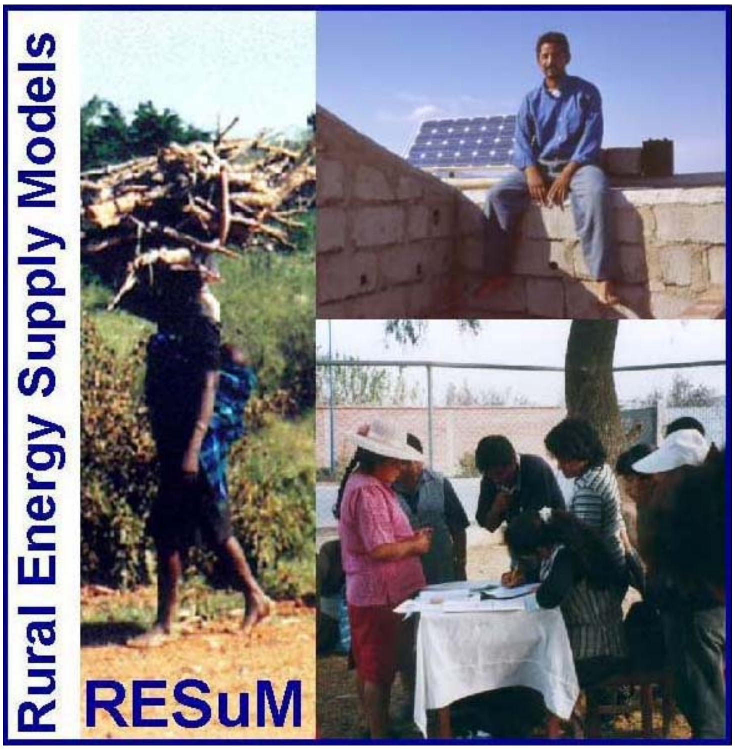
ISES
International Solar Energy Society

Rural Energy Supply Models

- RESuM -



Executive Summary

This study was realised on behalf of the

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

July 2001

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1 Introduction

The necessity of reliable and affordable energy supply is a crucial point of discussion in developing countries, especially in the context of economic development and as a measure against poverty. Today, 77 % of rural households in developing countries are not connected to the grid, i.e. a total of two billion people world-wide is without access to electricity. As the populations of developing countries are continually growing, each day there are more people without electricity.

Grid extension is frequently not an option – the average consumption load is too low to justify the high cost of infrastructure. Decentralised stand-alone systems powered by diesel generators, hydro power, wind or photovoltaics (PV) are technically and commercially a viable alternative to grid extension. Cost calculations show that renewable energy systems in particular are very often ideally suited for decentralised rural electrification as they make people in remote areas independent of fuel deliveries and prices, they are best exploited on a small scale, and they are highly reliable. Therefore, local key players demonstrate substantial interest in alternative solutions.

The large number of households to be supplied however makes different demands on the involved actors, and new challenges like infrastructure development arise. For this reason, governmental institutions in many countries have started to adopt a rather market based approach to rural energy supply, and more and more private companies are involved in rural electrification activities. However, market and infrastructure development have in this context not yet been investigated, and it is a major objective to understand the mechanisms related to this important application.

The project on “Rural Energy Supply Models (RESuM)” deals with this subject-matter. Aim was the provision of a qualified instrument as a guide for governments, business, and financing organisations to providing energy to rural areas using renewables.

The project results are intended to help bridge remaining knowledge gaps on suitable models for market-based energy supply in rural areas. If the knowledge about indispensable requirements and certain obstacles to the dissemination models for rural electrification spreads, mistakes will be avoided in future projects, whereas promising strategies, adapted to the special conditions in the respective countries, may be given preference in similar future projects.

2 Approach and Proceeding

The focus of this study is on deployment models. These are regarded at business-level, i.e. at the level of interaction between the customer and the system or service provider, with the central question being: “How to get the product to the end user?”. The product could therefore either be an energy supply system for auto-generation, e.g., a pico-hydro system, or the energy service, e.g., electricity.

This study therefore collates and summarises information on the set-up of different deployment methods as well as experiences made with them. These are shown in a structured format to give a good overview of possible approaches and models.

This in itself does not recommend any certain model, since for deployment efforts of course the general framework and conditions need to be taken into account, such as e.g. already existing infrastructure, institutional surrounding, etc. Also, it is clear that different approaches may exist and be used in parallel. All of them have their advantages and disadvantages and may be more or less appropriate under given conditions and depending on the goal of the executing agency.

2.1 Method of Investigation

As a first step, a survey of existing programmes and projects for rural electrification based on renewable energy sources was realised. The search was carried out through the internet, literature and personal contacts. For those projects and programmes that were considered relevant, more detailed information was gathered by turning to contact persons who have been involved in some respect. Information could be submitted by answering a detailed questionnaire.

In parallel, a characterisation of RESuM was developed. This was done partly based on knowledge project partners already had, and partly on new information generated through information collection.

Advantages and key barriers (referring to the organisational process of projects) of the different models and their modules were worked out. In parallel a catalogue of critical success factors within the models was developed (see Chapter 3).

To get reliable results, a wide range of expert opinions was surveyed and included in the study. An internet discussion platform was developed for this purpose and expert workshops took place.

Final adjustments were then made to complete the RESuM theory and practice. The result is a structured presentation of different energy supply models, their characteristics, advantages and disadvantages. This structural analysis is supported by project examples for each category.

In Chapter 3 of this executive summary, only four of seven possible models are described: For more information, please consult the complete report or the website under http://resum.ises.org.

3 Rural Energy Supply Models

3.1 Cash & Carry

In the cash and carry scheme, customers buy an individual power supply system on a cash base. The ownership is directly transferred with the payment and the customer is responsible for installing, operating, and maintaining the system. Thus, the cash and carry business only comprises a sales infrastructure.

A fundamental advantage of cash & carry is that little capital is necessary for doing business, as only a minimal infrastructure is necessary and the system provider does not need to pre-finance the hardware. This means, that the system provider's financial risk is rather low.

Cash & Carry: Pico Hydro Systems in Vietnam

In Vietnam there is a business of selling pico hydro systems (100-200 W) for households following the cash & carry model. The systems are sold for cash on the markets in Hanoi and other northern province cities by shops that sell other electric equipment, like pumps or second hand generators, or that repair electric motors or agro mechanical equipment.

In the package there is a small explanation in Chinese on how to install the system. However, since there are already many installed (some say about 100,000), the people who buy a system can resort to those that are already are installed. There is no guarantee or after sales service provided by the shops or outlets. The users take care of operation and maintenance and might bring the generator to a local repair shop.

The installation is done by customers themselves with the help of friends or local technicians. People seem to manage, and their own constructions seem to work, but due to bad installations or tubing they may not get the full output of the system. The wiring (which may be too thin) is another limiting factor. As a result, a 100 W rated system may only produced enough power for a 15 W lamp and a radio.

Also, the customer being owner of the IPS system presents a specific advantage, as ownership increases responsibility, thus, may improve the care for the system. The immediate transfer of the ownership title indirectly reduces misunderstanding regarding agreements on O&M as responsibilities are extremely clear.

In contrast to these specific advantages, the cash and carry model also carries specific risks:

As a system failure only affects the system provider on the long-term and indirectly, there is a general risk that low-quality components are used, especially, as high quality components increase the system price. For the same reason, the system provider may limit user training to the provision of a manual for installation, use, and O&M. Consequently, systems may be installed improperly, and wrong components or inappropriate electric appliances may be used.

To avoid the problem of installation mistakes, it is necessary to assure sufficient user know-how at least in form of a **clear installation manual**. Besides, the system provider could offer components with **error protection** to prevent problems with the system due to installation mistakes. Additionally, the system provider could improve the chance for expertly done installation by sustaining **a network** of local technical partners.

To avoid the problem of use and operation, and maintenance mistakes, it is necessary to assure sufficient **user know-how** at least in form of a clear manual, better with additional user training. Herewith, information on the electric appliances, which can be used in the IPS system must be provided. Moreover, the system provider could establish **co-operation with local shops** to improve the provision of appropriate spare-parts like fuses and distilled water.

Regarding the quality issues, global key players like governments or NGOs, could initiate global measures like the realisation of **awareness raising programmes** or development of **national quality standards.**

Generally, the rather low market potential in consequence of the disability of the target group to pay the system on a cash base presents a fundamental barrier of this RESuM. To increase the market potential there is the possibility to offer:

- **smaller systems** meaning a lower price
- **modular systems** which enable a system extension according to economic capacity of the customer.

3.2 Instalment Credit

In this RESuM, the technical and the financial flow are separate, although interlinked. This means, that a technical intermediary (the system provider) who is responsible for the technical service like provision of the hardware, installation, operation and maintenance, and a financial intermediary (commonly a microfinance institution), who is responsible for credit disbursement and collection business, are involved. The customer pays an individual power supply system with a credit channelled from the financial institution to the system provider.

Most advantages of the instalment credit model can be derived of the structural advantage of involving a financial institution:

A main advantage of the instalment credit model is the reduction of the collection risk due to the fact, that financial experts are doing the credit disbursement, including the borrower screening, and the collection business.

As the system provider is pressured by the MFI to make sure that the systems works – so that credit is being repaid - he will make sure, that installation is expertly done, the system is in good condition, offer basic O&M service, and assure good user instruction.

Also, the access to capital for refinancing is improved, as the MFI's access to capital is much better than the system provider's.

The high market potential of approximately 25% is another advantage of the instalment credit model.

All the same, the instalment credit model, too, comprises problems and key barriers: The identification of a financial partner institution may be difficult, because of their low presence in rural areas. Further, financial institutions often still consider renewable energies to be a new technology, which makes it difficult to assess the technical risk connected to a credit for rural energy supply systems. A rather common and general barrier exists regarding communication between financial and technical experts: little effort is made to understand each other's business, and to identify the chances, effects, and challenges of a co-operation.

Instalment Credit: SELCO Solar Lanka Limited, Sri Lanka

SELCO Solar Lanka Limited (SSL) sells SHS through cash sales as well as through instalment credit, in partnership with its main micro-financing partner - SEEDS.

If customers take advantage of financing, they pay 10% as down-payment, and the remaining amount plus interest divided equally between the number of months their loan is for. Generally, they pay approximately US$10-15 a month. When a system is sold on credit, a contract is signed between SSL, the customer and the financing agency. It states that SSL installs and undertakes to maintain and service the system. The installation is carried out by technicians who are SSL employees, qualified by in-house training programmes. During installation, user training is provided. The customer is also given a user manual and clearly told how to use the system and what to expect of it.

SSL will further be attending to routine maintenance and complaint calls for free during the first two years and against a nominal charge from then on. The customers are not only offered lights or electricity, but also guarantees that it always works. The customers are given warranty cards which clearly state that they can expect service within 24 hours if a system does not work. The system is warranted for one year. Components are guaranteed according to the suppliers' warranties. The agreement between the SEEDS and SSL clearly states that the company has to provide adequate servicing to the customer. This is of great importance to the SEEDS, for if customers are dissatisfied with service, they stop paying their loan.

Payment is collected at the customer's house by the financing agency solar officer. In case of non-payment, customers are given three months to make good on the loan default, otherwise the system is repossessed by the solar company, on the advice of SEEDS.

The main problem encountered initially was the lack of access to financing, which seriously limited the market. This was resolved with the involvement of SEEDS. Advantages SSL encountered were that by keeping the installation and servicing in house, they can maintain a high quality of service, which together with the quality of product ensures that the customer feels a bond with the company and will not go elsewhere.

Still, it is extremely difficult to overcome problems, which lie in "natural " structures, measures can be taken:

A main problem exists regarding the strategic alliance between the system provider and the financial institution. Especially on the part of the financial institution, confidence in the partners and the choice of high-quality and reliable partners are fundamental. This might be a problem, as the financial institution is not an expert on rural energy supply. In consequence, there is the risk, that the financial institution chooses a "bad" partner or that its readiness for entering a new business field is low due to lacking know how.

This problem can only be overcome by laying down **clear definitions of duties, rights, and responsibilities** in the co-operation agreement. On a global level, **consultancy** could be offered for the identification of high-quality system providers. Also, national **quality standards** might ease the judgement of partners.

Regarding the low presence of formal financial institutions in rural areas rather **informal financial institutions** like credit associations or rotating saving and credit associations (ROSCAs) could be approached for doing the credit disbursement and the collection business. Still, such institutions normally lack good access to refinancing sources.

For raising the awareness of financial institutions regarding renewable energy IPS systems, the system provider could for instance install a **demonstration system** in the rural branches of the financial institution. For raising the awareness for each other's business and to identify joint interest in co-operation, staff exchange could be done for example in form of

practical trainings. This also facilitates the identification of interest overlaps.

These measures are extremely important, as they could increase market penetration in the instalment credit model: borrower screening technology for “Rural Energy Supply Loans” could be adapted and interest rates reduced due to an existing high quality collateral.

With two parallel infrastructures, operational costs for the whole business are comparatively high. To increase cost efficiency, the two partners could offer **bundled services** in co-operation, for example energy, water, micro technologies for agricultural purposes etc.

3.3 Finance Leasing (Hire Purchase)

Customer leases the IPS system for payment of regular leasing fees; system provider owner during leasing period; ownership title transferred with payment of residual amount; system provider installs the system; customer responsible for O&M; typical system provider: NGOs, dealers, intermediaries in “aid” projects

Market potential is comparatively high in the hire-purchase model, especially compared to the cash category, and even compared to the credit category. This is a main advantage of the hire-purchase model, particularly as the scheme is regionally not limited to areas, where a financial institution might be present, as the system provider himself is responsible for channelling financing and for the collection business.

The system provider being responsible for the installation is an advantage, as installation mistakes can be limited due to expertly done installation.

The customer is responsible for O&M. As mistakes in use, O&M affect the providers property, the system provider, he will make sure, that the system is in good condition, offer basic O&M service, assure good user instruction, and access to spare parts

Leasing: Power supply through SHS, Swaziland

In 1997, a leasing system for Solar Home Systems was established in Swaziland.

The product consists of a 40-50 W PV panel, a 5-10 A charge regulator, a 96-105 Ah battery and four 7-15 W lights. The whole package comes with installation, cabling, and mounting materials.

The cash price of a system is US$ 525. For the financing option, customers have to pay a deposit of 25-30 % of cash price, an interest of 2 % above prime interest rates, and they have a maximum repayment period of 36 months. Ownership of the system is only transferred after the full payment.

The complete system is guaranteed for one year. Within this period, any parts will be replaced by the supplier free of charge. After that the customer has to pay for maintenance and replacement.

Information on the systems is spread through a whole range of different actions like road shows with drama group, demonstration stands at trade fairs, radio advertisements, etc.

With Swaziland being so small (everybody knows each other or at least somebody close to that person), informal networks have generally been used to check the creditworthiness of the customers. There have been no strict rules, the only conditions being that customers should prove they are either employed, have a pension or earn sufficient money from their own business.

The system is installed by one of the suppliers’ technicians. For O&M however, users are themselves responsible. There are no regulations laid down in the contact on how to use the system.

For payment collection, people preferred to come to the shop. In the beginning (first two years) repayment discipline was very good. With more and more failing batteries and hence non-performing systems, the default rate has increased.

It is estimated that 1-2% of all rural households (generally those who are better off) are reached through this mixed approach.

On the other hand, the customer operating and maintaining the system provider’s property also presents a main barrier of the hire-purchase model, as mistakes in use increase the technical risk on the part of the lessor.

To overcome this problem, it is necessary to assure sufficient **user know-how** in form of a clear user manual and through good user training, e.g., during the installation. Further, information on the electric appliances that can be used in the system must be given. Moreover, the system provider could establish **co-operation with local shops** to improve the provision of appropriate spare-parts like fuses and distilled water. Also, the lessor could offer **O&M service contracts** at least during the leasing period.

The collection risk presents a key barrier in the hire-purchase model. Fee collection is done through system provider's staff, who are in general no financial experts and are often highly integrated into the local social structures. On the other hand, traditional financial institutions consider this collection risk to be that high, that typical system providers have difficulties in accessing financing. A significant collection and refinancing problem is the result.

The collection risk can be limited by **"financial" training** of the provider's staff, focusing on the collection business and **co-operation with financial institutions** for fee collection. Further, local technicians could be supported through **"urban" trouble shooters**, who are not part of the social structures and who may intervene if the system/components have to be removed in case of non-payment.

To overcome the problem of refinancing, it is important to improve the **communication** with the financial intermediary and raise their awareness for the renewable energy technology and rural customers potential. Further the system provider needs to try to understand the view, business and interest of the financial institution and improve the **quality of his business plans**.

In addition to measures taken by the system provider himself, more global measures can be taken, e.g. through governments, NGOs or others:

To improve the system providers' access to financing in the hire-purchase model, these players could **realise awareness raising programmes** for renewable energy technologies as well as rural energy supply focusing on financial institutions. Moreover, they could train system providers in **developing and realising high-quality business plans**.

3.4 Fee-for-Service

The customer pays regular service fees for electric service through individual or village power systems; the service provider is owner of the system and is responsible for installation and O&M; typical service providers: dealers, service companies (e.g. utility)

Two main advantages do exist in the fee-for-service model:

One, the fee-for-service model is a long-term model, thus the conception, business, infrastructure, and financial calculation are designed on a long term. In consequence, quality is of fundamental significance, among others for components, installation, technical service, and staff. Thus, the technical service is not only expertly done, but often also at higher quality. Long-term design is also the reason, why the service fees are comparatively low.

Two, in consequence of the former aspect, compared to other RESuM, a very high market potential of approximately 50% can be reached. Such market penetration is of special meaning in the context of national rural energy supply programmes.

On the other hand, the elevated requirements in the fee-for-service model, obviously lead to substantial specific problems and key barriers:

The long-term design of fee-for-service businesses with long-term technical and financial binding implies risks, as it may be difficult to take consideration of important short-term changes and integrate them or follow technological progress. To reduce this risk, the service provider should become a player in a **second hand market** for energy supply systems. To limit the financial risk, the service provider should **limit stocks** and **limit the amount of imported products** not to be affected strongly by fluctuations in the exchange rate.

Fee-for-Service: Soluz Honduras, S.A. de C.V.

Soluz's rural energy delivery operations provide PV systems to rural households and businesses on a fee-for-service basis in addition to cash and credit sales. Around 70% of the installed systems are fee-for-service, which has become the most popular model.
By maintaining ownership of the PV system assets, Soluz is able to provide them at affordable monthly rents, ranging from US $10 to $ 20, prices equivalent to that now paid for kerosene, dry cell batteries, and the recharging of car batteries.

Under the fee-for-service provision, the service is defined by the rental of a particular size PV system (20-100 W) and includes a certain number of lighting fixtures. Ownership of PV systems is retained indefinitely by the company, however, the battery is the property of the customer.

Soluz Honduras has local installation technicians (employees of the company) who are responsible for the complete installation. All maintenance is included in the monthly fee. Systems are maintained by zone managers and their assistant technicians. Verbal training is provided at the time of installation. Printed materials in Spanish are also provided. Service calls occur in the event of failure, no visits are made for preventive maintenance. Customers have guaranteed service, and the company aims to remedy failed systems within a specified time. Customers are responsible for simple maintenance tasks such as adding distilled water to the battery. When the battery reaches the end of its life, the customer purchases a new one, typically from Soluz Honduras on a payment plan.

Payments are made at rural collection points that are responsibility of Soluz Honduras collection agents. There is monthly contact at these points. The agents are contracted by the company and are not employees. The collection rates are essentially 100% in that either the payment is collected or the system is collected. Incentives are used to motivate collection agents and zone supervisors. Non-payment results in the rapid removal of the rented system.

In some areas, up to 50 % of the population are reached through fee-for-service. Customers care for their systems because they want to continue Soluz Honduras' service. The main problems encountered with fee-for-service and the credit approach is the significant capital that needs to be raised.

The extensive infrastructure needed for the fee-for-service business is extremely capital intensive, regarding up-front and continuous investments, as well as operational costs. Thus, the service provider needs an impressive amount for pre-financing, and bears a huge financial risk. To lower the investments for building up the infrastructure, the service provider could try and identify existing infrastructures, which could be used for the fee-for-service business. Investments in training the staff in existing infrastructures could be more cost efficient. Entering a **joint venture with other rural service providers** (e.g., LPG), and sharing costs of infrastructure can present a viable solution. Such co-operation might also present a possibility to lower operational costs. Also, to improve cost-efficiency of the infrastructure, the service provider could offer **bundled services**, meaning offer services like water or telecommunication in addition to electricity.

Further, the customer never gets owner of the energy system, thus incentive to use the system in a careful manners is lacking. As the customer uses the property of the service provider, careless use increases the technical risk, which is borne by the system provider. **Sufficient user know-how** through providing a clear installation manual, and intensive user training should be realised. Additionally, it is necessary to inform the customer on the electric appliances, which can be used in the system and even **limit the free choice of appliances** by contractual regulations. Further, making the customer **owner of at least part of the system**, at best a strategic component like the battery, should be approaches as ownership increases responsibility.

The identification of reasons for system failure presents a huge problem, especially as service is guaranteed and definition of the responsibility for system failure is important. To limit arising problems, at least **mechanical measures,** like sealing, should be realised.

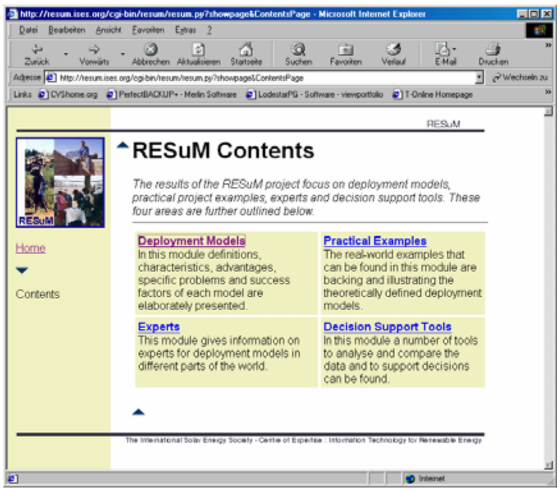
In case of fee-for-service comprising metering or pre-payment systems, the necessary equipment may not be available, as products currently available are not suited to RE applications. (e.g. high self-consumption) To remove the problem of lacking meters/pre-payment systems, etc., it is necessary to **develop new technical components**. Supportive programmes or financing for the development of innovative components might be offered by governments.

4 Web-application

In accordance with the political aim of the last G8 summit, a main consideration in the development of this project was global accessibility of the results through the internet. Therefore an integrated internet platform was created as a tool to enable users from all over the world to participate in the global debate, allowing them to exchange ideas, discuss them and cooperate in their realisation.

Therefore the RESuM project was deemed to require an extensible information dissemination platform that would not only make the results of the activity available to as wide an audience as possible, but also to allow for comparison and decision making support. As a dynamic environment was required, it was decided to create the site in the form of a web application, which would allow scientific project team members the ability to update, create and manipulate content at will without requiring web publishing skills.

The system is made up of four content areas, as may be seen below.



4.1 Deployment Models

This area contains the various deployment models, categorised, structured, described and illustrated.

The categories are briefly described, with an elaboration of the theoretical modalities of each category available. The individual models resorting under each respective model category are in turn described so that an intelligible overview may rapidly be obtained.

Each model is described in detail in terms of various sets of modalities. These include Contract and Regulations, Project Procedures, General Issues, Advantages, Barriers and Critical Success Factors.

Each set of modalities may be inspected individually, or alternatively all may be displayed, especially useful for printing and archival purposes. For each deployment model, links are automatically provided to example projects, where the model is used in practice, as well as to experts that have practical experience in the implementation of the model and that may be consulted should questions remain unanswered.

4.2 Practical Examples

Practical examples illuminate real world projects in which one or more of the described theoretical models where utilised are presented in this content area. All example project descriptions result from the analysis of material provided by experts and organisations from all over the world. The material has been standardised to coincide with the theoretical structures presented elsewhere, and are available by deployment model used and by region of implementation.

A facility has been created whereby additional, unreviewed projects may be entered by third parties anywhere using only a web browser.

4.3 Experts

As in the case of example projects, experts that have indicated their willingness to be consulted on issues relating to specific deployment models are listed both by model and region in this content area.

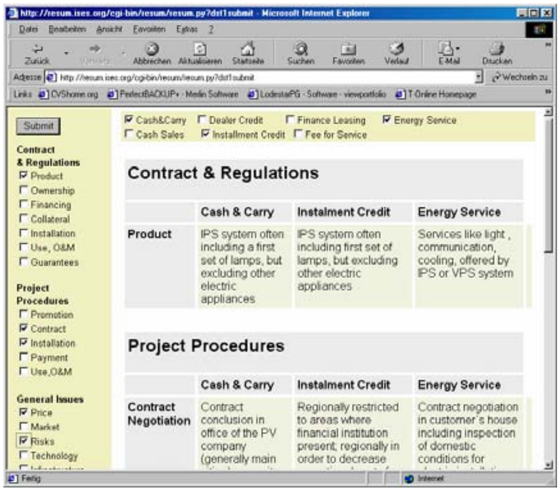
Here also, a facility has been created so that individuals wishing to share their experience and expertise on specific implementation models may add their information.

4.4 Decision Support Tools

The area of decision support tools contains two tools to allow for selective display of the information contained in the system, allowing for direct access to relevant information as required by the user.

At this stage, two decision support tools are active: DST1 and DST2. DST1 allows for the direct comparison of model specifics across areas of modality and models. An example of the output of DST1 is presented below:

The integrated DST2 is a rapid information display tool to allow for access to and comparison of project and experts based on regions of relevance and related models. As such, it simplifies the task of finding projects and experts that may be of use as background information or consultative partners in the regions of choice within the framework of the models of choice.



5 Outlook

5.1 Dissemination of Information

Information on the results of the RESuM project will be provided in printed and electronic format (CD-ROM and internet). The described internet platform provides state-of-the-art information management functionalities for the exchange of ideas with experts and to facilitate global access to the information generated during the project.

It is foreseen to realize various dissemination activities during the next time. Among these are awareness raising and spreading information through different newsletters, magazines and other publications. Other dissemination efforts that are planned to reach important actors include the realisation of workshops for utilities, government officials in different countries, workshops for development bank officials, etc.

5.2 Continuation

In view of the fact, that especially concrete project examples and innovative solutions are very helpful and can be replicated, it is our concern that more project information will be entered through the responsible players in the future. As explained, the database is therefore designed in a way that allows its continuous, decentralised extension.

A further aim is the continuation of inter-communication between experts, which is why a discussion forum will be maintained, the list of experts will be extended, and workshops will be initiated as parallel sessions at conferences. Such exchange of experiences is also focusing on further identification of institutions and experts working on similar or complementary subjects to bring the global development forward.

5.3 Future Activities

As mentioned before, this study by no means explored all the relevant levels on rural energy supply, but focused on the relation between the system respectively service provider and the customer.

Especially in the context of market development and governmental rural energy supply programmes, it is important to regard other institutional and organisational levels, which strongly influence the success of the implementation of RESuM. In the context of governmental programmes, the design of a legal framework and subsidisation structures could in a future project be derived from the RESuM structure presented, especially with consideration of financial conditions and needs as well as existing risks on the side of the system/service provider.