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DEVELOPMENT OF A CERTIFICATION PROCESS FOR MICROENERGY SYSTEMS

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ABSTRACT
Actually more than 1.6 billion people lack access to electricity and 2.4 billion rely on traditional biomass for cooking and heating. Most of those households and small enterprises are helping themselves by using inefficient low quality appliances. They are often victims of plagiarism and suffer indirect economic impact on health and education. Consequently they are facing increasing energy costs which can come up to half of the monthly income.
Access to efficient microenergy systems can therefore have a huge impact on this target group. As the high investment costs are a main barrier, microfinance institutions have been identified as an lucrative partner in the implementation process.
The fact that customers ability and willingness to pay back the loan is depending on the performance of the financed microenergy system, the microfinance institutions have a high economic interest in assuring quality. This makes them to a crucial stakeholder in a certification procedure with the goal to implement efficient microenergy systems including a consumer protection mechanism and impulses towards product development for the sector.

Keywords: Microenergy Systems, Micro Finance, Developing Countries, Product-Service System, Comparison and Evaluation Instruments, Certification

1 INTRODUCTION
The research focuses on those regions with weak infrastructure and low incomes in developing countries where households and small and medium enterprises (SMEs) have insufficient access to modern energy services. According to the World Bank and the World Health Organization, more than 1.6 billion people lack access to electricity [1] and 3 billion rely on traditional biomass for cooking and heating [9]. To meet the tremendous demand for adapted solutions, logistical and technological innovation is required. To assure that innovation is meeting the demand towards a sustainable development, quality assurance and consumer protection play a crucial role.
The post graduate program *Microenergy Systems* of the Hans Boeckler Foundation in Germany (www.tu-berlin.de/microenergysystems) is an interdisciplinary research project looking at energy issues in regions with weak infrastructure and low incomes. One of nine PhD thesis, focuses on quality and consumer protection aspects by developing a certification procedure for products and services in this field. The background , the approach, and the first results are presented in this paper.

2 BACKGROUND
In former research, the author classified the regions described above as the *microenergy sector* in contrast to the *conventional energy sector* as shown in the following Figure 1

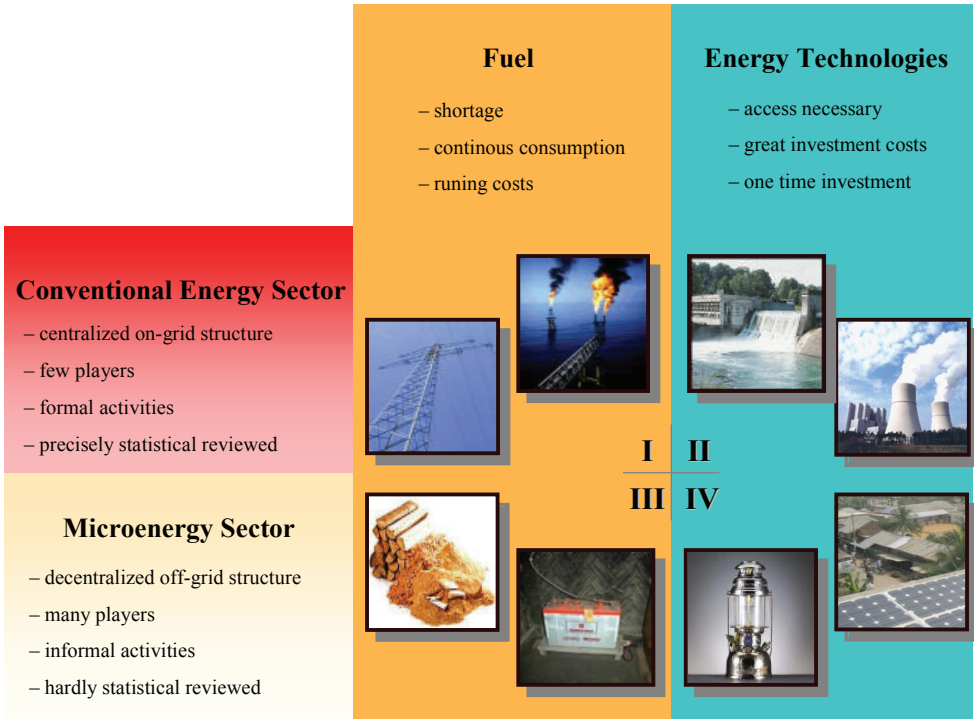

Figure 1 - Overview Energy Sectors

The conventional energy sector is characterized by enormous power plants and a centralized on-grid structure(e.g. electricity grid and oil or gas pipelines), its complex and expensive technologies require long-term investments and very specialized knowledge. This is the main reason why only few public and private players are dominating the life cycle of fuel and electricity. Furthermore, the performance of the conventional energy sector is considered an important national economic indicator and thus statistics and detailed information are easily available [2].
In contrast to the conventional energy sector, the microenergy sector is characterized by a decentralized structure with mainly informal economic activities and various small private players using more or less adapted small decentralized energy systems.
The Author's research group defines an energy converting appliance in the microenergy sector as a *microenergy appliance* (MEA). As far as the approach is expanded to a group of appliances and the system framing, the term *microenergy systems* (MES) is used. The dominating MEAs in the microenergy sector (e.g. kerosene lamps, car batteries, wood and charcoal stoves) are simple and poor in quality. Although the investment costs for those technologies are low, it will be demonstrated later in this paper that the accumulated energy costs are relatively higher per unit than in the conventional energy sector.
This is also reflected by the fact, that the global economic significance of the microenergy sector has considerably grown during the past decades as the use of energy for lighting clearly shows: Whereas the conventional electric lighting market has a volume of 185 billion US$, the off-grid (fuel-based) lighting market in the microenergy sector amounts to 38 billion US$ with 17 billion US$ only in Africa[3]. Households and SMEs are facing exploding energy expenditures, mostly for low quality products and services.

2.1 Microenergy Needs and Demand

Former field and market research has shown that appliances using and converting energy are widespread in the microenergy sector:

- The need for light already described is met by an increasing use of kerosene lamps. Kerosene is a liquid petrol derivate that became popular among the poor and remote population because it is easy to transport in plastic containers and purchasable in very small units.
- The need for information and entertainment is met by a growing demand for radios and black & white TVs based on 12V technology who are run with batteries or even color TVs in combination with DC/AC converters. With the help of accumulators, especially car batteries, electrical power is stored and transported to regions situated many kilometers away from the electricity generation source or the grid [4][5].
- The need for communication is reflected by the tremendous demand for mobile phones [6]. To recharge them, users travel many kilometers to a place where electricity is provided by an accumulator, a diesel generator or a grid connection.
- The need to overcome poverty basically means to increase income by enhancing the productivity of farming and other small businesses. For this purpose, diesel generators run pumps, mills or supply small decentralized grids with electricity. The engines used are inefficient and the running costs for fuel are high because of the long distance or difficult transport to rural and remote areas.
- The fast growth of the population, especially in urban and peri-urban regions, leads to a rise in centralized demand for cooking fuel, mostly wood and charcoal who gain importance as an commercial good[7][8]. Unfortunately, this rise in demand does not go hand in hand with an adequate sustainable resource management. Scarcity and commercialization hinder access to cooking fuel for low income families [8].
- In accordance with current brochures of the World Health Organization (WHO), more than three billion people still cook with traditional fuels inside their homes. The resulting indoor air pollution is responsible for more than 1.5 million deaths per year. Millions more suffer every day from breathing difficulty, stinging eyes and chronic respiratory disease[9].

To meet this tremendous demand with adapted solutions, logistical and technological innovation is required. The quality of products and services and effective consumer protection instruments play a crucial role for a sustainable implementation of those innovations.

2.2 Microenergy Economics

According to the International Finance Corporation and the World Bank, the expenses for lighting are already consuming an average of 33% of the household income in Africa [5]. Looking at all the other common MEAs, it can be assumed that energy costs come up to half or more of the monetary income.
But SMEs and households in the microenergy sector are not only facing increasing running costs for energy, the inferior efficiency and quality of MEAs is an additional burden that makes people pay much more per energy unit and thus increase production costs compared to households and entrepreneurs in the conventional energy sector. In her former research, the author has calculated a price of 1,70 US$ per kWh that households in the microenergy sector in Bangladesh have to pay for lighting and entertainment while the subsidized price in the conventional energy sector of Bangladesh was 0,05-US$[1][10].
Furthermore, there is a range of indirect economic effects due to the worse conditions for education given e.g. the poor quality lighting and the exposure to health hazards due e.g. to indoor air pollution caused by traditional cooking MEAs[9].
Another phenomenon that has been observed by the author during her current research, is the vast spread of plagiarism in markets where users do not have the opportunity to defend their rights because of missing effective consumer protection instruments and product warranties: In many cases, the savings of many years were invested in a solar system, a diesel engine, a household appliance or a productive machine with parameters branded wrongly. Consequently, those MEAs are not working at all or not as they should.

2.3 The role of Certification in Consumer Protection and Innovation enhancement

Product certification is the process of certifying that a certain product has met a predefined set of quality standards. The certification process is not only a proved consumer protection instrument, it is also helpful in leading innovation into a predefined direction by a regular renewing of the standards

[1] As a comparison – The average price for a kWh in Germany is 0,3 US$.

towards a normative goal like e.g. higher energy efficiency. It also leads to the standardization of products and services.
Certification is generally processed through a governmental organization or a neutral entity which is accredited by government. It also requires regular governmental control. The challenge of the implementation of a certification procedure for microenergy systems lays in the fact, that the microenergy sector is highly informal and governmental control almost impossible. In this case, innovative solutions for consumer protection are required.

3 THE INNOVATIVE FUNCTION OF MICRO FINANCE INSTITUTIONS

Against the background of the former chapter, it can be summarized that the dominating MES in the microenergy sector are poor in quality because they:

- cause high running costs due to energy inefficiency
- have indirect economic effects due to higher risks for health and basic educational restrictions
- bear high investment risks due to widespread plagiarism

All these factors make the dominating MES very expensive and thus offer a great economic substitution potential for better quality energy systems which are more efficient and can be run with renewable energy[5][4][10]. But in most cases, the investment costs are so high that the target group can not afford them. Credit financing is required. Furthermore there is a lack on reliable supply chains who can assure sustainable availability of services and protection against plagiarism.
Since the year 2005 was declared the *United Nations Year of micro finance* and Muhammed Yunus and the Grameen Bank received the Nobel Prize for Peace in 2006, micro credit has become well known as a successful tool to reach the poor in regions with weak infrastructure and low incomes[11].
Microfinance is not only an instrument that splits high investment costs into affordable monthly installments, it is also offered through Microfinance Institutions (MFI) that maintain a whole network with close relationship to their customers. Credit clients have to be assessed, credits have to be disbursed, installments have to be collected and failures have to be followed up and, in the last case, collateral have to be recovered.
The implementation of MES through MFIs offer a very innovative approach to meet all the challenges described:

- Micro credit offers the possibility to overcome the investment barrier as customer can pay the costs in installments. Those equal the savings the user makes on running costs of fuel thanks to better efficiency [4][10].
- The cost of the MES is now more subject to the impact of the technology than to the social status of the customer and his ability to pay in cash. This way, the focus in product design is shifting from a single low-price-orientation towards the adaptation and the quality of the MES.
- Moreover, the mechanism of credit financing described above also offers the opportunity to include social and ecological standards for MES, which hence can be produced and traded under sustainable development policy aspects.
- MFIs offer an attractive backbone for integrated Product-Service Systems (PSS) due to their institutional network and their expert knowledge of the socio-cultural and economic conditions in the microenergy sector – This fact opens up a range of opportunities for better quality control of the life cycle of MES and thus for better quality products and services in the microenergy sector [12].
- The fact that customers ability and willingness to pay back the loan depends from the performance of the financed microenergy system, makes the MFIs having a high economic interest in assuring quality. This makes them to an attractive potential non-governmental stakeholder in a certification procedure for the microenergy sector.

Currently, the World Bank assumes that more than ten thousand MFIs worldwide offer credits to the poor. The micro credit summit, an international organization that evaluates the development of the industry, counts almost 155 million borrowers in the year 2007[13]. At current stage, only an estimated 20 to 30 MFIs have experienced financing MES. Some of them have been successful, others are facing challenges and are not able to seriously expand their business[10][14].

4 RESEARCH DESIGN

The author assumes that the quality of products and services are a crucial success factors for the microenergy business and that a certification procedure with quality standards reflecting the needs and success factors of MFIs and their clients can enhance the development of the microfinanced MES industry who can by this way become an important stakeholder for consumer protection in the microenergy sector. Furthermore, the evaluation methodologies of the MFIs can give important impulses to MES designers who hence can improve and develop adapted solutions.
The research is focusing on one hand on the microfinance industry, looking for the reasons why only so few MFIs are financing MES and what are the main challenges. On the other hand, the MES industry and life cycles are analyzed with the goal to find out the best way to implement quality standards and consumer protection instruments. In the following the main research questions and assumptions are listed:

4.1 Research Clarification

A number of obstacles and challenges keep MFIs from starting or developing their already existing MES business

I. **Assumption 1**: The reasons for underdeveloped financial services for MES are:
   - missing knowledge regarding the requirements of MFIs in terms of product quality in the MES industry
   - difficulties for MFIs in evaluating and comparing MES regarding quality issues using the existing certification instruments.

II. **Assumption 2**: Certification is an supportive instrument in overcoming the challenges described in assumption 1, it can help:
   - MFIs to start a MES business
   - grow their already existing MES business
   - translate the requirements specification of the MFI industry into target specification for the MES industry

III. **Assumption 3**: The Product Service System Approach is helpful for
   - a comprehensive description of MES
   - the comparison and evaluation of MES

The author has chosen a data driven approach and her research activities have been undertaken with different MFIs at different stages of MES implementation to find out if product quality was a major criteria.

- An MFI skeptical about MES
- An MFI willing to introduce MES
- An MFI starting to introduce MES
- One MFI which has been successful for years and is currently struggling with the MES program
- One MFI which is successfully implementing MES

Because the implementation status is the leading criterion, research was done in various countries: Uganda, Tanzania, Sri Lanka, Bangladesh and India.
Furthermore, 15 economic and political stakeholders were interviewed in Germany and in the US.

4.2 Descriptive Study I

To specify the requirements of the MFIs a vast amount of data has been collected for this project, partly by the author, partly by associated researchers.

- Qualitative and quantitative empirical research among existing and potential users:
  - 3 participatory observations in Uganda
  - 60 individual interviews in Uganda, Tansania and Sri Lanka
  - 8 focus group discussions in Uganda
  - 54 questionnaires in Tanzania
- 15 expert interviews with different stakeholder of MFI and MES industry and policy
- 17 efficient MES implemented were inspected and analyzed in order to find out typical technical weaknesses during the usage-period.

The main conclusions will be described later in the paper

4.3 Prescriptive Study

Based on the outcome of her initial descriptive study, the author has developed a first draft of an instrument that aids MFIs in comparing and evaluating MES. The instrument is described in details in Chapter 6 of this paper. It has been discussed with stakeholders and other researchers with the following results:

- A workshop concept addressing MES designers was developed for the second descriptive study. It is based on the Product Service System Approach[12]. The goal of the workshop is to work out if and how the criteria identified can be integrated into the product design process of MES as well as to find out whether there is a way to standardize the procedure. Standardization is an important step toward certification, as described in chapter 2.3.
- A second workshop concept will be developed to address MFIs during the second descriptive study. The goal of this workshop is to find out if and how the criteria identified can be integrated into the development process of an MES business and whether the procedure can be standardized.
- Based on the outcomes of the MES inspection, a training concept for users and service technicians will be developed and evaluated in cooperation with different MFIs.

4.4 Descriptive Study II

The last period of the research will focus on the evaluation of the training and workshop results and on making recommendations for a certification process or, depending on the results of the evaluation, propositions for another adequate instrument which will support the sustainable implementation of MES through MFIs.

5 FIRST RESULTS

In the following, the current results of the initial descriptive study are summarized:

5.1 Income Generation Focus

As shortly described earlier in the paper, a certification process requires a normative goal, a benchmark towards which it leads technology development. The author has chosen the first Millennium Development Goal (MDGs) as the benchmark for the certification process.

The eight Millennium Development Goals were promoted by the United Nations Millennium Declaration in the year 2000[15]. 192 United Nations member states and 23 international organizations have committed themselves to achieving them by the year 2015. A particular aspect about this declaration is that these goals are of quantitative nature and that all signing members have to develop a strategy how to reach them. Those 8 goals are listed below:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and promote women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

The author chose the first goal because it is the one generally shared by the microfinance industry: MFIs often evaluate their work towards reaching MDG1; against this background it makes sense to evaluate MES regarding their ability to support this goal. It means that the contribution to enhancing income generation for the MFI customer is the most important factor.

For this reason, the identification of the clients' needs means mainly an assessment of the income generating activities of the clients of the MFI as well as an analysis of the role that energy can play to help the business grow.

5.2 Revision of the Energy Sector View

The author had to revise her view on the energy sector. Research has shown that splitting the energy market into a conventional and a microenergy sector is not sufficient, especially regarding

electrification because a lot of *off-grid* households and SMEs physically exist within the conventional energy sector and thus have other boundary conditions regarding income generation through energy because they compete with businesses using cheap and subsidized grid electricity and not with others who also use kerosene or batteries.
Especially in the African context, microfinance is prevalent in urban and semi-urban areas and only slowly developing in rural communities. For this reason, the majority of microfinance clients in the African context lives in off-grid conditions competing with businesses in the conventional energy sector and thus needs other solutions than clients living off grid in the microenergy sector. The research in Uganda, for example, has shown that an efficient MES offering light is an adapted solution in the microenergy sector, but off-grid clients in the conventional energy sector have a much more evident need to run fridges due to their competitive situation with their on-grid neighbors. Both needs require very different MES: While the need for off-grid lighting in the microenergy sector can be met by a solar system which is financed, supplied, installed and maintained by a PSS approach of the MFI, the need to run a fridge requires access to grid electricity. In these cases, MFIs can offer loans for grid connections and use their institutional size and position to provide access to a low income target group in the conventional energy sector.

5.3 Technology Neutrality

Although both needs (light/fridge) are related to energy, solar systems and grid connections require very different technological approaches and therefore have different life cycles and supply chains. One main problem that has been identified during research is that MFIs which are willing to start or develop an MES business are often approached by stakeholders representing a certain technology and thus have predefined expectations towards the results of market- and field research.
To go into field or market research with fixed expectations towards a certain solution hides the risk of self-fulfilling prophecy. This is why the consultation of stakeholders neutral to technology for the initial determination of MFI clients' energy needs and for product and service development has been identified as an important part of the process towards assuring sustainable solutions for the target group.

5.4 Requirements towards appliances and service

Research has shown that even the installation of best quality appliances can still lead to system failures due to wrong installation, insufficient training of service and customers as well as plagiarism even regarding support technology like cables and measurement instruments.
These challenges require the control of key parts of the supply chain and all kinds of activities to ensure the quality of the energy supply for the customers. A lot of innovation is required here, especially regarding service. This is why a certification should not only focus on the quality of the appliance, but also evaluate service offered.

5.5 Strategy towards MDG1

As described at the beginning of this chapter, a certification requires a normative goal. This goal should be difficult to reach. Against the background of the research results, the author concludes that reaching the target group of MDG1, which is defined as people earning less than a dollar a day, will be the biggest challenge. This is why the certification will also evaluate the strategies of the businesses towards reaching MDG1.

6 THE MICROENERGY CERTIFICATE

All results have been summarized and fed into a first instrument draft that will be the backbone of a certification procedure later on.
The certificate can be used as an evaluation tool and as a means to compare modern MES. It will be fitted to the *Product-Service-Systems* offered by MFIs. Moreover, the certificate aims at stimulating product development, production and the implementation industry.
Figure 2 gives an overview of the first draft of the certification procedure.

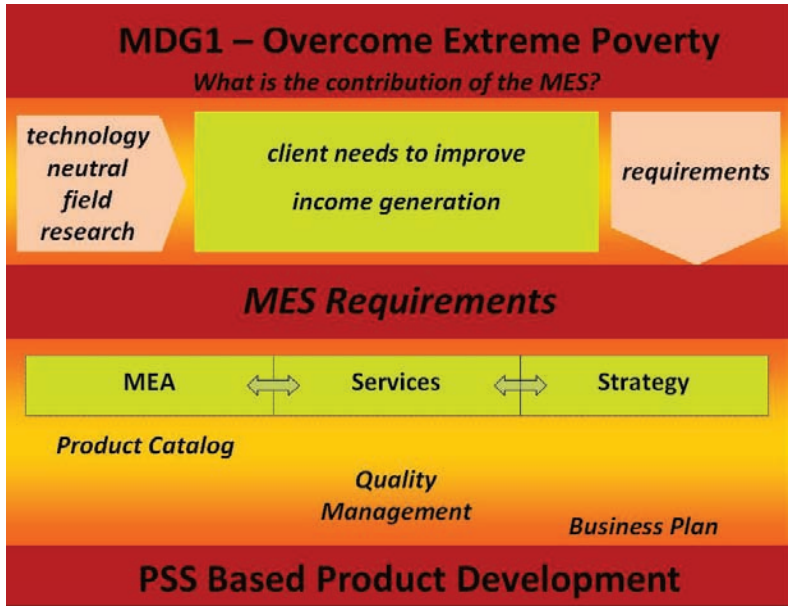

Figure 2 - Comparison & Evaluation Instrument

The requirements of the MDG1 "Overcoming Extreme Poverty and Hunger" and the question how the MES is contributing to this objective – these are the focal points.

Through technology-neutral field research the income generation activities of MFI clients have to be identified. Once this is done, the link to energy and how it can contribute to meeting the demand has to be found. By doing so, the requirements of the MES can be deduced.

If the instrument is used to evaluate a MES which has already been implemented, it has to be measured with these requirements. For the design and optimization of a new MES, the *Product-Service-System* approach [12] is used. Three aspects of the MES are now relevant:

1. The **Microenergy Application** is the artifact within the MES e.g. a Solar Home System including all its components. In this case, existing certification procedures such as PV-GAP [16] should be used for evaluation.
2. The **Microenergy Services** summarize all the activities undertaken by the implementer of a MES along the part of the life cycle he controls. The first descriptive study has shown that the control of large parts of the life cycle is a crucial success factor. Evaluation of these aspects should be done using quality management tools such as ISO 9000 and ISO 14.000. To evaluate social and ecological production conditions, standards used by institutions like the International Finance Corporation (IFC) should be implemented.
3. Some of the requirements may neither be fulfilled by the Microenergy Application nor by the Microenergy Services. In this case, the **Microenergy Strategy** is an important business development tool used by the implementer to show how he is planning to meet these requirements in a middle or long term.

This instrument can help evaluate MESs, but it does not offer a suitable possibility yet to compare various MES. This will require a standardization of the indicators and of the entire procedure. Results are expected after the second descriptive study.

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The combination of practice and science has always been specific for the career of Noara Kebir: She started as a trainee for machines and systems at Siemens Corporation and graduated while working in half time as a technician for service and maintenance in the same company. She got her diploma with great distinction in energy and process engineering at the Technische Universität Berlin/Germany in 2004. After an energy research project in cooperation with the microfinance institution Grameen Bank in Bangladesh, she founded the Company MicroEnergy International in 2003. The company supports microfinance institutions developing energy programs and is active in many countries in Africa and Asia. Actually she is completing her PhD at Technische Universität Berlin and the University of Luxembourg.