10 of the Kyoto Protocol urge developed States parties to the convention, to take all steps to promote, facilitate and finance the transfer of or access to environmentally sound technologies and know-how.

[13] Wanna Tanunchaiwatana, "Climate Change and Technology Transfer" (1998) 4 Linkages Journal, Vol. 3, 1 at 1.
[14] United Nations Framework Convention on Climate Change (1992) 1771 U.N.T.S 107.
[15] Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997) 2303 U.N.T.S. 148.
[16] A. Dechezlepretre, M. Glachant and Y. Meniere, "Technology transfer by CDM projects: A comparison of Brazil, China, India and Mexico" (2009) 37 Energy Policy 703 at 704; "Climate Change, Technology Transfer and Intellectual Property Rights" published by the International Centre for Trade and Sustainable Development (ICTSD) at 2-3.

3. The different models of SHS in rural Africa

A SHS is constructed of a solar photovoltaic panel/module, a battery and a regulator that controls the charging and the discharging of the battery.[17] Only so much electricity can be used daily as it can be stored in the batteries. Thus, the use of electricity from a SHS is limited. A typical SHS can provide enough electricity only for a limited time of lightning (2 to 3 hours) and the operation of radio or TV (1 to 2 hours).[18] Most of the electricity in rural African areas is used for listening to the radio, watching TV or charging cell phones and less for lightning.[19] Though the limited amount of electricity produced may seem as a disadvantage, this is exactly the reason why the SHS has been widely promoted for the electrification of rural Africa. It is believed throughout the literature that the demand for electricity of rural population is low and does not exceed the mentioned limitations.[20]

In Africa there are currently two different user models of SHS established. Under the first user model, SHS are provided by a local Energy Service Company [hereafter ESCO].[21] This paper refers to these, as the "fee-for-service SHS". The "fee-for-service SHS" are owned by a local

[17] M. Gustavsson, "With time comes increased loads – An analysis of solar home system use in Lundazi, Zambia" (2007) 32 Renewable Energy 796 at 797; A. B. Sebitosi, P. Pillay and M. A. Khan, "An Analysis of Off-Grid Electrical Systems in rural Sub-Saharan Africa" (2006) 47 Energy Conversion and Management 1113 at 1114.

[18] Gustavsson, *supra* note 17 at 797; Wamukonya, *supra* note 1 at 8; I. Madamombe, "Solar Power: Cheap Energy Source for Africa" (2006) Africa Renewal Vol. 30, No. 3, 10 at 11.

[19] Also in areas where there is no TV signal, the electricity is mostly used for watching videos and listening to cassettes. M. Gustavsson and A. Ellegård, "The Impact of Solar Home Systems on Rural Livelihoods. Experiences from Nyimba Energy Service Company in Zambia" (2004) 29 Renewable Energy 1059 at 1062; A. Jacobson, "Connective Power: Solar Electrification and Social Change in Kenya" (2007) World Development, Vol. 35, No. 1, 144 at 153-157; F. D. J. Nieuwenhout, A. van Dijk, P. E. Lasschuit, G. van Roekel, V. A. P. van Dijk, D. Hirsch, H. Arriaza, M. Hankins, B. D. Sharma and H. Wade, "Experience with Solar Home Systems in Developing Countries: A Review" (2001) 9 Prog. Photovolt: Re. Appl. 455 at 462.

[20] Wamukonya, *supra* note 1 at 8; Karakezi and Kithyoma, *supra* note 1 at 1073.

[21] F. van der Vleuten, N. Stam and R. van der Plas, "Putting Solar Home System Programmes Into Perspective: What Lessons are Relevant?" (2007) 35 Energy Policy 1439 at 1440.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

stakeholder that provides the SHS to the user and maintains it in exchange for an installation fee and monthly consumption fees.[22] For example, such a model is in operation in Lundazi, Zambia. It is operated by the local energy service company Lundazi Energy Service Company, which is operating 152 SHS.[23] Under the second user model, the SHS is bought by the user on the market under commercial terms.[24] The paper refers to all these as "market SHS". Under this market model, the user has start-up expenses with the initial purchase of the system and with technical support, such as installation, maintenance, repairs and renewal of batteries.[25] The user does not have to pay a monthly fee for the produced electricity. Such a model is in operation in Kenya, which is also considered to be the most developed SHS market in Africa.[26] Both of these user models have advantages and disadvantages over each other. These are presented in the following paragraphs.

3.1. Consumer costs of electricity

Costs differ among different user models of SHS. Under the "market SHS", the user bears the initial costs with the purchase of the system and when the battery has to be replaced. On the contrary, in the "fee-for-service SHS" model, the user pays the installation fee and monthly consumption fees. This cost is equal to the conventional grid electricity, which is paid for also in monthly fees (in kilo watt hours (kWh)) according to the amount used. To compare the costs of these, the price of the electricity provided by the "market SHS" has to be calculated in kWh.

---

[22] Gustavsson, *supra* note 17 at 798.
[23] *Ibid*. at 799.
[24] Vleuten, Stam and Plas, *supra* note 21 at 1440.
[25] *Ibid*.
[26] Such a system is also in operation in Morocco and Zimbabwe. *Ibid*.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

This is done by calculating all the costs of the SHS in its life-cycle and the life cycle of the SHS, which is approximately 25 years.[27] Using this method it has been estimated that the direct consumer costs of the electricity generated by the "market SHS" in Africa is between US$1.7 to US$2.88 per kWh.[28] The consumer costs of the "fee-for-service SHS" electricity in Zambia, for example, are above US$1 per kWh with the installation fee of US$3.[29] This represents 363.63 per cent per GNP per capita in Zambia.[30] In Kenya, the consumer costs of "market SHS" are at 177.14 per cent per GNP per capita.[31]

To put this in perspective, these are the costs of the conventional grid electricity. The tariff of electricity generated by the conventional grid system and paid by the user is as low as between US$0.03 to US$0.10 per kWh.[32] The installation fee is however higher for the conventional grid and the waiting time for installation is much longer.[33] In Ghana the installation fee for a rural village user would be around US$377.[34] These fees are normally this high because of the great lengths the grid lines have to be laid.[35] These high initial investment costs are also the reason why electricity providers are not attracted to extend the conventional grid to rural African areas.[36]

---

[27] J. Nässen, J. Evertsson and B. A. Andersson, "Distributed Power Generation versus Grid Extension:An Assessment of Solar Photovoltaics for Rural Electrification in Northern Ghana" (2002) 10 Prog. Photovolt: Res. Appl. 495 at 501.
[28] Wamukonya, *supra* note 1 at 8.
[29] Gustavsson, *supra* note 17 at 800.
[30] Karakezi and Kithyoma, *supra* note 1 at 1075.
[31] *Ibid*.
[32] Wamukonya, *supra* note 1 at 8.
[33] Gustavsson, *supra* note 17 at 799-800.
[34] Nässen, Evertsson and Andersson, *supra* note 27 at 503.
[35] *Ibid*. at 507; Haanyika, *supra* note 3 at 1045.
[36] Vleuten, Stam and Plas, *supra* note 21 at 1445.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

The above data demonstrates several significant differences between the two SHS models and conventional grid electricity. Though the rates of electricity in kWh provided by the SHS might be high and most of the poor rural households cannot afford them,[37] this option is in general still less costly than extending the conventional electricity grid. In countries with the "market SHS" model, financial solutions, like micro-loans or other specific credits for solar power, have been developed.[38] This divides the payment for the system into small monthly or weekly instalments. In countries with the "fee-for-service SHS" user model, the fee for electricity is paid monthly similar to the conventional grid electricity. However, the above facts show that the installation fees are much lower for the "fee-for-service SHS" than for the conventional grid electricity. This makes also the "fee-for-service SHS" model more affordable for the rural population than an extension of the conventional grid. The literature provides no information whether any micro-loans are available to ease out the costs of the installation fees for the extension of the conventional grid. Moreover, most of the SHS models in Africa are partly financed by foreign donors or state subsidies, which can significantly reduce the costs the users have to pay.[39]

3.2. Financing

As there are two different SHS user models, there are also two approaches to how the SHS are financed. Most of the SHS in Africa are financed through various development projects by foreign governments, international organizations, NGOs and foreign donors mostly as a

[37] Karakezi and Kithyoma, *supra* note 1 at 1076, 1082.
[38] See part 3.2. at 15.
[39] Karakezi and Kithyoma, *supra* note 1 at 1082.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

technology transfer measure.[40] However, only around 15 per cent of all the costs of a SHS project are paid for by the foreign donors.[41] The rest is funded by the recipient State.[42] In his paper Wamukonya presents a financial study of 8 projects financed by Global Environment Facility [hereafter GEF] in Africa. Out of the total cost of US$103.8 million for these projects, the grants of GEF amounted to only US$23.8 million (23 per cent).[43] The rest was financed by the recipient States.

The foreign funding for the "fee-for-service SHS" user model is provided in the form of capital investments and favourable loan models to the local ESCOs to purchase the SHS.[44] The foreign funding for the "market SHS" is provided to individual users in form of establishing micro-loan arrangements at local banks or other financial institutions.[45]

3.3. Ownership of the materials of the SHS

From the above paragraph on financing, the ownership of the SHS can be clearly derived. The solar panels, batteries and transformers of the "fee-for-service SHS" are owned by the ESCO. Thus, the ESCO is also responsible for the installation of the SHS and its regular maintenance. In the "market SHS" the SHS is owned by the user.

[40] Wamukonya, *supra* note 1 at 8.
[41] *Ibid*. at 11.
[42] *Ibid*. at 12.
[43] *Ibid*. at 11.
[44] Gustavsson, *supra* note 17 at 799.
[45] Vleuten, Stam and Plas, *supra* note 21 at 1440.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

3.4. Operation and maintenance

Maintenance of both SHS user models and the conventional grid is difficult. The solar panels have to be cleaned on a regular basis and the batteries have to be changed regularly, approximately every 5 years.[46] This requires a certain technical knowledge about the functioning of the SHS. Therefore, SHS can be a sustainable source of electricity only if there is a technician available for regular maintenance. Currently this problem is solved in two ways. Where the SHS is operated by an ESCO, the ESCO usually educates one or more villagers to perform the maintenance tasks of a technician.[47] For example, in Zambia, the ESCO employed technicians make monthly inspections on all the SHS and if there is a malfunction they are at the site within 2 working days.[48] All these costs are born by the ESCO.[49] In countries like Kenya, where a market in SHS is developed and the distribution of SHS is disseminated throughout the country, the market competition has also forced the creation of branches of services throughout the county.[50] The user has to pay for the maintenance work at commercial prices.[51] An additional disadvantage of the "market SHS" model compared to the "fee-for-service SHS" model is the access to low quality SHS. Such systems have a low performance, they break more

[46] Life time of the battery is 5 years only if the SHS is installed and used properly. However, where the SHS is purchased by the users themselves, the users tend to lower their costs, by not purchasing all the pieces of the system or a lower quality system. This reduces the life time of the battery for more than a half, to 2 years. Plas and Hankins, *supra* note 7 at 300; Nässen, Evertsson and Andersson, *supra* note 27 at 503; Gustavsson and Ellegård, *supra* note 19 at 1066.
[47] Gustavsson, *supra* note 17 at 797; Haanyika, *supra* note 3 at 1050.
[48] The study of solar power electrification in Ghana demonstrated similar availability of village technicians. Nässen, Evertsson and Andersson, *supra* note 27 at 504; Gustavsson, *supra* note 17 at 800-801; Gustavsson and Ellegård, *supra* note 19 at 1066.
[49] Gustavsson, *supra* note 17 at 801; Gustavsson and Ellegård, *supra* note 19 at 1066.
[50] Vleuten, Stam and Plas, *supra* note 21 at 1441.
[51] *Ibid*.

often and have a higher instance of power shortages.[52] This increases the maintenance and repair costs for the user.

3.5. Reliability

The reliability of both the SHS and the conventional grid is questionable. As abovementioned, the SHS can provide only a limited amount of electricity. That is, as much electricity as can be stored in the battery. When this amount is used up, the battery has to be charged again. This means that if too many appliances are connected to the system, the battery will discharge itself and the household will temporarily lose power.[53] As long as the operating hours of the SHS and the limited amount of appliances connected are respected, as well as the panels are regularly cleaned to receive the full amount of sun power, the SHS is very reliable.

In comparison, the study conducted in Ghana demonstrated that the conventional grid is far less reliable than the two SHS user models. Owing to the prolonged droughts and the smaller water volume in the Volta Lakes, the problems with the power shortfalls in the conventional grid electricity are more common.[54] Similar drought related problems are occurring in Kenya and elsewhere in Africa.[55] These power shortfalls mostly affect the rural and less populated

[52] R. D. Duke, A. Jacobson and D. M. Kammen, "Photovoltaic Module Quality in the Kenyan Solar Home Systems Market" (2002) 30 Energy Policy 477 at 482.
[53] Gustavsson and Ellegård, *supra* note 19, at 1065.
[54] Nässen, Evertsson and Andersson, *supra* note 27, at 507.
[55] K. V. O. Rabah, "Integrated Solar Energy Systems for Rural Electrification in Kenya" (2005) 30 Renewable Energy 23 at 26.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

areas.[56] Due to remoteness of the rural areas, the power outages are much longer than in the urban areas, as distance affects the technician's ability to come and remove the interruptions.[57]

4. "Fee-for-service SHS" vs. "market SHS"

As presented above, there are two major models of access to SHS: "fee-for-service SHS" and "market SHS". Only 13 per cent of SHS in the World are "fee-for-service SHS", while 79 per cent are "market SHS".[58] There is no data available for Africa only. The reason for the development of two different models of access to SHS lies in the different institutional backgrounds of the African countries. Why is the "fee-for-service SHS" the most appropriate model for Zambia and why the "market SHS" model is more effective in Kenya?

4.1. "Fee-for-service SHS" model in Zambia

The "fee-for-service SHS" model in Zambia was designed as a complex and large-scale project by the Government of Zambia and the Swedish International Development Agency [hereafter SIDA] and the GEF, as the donor organizations.[59] The donations of SIDA and GEF lowered the total costs of the SHS for the end-user.[60] Such a project is a complex and lengthy

[56] Nässen, Evertsson and Andersson, *supra* note 27 at 507.
[57] *Ibid*.
[58] Nieuwenhout, van Dijk, Lasschuit, van Roekel, van Dijk, Hirsch, Arriaza, Hankins, Sharma and Wade, *supra* note 19 at 457.
[59] Vleuten, Stam and Plas, *supra* note 21 at 1441; Haanyika, *supra* note 3 at 1054.
[60] Vleuten, Stam and Plas, *supra* note 21 at 1443; Haanyika, *supra* note 3 at 1054.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

process that demands a certain institutional capacity of the recipient country.[61] Especially, the legal institutions have to be developed and have to function properly. Zambia has adopted a whole set of legal rules governing rural electrification and has established an Energy Regulation Board. This board oversees the functioning of the ESCOs and their provision of SHS, determines the electricity price and defines the rules of the provider-user relationship.[62] Moreover, the functioning of a strong judiciary body is also necessary to ensure that the fees are paid regularly, as well as contracts between the provider and user, technicians' employment contracts and the agreements regarding the operation and maintenance of the SHS are respected.

In Zambia three ESCOs in Lundazi, Chipata and Nyimba were established to hold the role of the SHS provider and to manage the SHS.[63] In all three cases, local farming businesses have taken up the function of an ESCO as an additional service.[64] The Nyimba ESCO [hereafter NESCO] provides the users with a SHS (the users do not have the ability to choose between different types of SHS)[65] in return for an installation fee of US$33.33 and it collects also the monthly fee.[66] This fee is around US$6.25 for an average user, regardless of his consumption.[67]

---

[61] Vleuten, Stam and Plas, *supra* note 21 at 1441.
[62] Gustavsson and Ellegård, *supra* note 19 at 1062; Haanyika, *supra* note 3 at 1051, 1055.
[63] A. Ellegård, A. Arvidson, M. Nordström, O. S. Kalumiana and C. Mwanza, "Rural People Pay for Solar: Experiences from the Zambia PV-ESCO Project" (2004) 29 Renewable Energy 1251 at 1253; Gustavsson and Ellegård, *supra* note 19 at 1061.
[64] Gustavsson and Ellegård, *supra* note 19 at 1061.
[65] Ellegård, Arvidson, Nordström, Kalumiana and Mwanza, supra note 63 at 1253.
[66] Madamombe, *supra* note 18 at 11.
[67] *Ibid*.; Gustavsson and Ellegård, *supra* note 19 at 1063.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

Because of inflation the fees change annually.[68] Thus, to reflect this, the contract between NESCO and the user is also renewed annually.[69] The SHS is installed on the premises of the user to give them social control over the system and avoid theft.[70] The users also sign an agreement with NESCO to take responsibility over the equipment.[71] Under this agreement they are liable to very severe costs if the SHS gets lost or sold.[72] As the provider of SHS, NESCO has the responsibility to provide all the technical support. Therefore, it employs technicians that conduct regular maintenance work and change the batteries for the end-users. However, the NESCO is only the provider and the real owner of the equipment is the Government of Zambia.[73] A study showed that the Zambian users are very satisfied with the availability of the NESCO staff for maintenance, servicing and other client contacts.[74]

The low installation and monthly fees make the SHS accessible to the wealthier rural population.[75] Unfortunately, the poorest of the poor still cannot afford an SHS.[76] The SHS is accessible to the rural population in Zambia, because the costs of the electricity are divided into small monthly payments combined with the fact that they do not hold the cost of maintenance and reparation. Such small payments are more affordable to the rural population than a big initial investment. Moreover, taking a credit to purchase the SHS is nearly impossible for the

[68] Gustavsson and Ellegård, *supra* note 19 at 1064.
[69] *Ibid*.
[70] Ellegård, Arvidson, Nordström, Kalumiana and Mwanza, *supra* note 63 at 1255.
[71] *Ibid*.
[72] *Ibid*.
[73] *Ibid*. at 1259; Gustavsson and Ellegård, *supra* note 19 at 1061.
[74] Gustavsson and Ellegård, *supra* note 19 at 1070-1071.
[75] Ellegård, Arvidson, Nordström, Kalumiana and Mwanza, *supra* note 63 at 1255.
[76] *Ibid*.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

rural population in Zambia, as the lending policy of the banks in Zambia is very discouraging. The banks either do not have their services in rural areas, or do not offer credits there.[77] Moreover, they have no interest in arranging a micro-loan lending policy for the purchase of a SHS.[78] An additional discouraging factor is the interest rate for credits at 50-60 per cent.[79] Thus, the "fee-for-service SHS" model is the most convenient model of access to SHS for the rural population in Zambia.

4.2. "Market SHS" model in Kenya

Kenya has the largest private sector dominated SHS market in any of the developing countries.[80] In Kenya the access to SHS is self-organized by the user within the framework of an unsubsidized over-the-counter commercial market.[81] Only 25 per cent of sales are government or donor financed.[82] The market is spread throughout the country with a total of 150,000 households in Kenya that had a SHS installed as of the year 2000.[83] Currently there are 10 major SHS manufacturing and importing companies in Kenya and hundreds of rural vendors and services.[84] Moreover, the demand is increasing.[85] The user has to buy the SHS from a local

[77] *Ibid*. at 1258.
[78] *Ibid*.
[79] *Ibid*.
[80] Duke, Jacobson and Kammen, *supra* note 52 at 478; A. Jacobson and D. M. Kammen, "Engineering, Institutions, and Public Interest: Evaluating Product Quality in the Kenyan Solar Photovoltaics Industry" (2007) 35 Energy Policy 2960 at 2960.
[81] Vleuten, Stam and Plas, *supra* note 21 at 1440; Jacobson, *supra* note 19 at 146.
[82] Jacobson, *supra* note 19 at 159.
[83] Vleuten, Stam and Plas, *supra* note 21 at 1446.
[84] Duke, Jacobson and Kammen, *supra* note 52 at 481; ESMAP, *supra* note **Error! Bookmark not defined.** at 3; Hankins, *supra* note 4 at 94, 96.
[85] Plas and Hankins, *supra* note 7 at 296; Jacobson, *supra* note 19 at 146.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

distributor and can chose between several different types of SHS.[86] This also means that the users have the ability to choose between different qualities of the systems and different cost structures. Since not all the users can afford the higher quality SHS, several users choose the lower quality SHS or decide not to purchase all the parts of the system, which results in lower performance of the system.[87] However, costs of the SHS in Kenya are steadily lowering due to the increased competition.[88] The SHS is thus becoming increasingly more available also to the lower income rural population, not just the rural middle class.[89] The Government of Kenya has also helped, by reducing the import duties on the solar modules/panes to 5 per cent and removed the value added tax for these modules.[90] The SHS in Kenya costs around US$40-80,[91] while the average household income is US$90 per month.[92] The SHS are bought by cash.[93] Such a large investment is acceptable for the user only if the banking system is sophisticated enough to offer micro-loans to the population.

As in Zambia, also in Kenya the banks were in the beginning reluctant to offer credits to rural population. The employed rural population could get loans for SHS from banks at

[86] Vleuten, Stam and Plas, *supra* note 21 at 1440; Duke, Jacobson and Kammen, *supra* note 52 at 478.
[87] Plas and Hankins, *supra* note 7 at 296-297.
[88] The costs of a SHS in 1996 were around US$217, while in 2007 they lowered to around US$40-80. Plas and Hankins, *supra* note 7 at 298-299; Jacobson, *supra* note 19 at 151.
[89] Jacobson, *supra* note 19 at 148-149; ESMAP, *supra* note **Error! Bookmark not defined.** at 4; Hankins, *supra* note 4 at 92, 96.
[90] However, import duties and value added tax remains for batteries and charge regulators at more than 35 per cent of their price. Hankins, *supra* note 4 at 98.
[91] Vleuten, Stam and Plas, *supra* note 21 at 1446; Duke, Jacobson and Kammen, *supra* note 52 at 481; ESMAP, *supra* note **Error! Bookmark not defined.** at 3-4; Hankins, *supra* note 4 at 94.
[92] Plas and Hankins, *supra* note 7 at 298; Duke, Jacobson and Kammen, *supra* note 52 at 481.
[93] Duke, Jacobson and Kammen, *supra* note 52 at 481.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

commercial retail rates.[94] Thus, a system of hire-purchase companies evolved in Kenya.[95] Under this system an employed worker signs up with the hire-purchase company.[96] This company purchases the SHS for the employer and automatically deducts monthly payments for the SHS from the employer's salary with interest rates around 40 per cent a year.[97] Today 15 per cent of SHS purchase in Kenya is made through a hire-purchase company.[98] Moreover, four of the major importers of SHS have connected with the hire-purchase companies and supply the SHS directly to them.[99] Despite the hire-purchase companies, the rural population without a regular salary cannot get a loan for SHS neither from the bank or the hire-purchase company. Therefore, the World Bank and International Finance Cooperation [hereafter IFC] are trying to promote special financing for the purchase of SHS in forms of loans with lower interest rates than commercial.[100] The demand for such loans is high and commercial banks and rural savings and credit cooperatives are slowly realizing the need for such loans.[101] Moreover, the IFC and the GEF have initiated a Photovoltaic Market Transformation Initiative [hereafter PVMTI].[102] Under this initiative they provide altogether US$5 million in capital to local banks.[103] The local

[94] Hankins, *supra* note 4 at 95.
[95] *Ibid*.
[96] *Ibid*.
[97] *Ibid*.
[98] *Ibid*.
[99] *Ibid*.
[100] *Ibid*.
[101] *Ibid*.
[102] J. P. Ross, "Financing Off-grid PV" (2001), published by Centre for Resource Solution, available online at: http://www.resource-solutions.org/lib/librarypdfs/DistRural-FinancingoffgridPV.pdf (last visited April 24, 2008) at 2.
[103] *Ibid*.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

banks then pay the retailers for each SHS sold individually, while the user has to pay the cost of the received SHS to the bank over the course of a favourable loan.[104]

5. Discussion

The above comparison between the two different models of access to the SHS in Zambia and Kenya illustrates an important fact. The user model of the SHS in a developing country largely depends on which institutions are developed and how well they function. In Zambia the legal institutions and judiciary are more developed than the financial institutions. This means that contract enforcement mechanisms are strong and thus contracts between users and the ESCOs are well respected resulting in regularly paid fees for electricity.[105] Hence, the "fee-for-service SHS" model is very effective in providing wireless electricity. Due to inaccessibility to credit for the rural population in Zambia, an unsubsidized over-the-counter market in SHS would not function. The situation is contrary in Kenya, where the financial institutions, especially the access to loans, are well developed. The rural population has access to loans for the purchase of SHS. This enables the unsubsidized market in SHS to flourish. While the respect for rule of law is lower in Kenya and corruption a big problem,[106] the "fee-for-service SHS" model that requires respect for contracts and agreements would not function.

[104] *Ibid*. at 2-3.
[105] Gustavsson, *supra* note 17 at 800.
[106] Strong World Bank Support for Anti-corruption Efforts in Kenya, available online at: http://go.worldbank.org/QG81C8R591 (last visited April 24, 2008).

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

These findings are supported by the data of the World economy rankings. In the category of enforcing contracts, Zambia is ranked 86th and Kenya 107th out of 178 world economies.[107] However, in the category of getting credits Kenya is ranked 13th and Zambia 97th.[108]

Nevertheless, the fact that the research on SHS concentrates on Zambia and Kenya, the abovementioned findings can be applied also to other areas of the World. Zimbabwe and Indonesia are both examples of successful "market SHS" user models.[109] In both countries the SHS were bought by the households on the market. Since the availability of the SHS to the rural population was partly funded by the GEF and the governments, only high quality SHS were available to the end users.[110] Additionally, the governments of both countries together with the funding organizations established a self-sustaining finance facility that enabled the households to pay only a smaller per cent of the installation costs of the SHS at the time of installation.[111] The balance was to be paid over three years at a low interest rate.[112] The "market SHS" user model in Zimbabwe and Indonesia had such a wide outreach because the Government enabled the establishment of a financial institution that provided loans for the poor rural households.

[107] Doing Business 2008 Report, available online at: http://www.doingbusiness.org/economyrankings/ (last visited May 10, 2009).
[108] *Ibid*.
[109] Nieuwenhout, van Dijk, Lasschuit, van Roekel, van Dijk, Hirsch, Arriaza, Hankins, Sharma and Wade, *supra* note 109 *supra* note 19 at 462; I. Dube, "PV for rural areas – the power utility (ZESA) Zimbabwe's experience" (2001) 24 Renewable Energy 517 at 519; "Photovoltaics for Household and Community Use" UNDP project, available online at http://gefweb.org/Outreach/outreach-PUblications/Project_factsheet/Zimbabwe-phot-2-cc-undp-eng-ld.pdf (last visited May 10, 2009)
[110] *Ibid*.
[111] *Ibid*.
[112] *Ibid*.

Maša Kovič, LL.M.

masa.kovic@alumni.utoronto.ca

A great example to illustrate the importance of institutional development is Kiribati in Pacific Islands. The SHS were initially sold on the market for commercial prices.[113] Since the households could not afford to pay the full price of the SHS, several households bought under-sized systems, cheap replacements and were unwilling to pay for professional installation.[114] Thus, less than 10 per cent of the SHS were more than marginally operational and the dissatisfaction with the SHS was high among the population.[115] The reason for this is the lack of available loans to the rural population. The local banks and other financing institutions were reluctant to give loans for non-productive investments to rural population and the loan administration and collection may be costly.[116] After the failure of the "market SHS" model the Kiribati Solar Energy Company set up the "fee-for-service SHS" model.[117] Each household pays an installation fee and a monthly fee to cover the costs of operation of the SHS, battery replacement and maintenance of the system.[118] Every month a field technician collects the fee and checks the system.[119] The user satisfaction with this model is significantly higher.[120] This clearly shows that the "fee-for-service SHS" model is more appropriate for Kiribati. As the World economy rankings data also demonstrates, the financial institutions in Kiribati do not function as well as the legal institutions. The Kiribati placed 75th among all the states in the World in the category of contract enforcement and only 131st in the category of availability of

[113] Nieuwenhout, van Dijk, Lasschuit, van Roekel, van Dijk, Hirsch, Arriaza, Hankins, Sharma and Wade, *supra* note 19 at 462-463.
[114] *Ibid*.
[115] *Ibid*.
[116] *Ibid*.
[117] *Ibid*. at 464.
[118] *Ibid*.
[119] *Ibid*.
[120] *Ibid*.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

loans.[121] Similarly successful operation of the "fee-for-service SHS" model is reported also from the Dominican Republic and Argentina. Both of these countries have more developed legal institutions and judiciary than the financial institutions.[122]

Conclusion

Studies show that wireless electricity in the form of SHS is more appropriate for the electrification of the rural African areas than extension of the conventional electricity grid. It is safer, more environmentally friendly and provides a sufficient amount of electricity for the needs of the rural population. Most importantly it is also more cost friendly to the consumers. However, all of this depends on the institutional framework in the developing countries. The rural population can afford the SHS in countries where the banking system allows the rural population to take micro-credits to finance the SHS and make sure that the user-provider contracts are respected; that the prices of the electricity are controlled and that they remain within the range of consumers' affordability.

The importance of this research lies in its illustration that the success of a technology transfer project is not dependent only on emission reductions, but also on the accessibility of the project to the targeted user. This latter requirement however, depends on how well the

[121] Doing Business 2008 Report, *supra* note 107.
[122] *Ibid*.

Maša Kovič, LL.M.
masa.kovic@alumni.utoronto.ca

project takes into account which institutions are developed in a State and how well they function.

To conclude, I would like to point out an interesting fact. Though wireless electricity is perceived by the majority of us as a direct tool to increase the development level of the rural population in a developing county, it rarely is so. Both studies in Zambia and Kenya showed that electricity was in rare situations used for lightning, for children's studying and for small businesses. The majority of the population used the electricity from the SHS as a social and entertainment boost. It enables the rural population to listen to the radio, watch TV or videos and get the information on what is going on around the country as well as the rest of the world.[123] It is also extensively used for charging mobile phones which increase the connectedness of the rural population with the national and international urban centers.[124] However, I think that also such use of electricity has a positive, though indirect impact on the development of the countries. Namely, the great impact of mobile phones on development has been already proven. As technology creates a more connected world these nations will have increasing entrepreneurial inspiration to help stir development and innovation.

[123] Gustavsson and Ellegård, *supra* note 19 at 1062; Jacobson, *supra* note 1918 at 153-157.
[124] Jacobson, *supra* note 19 at 153-157.