BRINGING DECENTRALIZED CLEAN ENERGY SOLUTIONS IN CENTRAL ASIA

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Abstract: *Tajikistan and Kyrgyzstan are two of the poorer developing countries in Central Asia with GNI per capita of US$ 1,080 and US$ 1,250 respectively. This is below the average for lower middle income countries. The two countries are facing a a number of different socio-economic and environmental challenges, particularly affecting the rural areas where more than two thirds of Kyrgyzstan's population and almost three quarters of Tajikistan's population reside.*

Additionally, despite nearly universal grid connection rate, approximately 70% of the Tajik population suffers from extensive shortages of electricity during the winter. These electricity shortages are caused by a combination of: a) insufficient winter hydropower output when river flows are low and b) high demand driven by heating needs in the winter. These shortages, estimated at about 2,700-4,000 GWh/year represent economic losses of 3% of GDP.

The unmet demand for electricity in Tajikistan, combined with households' current spending on alternative fuels in the winter, represent a potentially large market opportunity for decentralized energy services in rural areas. In order to open up this market, the United Nations Development Programme (UNDP) has set up a project "Green Villages in Central Asia" which focuses on providing electricity and heat energy to households and the private sector in Tajikistan and Kyrgyzstan through improved access to renewable energy.

An integrated approach in the project focuses on three pillars: a) decentralized renewable energy technology solutions; b) innovative financing models; and c) involving SMEs to unleash the market (such as RESCOs, energy cooperatives, DIY technologies etc.).

This paper discusses recently piloted innovative finance and business models for green energy and identifies barriers and lessons learned from that process. The conclusion is that

decentralized renewable energy is a serious alternative to the business-as-usual energy system based on centralized fossil fuel power plants.

Key words: energy access, energy poverty, RESCO, solar energy, innovative financing, energy cooperatives, Tajikistan, Kyrgyzstan

1. INTRODUCTION

According to World Development Indicators from 2014, Tajikistan and Kyrgyzstan have GNI per capita of US$ 1,080 and US$ 1,250 respectively which classifies them as the poorest and least developed countries in Central Asia [1]. Socio-economic problems which are present in both countries are largely related to the unfavorable situation in the energy sector which causes environmental problems as well. The population living in rural areas, where more than

reside, is the most affected by these issues [2]. **A h**igh percentage of the rural population lives without reliable or affordable energy access which causes high unemployment rates and high general poverty.

Despite a 90% grid connection rate in Tajikistan, almost 70% of the population suffers from electricity shortages. Due to a high dependence on hydropower, the low river flows and high electricity demand cause the most frequent and extensive blackouts during the winter period. The unreliable energy supply causes further problems relating to the economy, development and the environment which inevitably leads to an increase in general poverty (this will be dealt with in more detail in the next chapter). The unreliable energy supply from the grid represents a large market opportunity for decentralized green energy services including renewable energy technologies and energy efficiency [3].

Similar to Tajikistan, electricity shortages occur in Kyrgyzstan during winter as the demand is much higher than in the summer period and the river flows are significantly lower. Those shortages more often occur in rural areas. Currently in Kyrgyzstan, less than 1% of renewable energy potential has been used which means that the country has a clear potential to solve the supply issues which would help mitigate other problems as well [4].

Future plans for energy access in both countries are relying heavily on a business-as-usual model of energy access development, i.e. through new centralized energy production. This approach has shown no or little benefits for local communities that are still lacking electricity during the large part of the year. There is a need for developing an alternative model of

energy access one which is based on decentralized energy solutions and based on renewable energy and community engagement.

Having this in mind, there was a need to develop and test a new model of power system development that would contribute not only to energy access but also to job creation and environmental sustainability. Energy experts from UNDP offices in Croatia, Tajikistan, Kyrgyzstan and the Istanbul Regional Hub joined forces to design and pilot a new model of energy access, which became known as the Green Villages model.

This current paper describes this new model of an integrated rural development approach: Green villages in Central Asia which have been implemented in pilot areas of rural Tajikistan and Kyrgyzstan. The model has been introduced in order to reduce energy problems in rural areas and other related issues directly caused by a lack of reliable energy access. The starting assumptions, model designing, pilot projects carried out, , lessons learned from the pilot projects and scaling up possibilities are described below in detail.

2. INTEGRATED RURAL DEVELOPMENT APPROACH – COMBINING RURAL ENERGY ACCESS WITH EMPLOYMENT AND ENVIRONMENT BENEFITS

There is a high correlation between energy poverty and general poverty. The inability to pay for energy or a complete lack of energy access directly influences the four components of poverty: health, education, income and environment [5].

Inefficient and technically poorly designed heaters and cookstoves, which are commonly used in rural areas of Tajikistan and Kyrgyzstan requiring firewood or other biomass, often cause indoor air pollution which could have a bad impact on health, primarily amongst women and children. Moreover, as they are usually responsible for biomass collecting, they are also more exposed to risk of injuries [6] [5]. Due to energy issues, education possibilities for many school children are very limited; many spend a lot of hours every day collecting biomass instead of attending school, studying hours are limited due to the non-existance of indoor lighting, conditions within public schools are mostly inadequate in terms of heating and school equipment and lack of access to modern technologies limits the access to information.

Any economic activities and entrepreneurship are very limited without reliable and affordable energy access which, coupled with poor education, results in economic growth stagnation.

Finally, the vast use of biomass leads to serious deforestation problems and the use of inefficient appliances results in higher energy consumption [5]. Therefore the prerequisite to mitigate the overty and foster development in Tajikistan and Kyrgyzstan is to provide reliable access to clean energy affordable to the local communities [7].

Integrated Rural Development (IRD) has already been tested in rural areas of Tajikistan before and it was proven to be a good approach to deal with energy and poverty issues. The IRD approach is based on combining locally available renewable energy sources, energy efficiency and fostering income which is related either to production of renewable energy technologies or to energy efficiency related activities [6].

For the successful realization of IRD it is important to have the community involved in the project design and implementation in order to ensure: sustainability, continuity of the project management after the set-up phase and its operation and maintenance (O&M) during its life time. It provides the opportunity for the community members to increase their income through direct work on the mentioned project activities or through newly started businesses and activities which become possible to set up due to increased energy access [6]. Moreover, successful realization of IRD improves living conditions, reduces health issues and provides opportunities for the whole community but especially for women and children. Women can dedicate more time to money making activities which generally result in higher gender equality and children have more time and much better opportunities and conditions for education. Implemented energy efficient measures and new technologies have a positive impact on the local environment and they foster sustainable development [8].

In 2008 UNDP started implementation of a pilot IRD project in Jamoat Burunov in Tajikistan. The project included refurbishment of two units in the Nurofar small hydro power plant, refurbishment of the hospital, school and kindergarten, construction of a mini-dairy, refurbishment of a pumping station, construction of a small greenhouse and establishment of the operator who was responsible for O&M and collecting the fees. It has been confirmed that the integrated approach improves the living conditions of the community and contributes to poverty eradication much more than simply building an energy source (in this case a small hydro power plant). The surveys conducted after the project have shown the importance of community involvement [6].

However, it was noted that the approach could be further improved by assigning responsibilities within a community for each project activity, by using only locally available,

affordable and replicable technologies (even if they are not the most efficient and reliable), by involving local experts and by educating local inhabitants about the implemented technologies. [6]

3. *GREEN VILLAGES IN CENTRAL ASIA* MODEL FOR ENERGY ACCESS

Lessons learned from the IRD project were taken into account for developing the *Green villages in Central Asia* model. A combination of innovative financing and various business models, decentralized green technologies and renewable energy and engagement became pillars of the new model. Significant roles in the project were given to the inclusion of the local community and local experts. Different local NGOs, cooperatives, companies and associations were fully involved in the project. The local experts were given in-depth familiarisation with the technologies planned to be implemented. They were also a valuable source of information about locally available materials and practices and their inputs were taken into account while designing pilot projects technologies as the implemented technologies were supposed to be easily replicable by local communities. Another important contribution of the local experts was easier communication with local inhabitants due to both no language barrier and the experts deep understanding of local community culture. Finally, local experts were assigned to help the local communities to accept implemented technologies, to train the people to use them and to help them to overcome any potential barriers. They conducted surveys among inhabitants after the set-up phase of the pilot projects and provided valuable information.

Another focus in the new model was placed on building capacity and training local people to be able to produce new technologies themselves. One do-it-yourself (DIY) workshop on how to build solar thermal systems was conducted in the village of Jilikul in Tajikistan. Fifteen women were trained during the workshop (it is worth mentioning that in the rural areas of Tajikistan the population is predominantly women as the men are working in Russia). Another workshop was carried out in Guzgef village in Tajikistan, during which 25 participants from all over Tajikistan were trained for a week to build a rocket mass heater. Both pilot projects are further described in the following section. The general idea of pilot projects which included do-it-yourself workshops or demonstration workshops was to build capacity and to transfer technology knowledge in the way that local inhabitants can easily replicate it themselves. Moreover, they are able to initiate green energy small and medium-sized enterprises (SMEs) based on the certain activity and technology. The established green

energy SMEs could create jobs, increase income, develop markets and play a significant role in economic development in general.

Finally, an important part of the model is the introduction of innovative financial models such as crowdfunding which are supposed to support some project activities, mostly regarding refurbishment of local public buildings, but they could be used for various other purposes in the future. The pilot projects have been conducted in 6 villages in Tajikistan and 2 in Kyrgyzstan. The areas for the pilot projects have been chosen based on a set of criteria in cooperation with the local experts and trusted local organizations.

3.1. Piloting small scale decentralized technologies

3.1.1 Solar thermal systems

Figure 1: Do-it-yourself solar thermal systems workshop in Jilikul

Enabling women to build solar thermal systems through do-it-yourself workshop.

The objective of the project was to introduce solar thermal system design to local companies and train women in rural households to build and use solar thermal systems from locally available materials thus making women-headed households more self-sufficient in energy use.

Within the project, three do-it-yourself workshops were held: one was held in Dushanbe for 12 participants from local companies, a technical university and NGOs and two workshops were held for 15 women recruited by the Women Resource Center in Jilikul village. Moreover, one of the participants trained during the workshop in Dushanbe organized the workshop in Pamir region later on, which was a great example of further knowledge transfer. However, it was later recognized how important it is to assign one of the local inhabitants as a competent technician who will help others in maintaining the solar systems. In rural areas without reliable electricity supply, this business model could be scaled up in future via SMEs. If those SMEs would be led by women, the business will not only enhance the economic

development but also will contribute significantly to women empowerment and gender equality.

3.1.2. Energy efficient cookstoves and solar lamps

Introducing and testing energy efficient cookstoves and solar lamps in un-electrified households. Cheap energy efficient (EE) cookstoves and solar lamps were introduced and tested in six villages (some of which are still without year-round electricity supply) in rural Tajikistan. The information provided through surveys among village users has suggested some design interventions for EE cookstoves, but it has been confirmed that about half of the firewood previously used for cooking is now used, which is very important for the regions with a lack of biomass due to serious deforestation. The surveys provided similar information for solar lamps which bring incredible value in regions without power supply. Therefore it has been concluded that both technologies could have market value that would be recognized and accepted by the locals.

Figure 2: Introducing energy efficient cookstoves

3.1.3. Large stoves for heating and cooking

Figure 3: Rocket mass heater workshop

Enabling locals to build efficient stoves for indoor heating and cooking. The idea of the pilot project carried out in Guzgef village in Tajikistan was to educate and train locals in a rural village, where biomass is scarce, on how to build an efficient stove for indoor heating and cooking

from only locally available materials. During a one week training one large stove was built in a local mosque, and two smaller ones in the local school. This training attracted people from all around Tajikistan (20 people) and it resulted in at least eight people being fully trained to build their own mass heater and others who would follow with more practice. Several additional designs have been developed, such as integral stoves for cooking and heating, or existing metal stoves adapted to a rocket mass heater. Although a manual on how to build and use a rocket mass heater was prepared, the survey conducted afterwards showed that the stoves had been improperly used by locals at first (it was not 100% dry before the use) which resulted in limited use of the stove. Consequently, another brief user manual was prepared with very straightforward instructions on how to use the stoves. It has been concluded that the manuals provided in areas like rural Tajikistan have to be very clear and very straightforward and that a local expert should always be engaged to help the local community to accept and get familiar with new technology after completing official training. However, more attention needs to be paid in selecting the village as not all locals were ready to accept the new technology. The technology would have the greatest impact in places with a lack of biomass, as the stoves can be produced locally by stove masters and local cooperatives.

3.2. Testing innovative financial models

As mentioned before, innovative financial models implemented are a breakthrough in the IRD approach. They give the community powerful tools to tackle the changes, improve their living conditions or to start SMEs, without relying heavily on the current economic situation (e.g. subsidies for green technologies) or the political climate in the country.

Within the Green V portfolio, a crowdfunding campaign was carried out in order to raise the funds for local school building refurbishment. A primary school with 137 children from Guzgef village and surrounding villages was chosen, which lacks basic conditions as the school is not connected to the electricity grid and has only a couple of old, inefficient heating stoves. The campaign was launched in May 2016 with the initial goal of collecting 8,000 USD. The refurbishment will include the introduction of renewable energy (solar panels), thermal insulation of the roof and walls and replacement of windows and the wooden floor.

Crowdfunding has proved to be a great tool for projects contributing to the development of local communities and as such it can be used in further projects. However, more advanced innovative financial models have been developed recently that could be implemented for

financing renewable energy projects, such as crowdinvesting and crowdlending. Platforms such as TRINE for crowdinvesting or KIVA for crowdlending have been used successfully for similar projects in other developing countries. These models have huge potential but they are still to be implemented and tested within the IRD approach.

3.3. Example of integrated development of green villages undertaken in Guzgef village

Guzgef is a mountainous village in a rural area of Tajikistan with 350 inhabitants living in 65 households. Due to its remote location, 2,000 m above sea level, the village is not connected to the electricity grid. With no access to electricity, the inhabitants depend only on coal or firewood in terms of heating and cooking, on petroleum for lighting and generally have very poor living conditions.

Several pilot activities have been introduced in Guzgef in order to mitigate many negative issues regarding lack of energy access and to boost further development. First of all, 30 small photovoltaic systems have been disseminated among households in the village. The project contributed to the improvement of living conditions as it enabled the use of indoor lighting for many families. Secondly, 30 efficient cookstoves have been disseminated which decreased the required amount of firewood used for cooking by half. In the area with serious deforestation issues, where women and children spend many hours a day collecting biomass, it was a significant improvement. The other pilot, which included the building of three efficient stoves for heating in public buildings, contributed as well to the decrease of biomass consumption in the village and a reduction of further deforestation of surrounding areas. Moreover, both projects reduced indoor pollution and increased comfort levels, thus providing better living conditions which prevent health problems. Thirdly, a crowdfunding campaign has been introduced in order to raise funds for local school refurbishment. Better conditions in local school buildings, indoor lighting which enables longer studying hours and reduced time required for biomass collection, provide better education possibilities for school children. Finally, three efficient stoves (highly efficient rocket stove mass heater design) were built at the workshop attended by 20 people, from Guzgef, surrounding areas and other parts of Tajikistan. Building capacity and providing locals with knowledge of new technologies is a fundamental step in economic development. The project can result in starting business: establishing of SMEs or cooperatives which will produce and sell the same type of stoves. It can raise the income of many village households and initiate further development. In all the projects carried out in Guzgef, local experts and local NGOs have been included. The local expert played a very important role in the period right after the efficient stove building

workshop. The local people were not familiar with the new technology before it was implemented in their village or even with the given instructions on how to use the stoves, they were struggling with it so much that they wanted to reject this new technology. However, the local expert that was later visiting the village helped the local people to overcome all the barriers they had regarding the use of the efficient stoves. Moreover, great attention was given to the fact that all introduced technologies are locally replicable which implied that all the materials used are locally provided.

3.4. Upscale of the proposed model for clean energy access

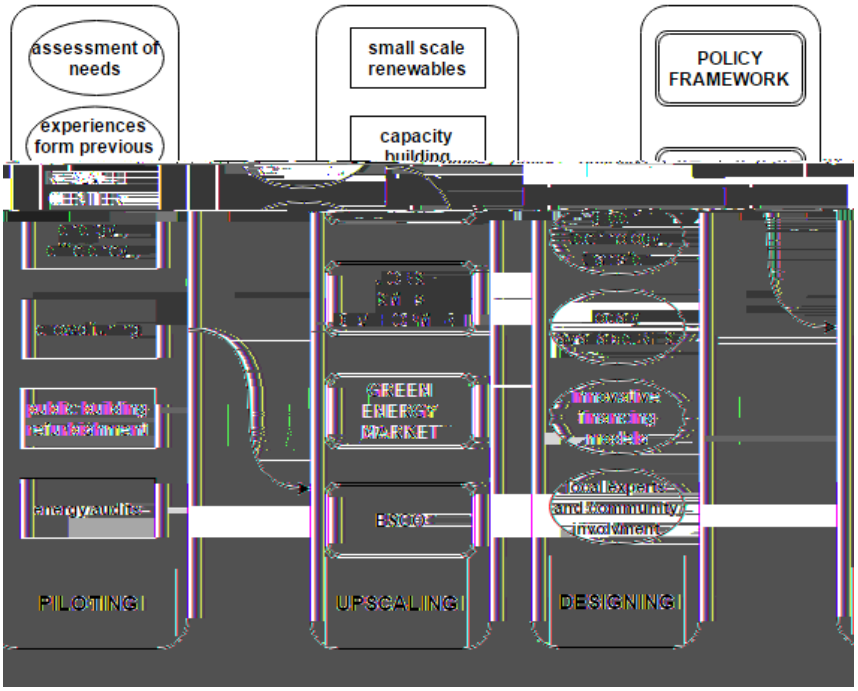

Figure 4: Upscale of Green Villages in Central Asia model

Development of the model started by analyzing the current issues and needs of rural areas of Tajikistan and Kyrgyzstan in order to develop a model that would be self-sufficient and easily replicable. As mentioned before, the results and lessons learned from previous IRD projects were valuable inputs and they were taken into account when designing the new model. The pilot projects were designed in a way to include as many components as possible, such as: various green technologies, capacity building and innovative financing. The experiences and lessons learned from pilot projects are now used to develop upscaled scenarios.

3.4.1. Establishing RES and EE Centre

It became clear through capacity building pilot projects carried out in Jilikul and Guzgef that a major interest in new technologies exists in Tajikistan. However, through surveys and

evident. One should have in mind that many participants have no access to modern communications or information providers due to lack of electricity access. Establishing spots where information can be provided or where trainings could be organized is essential for further capacity building. Therefore, it was concluded that a renewable energy and energy efficiency center (RES and EE Centre) should be set up in at least a couple of regions. The Centre should become a hub for education and practical demonstration on renewable energy technologies and energy efficiency. It should also provide information about equipment, products and services and promote networking among local RES/EE manufacturers and beneficiaries through green loans initiatives. People interested in starting a SME will be able to attend training on green technologies and receive support in business starting, e.g. legal and financial advice (including innovative financial mechanisms and financing schemes for green energy). Newly established SMEs will have the opportunity to present their products, find out about market trends, attend workshops and get information on financial possibilities. Finally, the centre will serve for general public education on energy efficiency and renewable energy technologies. The renewable energy and energy efficiency centres should initiate green energy development in the countries.

3.4.2. Role of green energy SMEs

The green energy SMEs could play an important role in economic development and they should be encouraged in terms of policy framework and financial possibilities. As described, RES and EE Centres could serve as a hub for green SMEs and they can provide information and advice. However, other instruments should be established in order to financially help business development. One possibility is a more active and significant role for national and international financial organizations. They could offer loans and microcredits for establishing SMEs or to already existing SMEs. Another possibility which has huge but unused potential is introducing innovative financial models such as crowdfunding, crowdlending and crowdinvesting on a large scale. This potential should be encouraged by establishing platforms for certain financial models in Tajikistan and Kyrgyzstan (such as Indiegogo, Citizenergy or Solarschool) and at the same time to establish a supporting centre which will provide support and guidance in creating and implementing campaigns. Through the platforms, the large community of Tajik and Kyrgyz people working abroad will get a

straightforward possibility to invest in green technologies and it will also enable participation of investors in green energy from around the world.

3.4.3. ESCO model in private companies

As part of the pilot projects, energy audits of 10 SMEs in Tajikistan have been undertaken. The consultancy provided recommendations for all audited SMEs
performances in area of sustainable use of natural resources with consideration to energy, waste, water saving and environmental aspects. Finally, the principles and approaches for conducting energy efficiency audit in SMEs with an energy, economic and environmental assessment have been introduced and set up. One of the conclusions of the pilot project is that no major progress could be made regarding energy efficiency improvement or the use of renewable technologies in private companies and industries without the development of Energy Service Companies (ESCO) or Renewable ESCOs (RESCO) on a wider scale. ESCO companies would remove the risk of high capital investments in energy efficiency and renewable technologies and they could provide services for both SMEs and for rural households. There are several options for this business model which should be considered: leasing model (the client rents a RES system and O&M risks are transferred to RESCO), hire-purchase model (RESCO retains ownership of the RES system until user has completed payments) and concession model (one or more RESCOs are contracted on a fee-for-service basis by the government to provide for example energy services to the public sector facilities).

4. CONCLUSION

Energy planning today needs to go hand in hand with thinking of wider socio-economic benefits [9] [10]. The model Green Villages in Central Asia which was presented in this paper, proved that the alternative approach for energy access based on decentralized and renewable energy solutions in rural Tajikistan and rural Kyrgyzstan brings multiple socio-economic benefits. The main barriers for further development have been recognized: the lack of finances for energy efficiency measurements and renewable technologies implementation, the lack of investments in green technologies due to many barriers, the lack of knowledge of green technologies, and finally the lack of support for green SMEs establishment and development. Therefore, four main prerequisites for further development of this model have been proposed:

- establishment of RES and EE Centres which would serve as a hub for education on green technologies and information exchange on market conditions;
- stronger support for new or developing green SMEs;
- further development of innovative financial models through establishment of crowdfunding platforms on a wider scale; and
- development of ESCOs.

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