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GRS - Garantierte Resultate von Solarstromanlagen

GRS - Guarantee of Results for Grid-Connected Solar Photovoltaic-Systems

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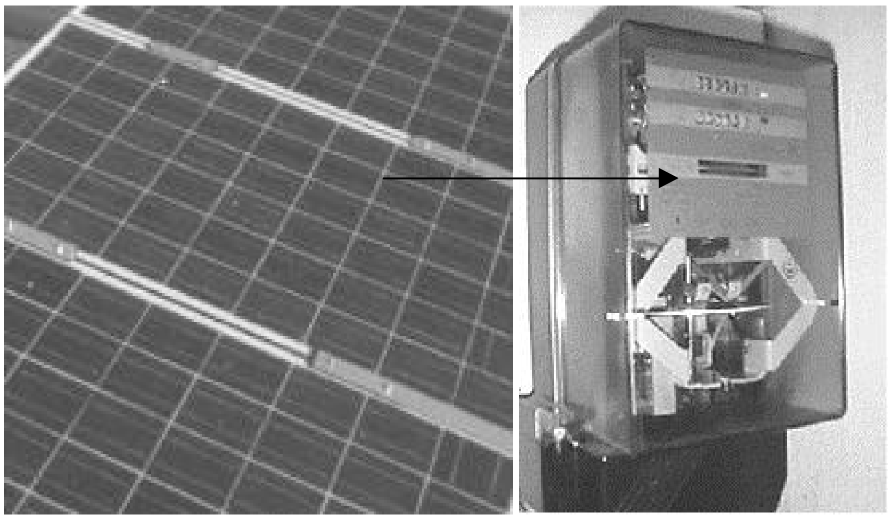

1 Projekt und Personen

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3 Zusammenfassung

3.1 Ansatz

Das technische Risiko ist - neben den Kosten - ein wesentliches Hindernis für eine verbreiterte Nutzung der Photovoltaik. Mit einer Übernahme von Garantien durch die Anbieter würde gleichzeitig die Qualität der Systeme und das Vertrauen der Käufer in die Produkte steigen. Damit könnten wesentliche Hindernisse für die Erweiterung des PV-Marktes abgebaut werden. Garantierte Resultate sind in vielen Bereichen ein gebräuchliches Marktinstrument. Durch die Garantie wird das Vertrauen der Kunden in Produkte und Dienstleistungen gestärkt. Dieses Werkzeug ist besonders wirksam im Falle von teuren Produkten, welche – wie zum Beispiel Photovoltaik-Systeme – mit einem hohen Anspruch an Zuverlässigkeit verknüpft sind. Um die weit verbreitete Skepsis gegenüber dem technischen Stand und der Zuverlässigkeit von Photovoltaik-Anlagen abzubauen, wurde ein Ansatz untersucht, der über die Garantie der einzelnen Systemkomponenten hinaus die Funktion des Gesamtsystemes garantiert.

3.2 Ziel und Ergebnisse

Im vorliegenden Projekt wurden die Rahmenbedingungen für die Einführung von Garantien bei Photovoltaik-Anlagen in der Schweiz in Zusammenarbeit mit Institutionen aus drei EU-Ländern im Rahmen des 'EU-ALTENER 1998 Project Round' untersucht. Neben der Untersuchung für eine mögliche Unterteilung in verschiedene Garantiestufen wurden die Einflussfaktoren für die Erfüllung der Garantien und des Projektablaufes dargestellt.

Ziel der Studie war es, die Anwendbarkeit des 'Garantierte Resultate von Systemen'-Prinzips (GRS-Prinzip) auf Photovoltaik-Systeme in der Schweiz zu untersuchen und die Möglichkeiten und Grenzen sowie auch die Zuverlässigkeit für die Schweiz abzuschätzen und zu beurteilen. Das GRS-Prinzip funktioniert dabei als eine vertragliche Übereinkunft zwischen einem technischen Partner und einem Investor. Der Vertrag dient dem Investor bezüglich der vereinbarten Leistungsfähigkeit des Photovoltaik-Systems als Sicherheit, was die Rückführung der getätigten Investitionen garantieren sollte. Wie jüngste Beispiele in der Schweiz im Rahmen von Solarstrombörsen zeigen, ist dies eine der wichtigsten Voraussetzungen, um entsprechende Anlagefinanzierungsverträge abschliessen zu können. Darüber hinaus können diese Garantien bei der Bearbeitung und Beurteilung von Kreditanträgen als Leitlinie und Benchmark dienen und bei der Ausarbeitung von Kreditverträgen als Sicherheit dienen.

3.3 Beteiligung der Schweiz

Durch die Teilnahme der Schweiz an diesem EU-Projekt eröffnete sich die Chance, im Rahmen von bereits erfolgreich durchgeführten EU-ALTENER-Projekten zum Thema GRS zu profitieren. Falls die EU mit ihren 1'000'000-Dächer-Programmen Ernst machen, so stehen im Bereich der Qualitätssicherung Lösungsansätze wie das GRS-Prinzip oben auf der Prioritätenliste, da ein Anlagenpark dieser Grössenordnung kaum auf eine andere Art sinnvoll und mit vertretbarem Aufwand bewirtschaftet werden kann, um die gewünschten Erfolge sicherzustellen.

Für die Schweiz bedeutete dies, einerseits von erarbeitetem Know-how direkt zu profitieren, andrerseits gab es der Schweiz auch die Möglichkeit, auf die Entwicklung in diesem Bereich Einfluss zu nehmen. Darüber hinaus konnte die international Verflechtung mit den Partnerorganisationen vertieft und die gewonnen Erfahrungen auf ihre Tauglichkeit in der Schweiz hin untersucht werden.

3.4 L sung

Aufgrund dieser Überlegungen wurden im Rahmen der Studie Möglichkeiten untersucht und Hilfsmittel erarbeitet, welche für die sinnvolle Abwicklung von GRS in der Schweiz eingesetzt werden können. Weiter wurde untersucht, wo die Grenzen für ein solches System sinnvollerweise zu liegen kommen und wo auch die Eignung für die Anwendung des GRS-Prinzips möglich, beziehungsweise nicht möglich ist. Um eine Aussage über das tatsächliche Systemverhalten machen zu können, wurden sämtliche Faktoren, welche die Leistungsfähigkeit der PV-Anlagen beeinflussen, berücksichtigt. Dies sind sowohl standortabhängige Einflussparamater, als auch die angewandte Technik und der Betrieb des Systems.

Für die Umsetzung des GRS-Prinzips in der Schweiz wurde in Zusammenarbeit mit den betroffenen Marktkräften (PV-Hersteller, Fachverbände, Finanzinstitute etc.) der Lösungsansatz diskutiert, geprüft und verbreitet.

4 Summary

Grid-connected PV-systems were first introduced in demonstration projects where mainly technical aspects of the systems were examined. The price for the systems was based on the STC power.

With rate-based incentives and the new renewable energy law in Germany it will become important for an investor to be able to calculate the kWh-price from a given system. To link system price and system performance PV-system suppliers should give a performance guarantee.

Evaluating existing projects and contacting important market players established a basis for the development of a draft contract for GRS^{PV}. The projects and contacts showed problems and barriers for using guaranteed results in the different countries. The experiences and the feedback directly influenced the further development of the contract (see chapter 2.1).

The process of definition and development is shown in chapter 2.2. The model contract is published in Germany by the solar magazine Photon. It is a framework with a lot of possible variations and adaptions to special PV projects.

Guaranteed Results are a powerful marketing instrument. They establish confidence and give advantages both to customers and PV companies. Within this ALTENER-project a model contract for grid connected PV systems including performance guarantees was developed. Using this GRS^{PV} method will increase the quality of the systems. Confidence of investors will help to increase the PV market.

5 GRS Experience in Switzerland

The situation in Switzerland is described by investigating 4 case studies, meaning four projects with different conditions and project partners.

A number of contracts described in the case studies were outlined in parts according to the GRS-model contract, and have been negotiated and signed by different PV-suppliers. Because of the timing, the contracts used in these projects incorporated some aspects according the GRS model contract.

5.1 Case Study 1: Large Flat Roof

During the preparation of the call for offer for one of the biggest pv-plants in Switzerland, it became apparent, that the competitive differences of the modules and systems possibly being offered will be rather small. As it holds true that - according to an advertisement of a big PV-Module manufacturer - "not all PV modules are created equal", it is rather difficult for the buyer to distinguish between possible different performances of modules of different suppliers.

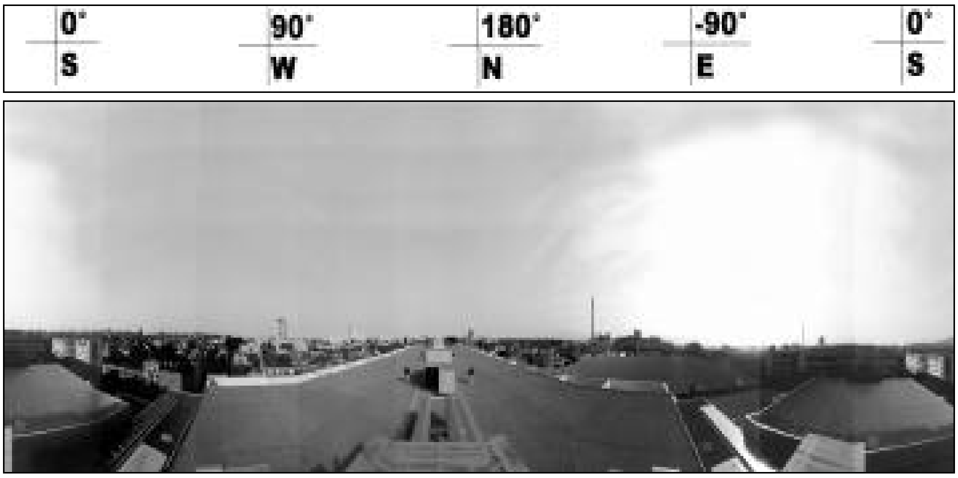
5.1.1 Novelty: Not kWp but kWh Guaranteed

With this background in mind, a GRS approach to the tendering and purchasing process was agreed on with the client. As a novelty, the main parameter for winning the contract changed from the best price per kilowatt peak to the best price per kilowatt-hour produced.

The PV contractors had therefore to estimate and/or simulate the kWh-yield for the system he was offering to deliver.

5.1.2 Horizon Under Special Consideration

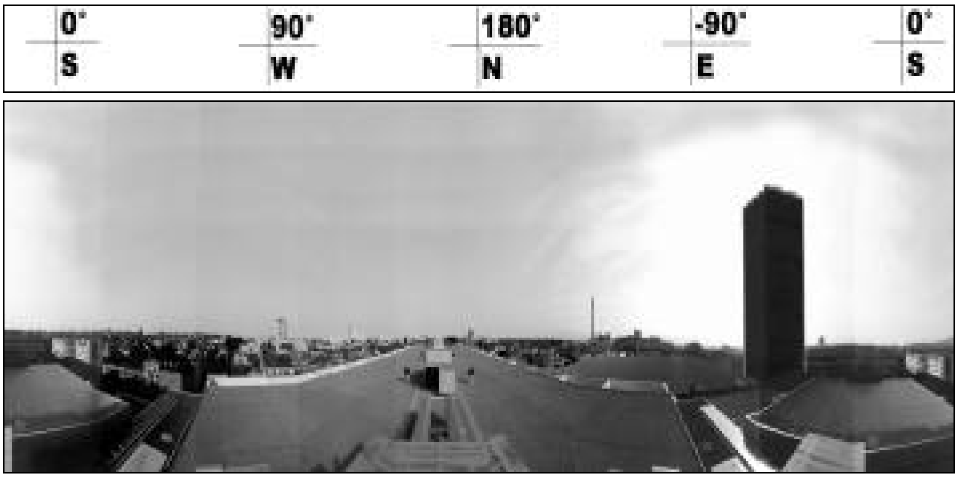
Even though the horizon for the roof top PV-system appeared to be close to perfect (see picture below), special consideration regarding the horizon had to be taken.



Picture 1. 360°-degree panoramic view without tall building

The picture shows the site for the solar PV installation prior to launch the call for offer. It was taken with an ordinary camera and the support tool PanoramaMaster 1.0, then stitched together with the software HorizON 1.0, both products developed by energieburo®.

In close proximity to solar PV installation, a tall building was under planning and expected to be built within the first 18 month of the PV system's operation (see picture below).



Picture 2.: 360°-degree panoramic view with tall building

Here, the site for the solar PV installation with the approximate position and size of a planned building next by is shown. The building will potentially reduce the solar performance of the PV-system. As the object will be built in the first 2 years of the PV-plant's operation, specific measures had to be taken to still insure GRS-performance evaluation.

The PV-supplier therefore was asked to guarantee 2 different yields: one without the tall building being built and one with the tall building. It was furthermore agreed to finalise the details, as the plans for realisation of the tall building would grew more mature and detailed.

As the system was at the time of reporting only four month in operation, so far no reasons for activating the guarantee were in sight.

5.2 Case Study 2: Slanted Roof Top

In the process of tendering larger PV installations, usually one general PV contractor will be issued the contact for turnkey delivery of an installation. As the pv contractor is usually an experienced professional, using proven materials familiar to him/her, it is the rule that what is stated by the offer of a pv contractor is taken for being reliable grounds.

This holds true for most of the Swiss PV market, as the pv contractor in most cases are also the importer and sole retailer for a specific brand of pv modules or inverters and have many years of good workmanship and sound reputation.

5.2.1 Novelty: Re-guaranteed Performance by the Manufacturer

However, as described in this case study, these assumptions cannot hold true when new suppliers with unknown products or unknown performances thereof enter the market.

In this case, ESTI (Ispra) certificates and similar proof are an important marketing tool and most often a prerequisite for accepting an offer at all by the client.

But the ESTI (Ispra) certificate in this case was only a proof of a certain STC-performance, but furthermore was regarded as an indication only for possible yield, but not as a reliable proof of the yield figures stated in the original offer.

In the case of the slanted rooftop PV-installation, a module manufacturer new to the domestic market was interested in delivering the PV modules, but did not posses a local PV contractor organisation.

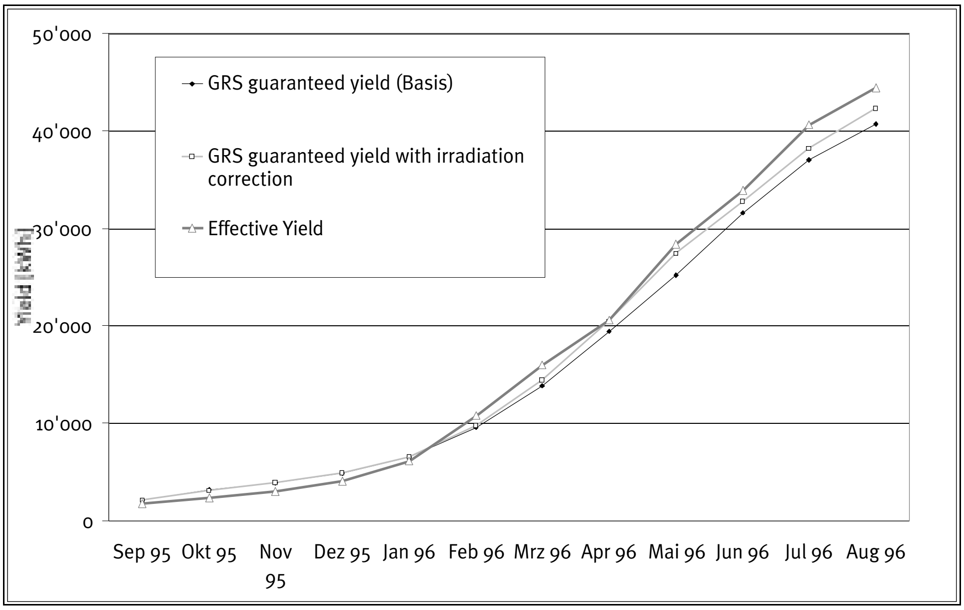
As the PV client still was insisting on guaranteed results in regards to yield, a different solution had to be found. A local PV contractor was found to install the system as a turnkey project, but was unable to sign a guarantee for modules he did not know in regards to their performance in this specific application. After detailed discussion between the PV module supplier, the PV client and the PV contractor, parts of the performance guarantee similar to the now existing GRS model contract was extended on to the PV module supplier.

Whereas the contract for a turnkey project usually is between the PV client and the PV contractor, the PV module supplier issued an additional performance guarantee to the PV client, even though they did not have any other legally binding relationship.

5.2.2 Check of Final PV System Layout

In order to fulfil his guarantee properly, the PV module supplier did test and check the final PV system layout, including mounting structure, shading issues and possible horizon, up till the length of the DC cabling length and cross section. In this way, the performance guarantee could be based on sound engineering practice and fast experience of both the PV contractor and the PV module supplier.

The process of establishing the re-guaranteed guarantee proofed to be critical in the successful realisation of this project. And to date, the system's performance is above the predicted and guaranteed results and yields, as the following picture of the first 12 month of system operation shows clearly.



Tabel 3. Guaranteed and Effective Yield

However, the process of re-guaranteeing took more time seems to be justified on an everyday basis. It is strongly suggested, to further develop and standardise the GRS contract with this possibility being laid out or already being tested and soundly formulated.

It was also found, that it would have saved quite some time to have an existing GRS contract ready to be used. Even though the discussions were positive and in a straightforward matter, many points need to be checked by specialists on both sides for validity and accuracy. In this regard, a further development of GRS can be only encouraged.

5.3 Case Study 3: Slanted Roof Integrated PV System

In this case described, an institutional PV client ordered a larger slanted roof integrated PV system from a PV module supplier and general PV contractor as a turnkey project. The contract between the PV client and the PV contractor consisted of the offer made by the PV contractor plus the usual legal bylaws and specific description for such contractor's contract.

The contract itself was prepared by an architect not familiar with specific PV procedures in regards to contracts or GRS, and it was signed with no GRS-specific articles and deliverables. Being the only PV specialist in the preparation of the contract, the PV contractor himself did naturally not see an urge to push information regarding GRS or similar issues forward. This would have made his live only more difficult, without raising more money for this. As he was the sole supplier asked for an offer, no one pushed the issue and so neither the PV client nor the architect preparing the contract was aware of possibilities such as deliverables similar to GRS demands.

5.3.1 GRS Unknown to Contract Parties

After singing the contract, the PV client decided, that it would be advisable to have a specialised consulting firm overlooking the building process of the PV system and ensuring the quality and schedule agreed on in the contract. This task turned out to be more demanding than anticipated.

The PV client was informed about common measures of PV contracts such as guaranteed kWp-delivery, how to test the modules delivered in regards to their STC-power, how to proceed with underperfoming installations, possibilities such as GRS and similar.

It became clear to the PV client, that he had underestimated the specific technical know-how still needed today to buy a PV system and expressed his surprise, that this industry did not posses any more stringing standards and well established rules.

5.3.2 Introduction of GRS Too Late

As the legally binding contract between the PV client and the PV contractor already was signed, the PV contractor did not see any need or urge to deliver more guarantees such as GRS performances guarantees.

The fact that he might would have been paid more for additional guarantees such as GRS did not really grasp on, because in his eyes it would most likely imply indirectly a hidden recognition that the system he delivered is not of ever best quality and therefor needs a GRS.

It seems, that introducing GRS in the beginning of a PV system tendering process is a valuable and accepted (but not necessarily liked) measure. Introducing it later in the tendering process however seems to have an annoying and disturbing, maybe even al little bit of a discrediting aspect of some sort.

5.3.3 Main Differences To Be Solved

The main differences between the PV client and the PV supplier were centering on topics, which were stated in the contract, but were not specified in detail and therefore gave room to many discussions.

As an example, the commonly used and widely accepted definition of the 10 year minus 10 % STC-power guarantee leaves way too much room for discussion, which quickly turn out to be potentially more expensive then the case they should help to solve. Further points arouse discussion on how to measure the minus 10% power after 10 years, how to take samples in the beginning and at the end of the guarantee period, and so on.

If GRS would have adapted in the beginning, a fair part of this discussion would have been not necessary to this extend.

5.4 Case Study 4: Integration in Insulating Glass Roof

For a building integrated PV system (BIPV) described in this case study, the decision was made to install PV solar cells integrated into large insulating, double glazing glasses. These glasses with an area of about 400 square meters are mounted horizontally and are functioning as a large glass roof over an entrance hall of a big publicly frequently visited building.

Because of the large glass roof pointing southward, the engineering team was considered about possible overheating in summer due to the green house effect. The decision for installing the solar cells was taken after learning, that an outside mounted shading system would be very costly to install and still quite costly to maintain. According to calculations, integrating solar cells into the insulating glass could reduce up to 85 % of the heat load brought into the building by sunrays without increasing the need for additional electrical lighting.

5.4.1 GRS not suitable yet

After detailed analysis followed by discussions with building technology engineers, heating, ventilation and cooling engineers as well as PV suppliers it became apparent, that a GRS approach for guaranteeing performance and yield was not the path to go.

It was found, that possibly too many factors beyond the control of the PV supplier would made it impossible at this stage of technological development, to accurately predict the possible yield of such systems.

5.4.2 Single Module test not suitable either

Also, the rather common practice of sampling a few modules and send them for flashing and calibration to a solar test installation such as ESTI was not a way to go either, because of the magnitude of such a module.

One single module had the size roughly of a king size bed and was weighing with its 55 mm thick cross section over 300 kg. In addition, the module was permanently sealed into the roof structure and a heavy mobile crane was necessary to install the modules, not be before having closed a main city road for traffic by the police.

5.4.3 Conclusion

Under this circumstances it was agreed, to ensure quality and performance by means of on-site measurements upon installation and putting into operation as well as one year later. This data was compiled and calculated together to form the basis for the upcoming guarantee period. As much literature suggests, this procedure leaves room for a number of measurement errors. In addition to this, it was also rather costly.

An applicable GRS would be of much value for demanding BIPV solutions such as the one described. Upon understanding more about the factors affecting the performance of the system, more detailed and precise forecasting and estimation can be done, which is the starting point of any GRS in effective operation

5.5 GRS Conclusions Concerning Switzerland

The main principle behind GRS - the guarantee of a simple measurable performance instead of a lengthy and costly investigation - is nowadays covering more ground in Switzerland. Especially in larger installation, hardly a PV contract is signed without a performance guarantee similar to GRS.

If the decision of the PV client to buy a certain system is increasingly shifting towards a simple look at the price per kWh ratio, the tendency of overestimating the possible yield by the system supplier is anticipated. It is feared that the promised yields will rise above the sound and realistic basis only in order to try to win a contract. This shall be compensated by GRS-penalties, which have to be paid by the PV supplier in case his system is under performing.

As it was found with most PV clients, they are interested in good, reliable, well prized systems, but not in penalties. The question, how to determine a yield guaranteed in an offer being though ambitious but realistic or being too hopeful and over ambitious will always remain. It probably can be put into correct correlation by experiences and good estimated judgement only.

A GRS-contract deals with technical, organisational, financial and legal issues. This clearly shows the importance of having a guideline for a GRS-protocol that deals with all the details and gives options for dealing with varying issues. This ensures that the people involved in drawing the contract would require less input from specialists.

Introducing GRS in the beginning of a PV system tendering process seems a valuable and accepted measure. Introducing it later on in the tendering process appears to have an annoying and disturbing, or even a little bit of a discrediting aspect of some sort.

In none of the projects described, the two-year period of the contract has ended yet. For one project, the first completed year was above expectation. A real test of the contract occurs, when the performance guarantee has not been met.

The main differences between the PV client and the PV supplier mostly centring around topics, which were stated in the contract such as power performance, but were not specified in detail and therefore gave room to many discussions. As an example, the commonly used and widely accepted definition of the 10 year minus 10 %, 20 years minus 20 % STC-power guarantee leaves way too much room for discussion, which potentially are more expensive then the case the should help to solve. In this regard, GRS can help initially.

Because GRS performance usually runs only for the first two years, the 10/10 20/20 guarantee still is needed. In this regard, the existing GRS is still unsatisfactorily and need further development

It is proposed to further test and refine the protocol in a follow-up project. The result of this project and the follow-up project can be brought in to a proposal for a European guideline. The time it takes to establish has clearly shown that standardisation of performance guarantee contracts is necessary.

6 GRS Experiences in Other Countries

6.1 The Netherlands

6.1.1 Introduction

The contract negotiation in the projects discussed below occurred parallel to the development of the draft GRS-PV-contract in most cases and all were started before the draft contract was developed. Therefore, the exact framework of the draft was not adhered to, although most individual items were covered. The differences between the draft-model contract and the actual contracts will be discussed per project.

The characteristics of the projects differ substantially from one project to another. For clarity on the type (size, etc.) of the projects, table I summarises the characteristics.

	Nieuwland	CO_2-balance homes, Leeuwarden	Annen
Location	Amersfoort	Leeuwarden	Annen
Project size (kW)	1300	69	188
Placement PV	500 homes a kindergarten a sports hall 3 school buildings	15 'CO_2-balance' homes	Ground based array on terrain of water company
Ordered by	Utility REMU	Utility Essent	Utility Essent
Supplier(s)	Shell Solar, BP Solar, RBB, Colt	Solarned / BP Solar	Solarned / BP Solar

Tabel 4. Project characteristics The Netherlands

6.1.2 Overview

To summarise the GRS-PV experience in the different projects, table II gives an overview of the different contract features in terms of the items of the draft GRS-PV model contract.

	Nieuwland-Shell	Nieuwland-BP Solar	CO_2-balance homes, Leeuwarden	Annen
Duration	1 year	1 year	1 year	5 years
Guaranteed energy yield				Increases from 90% to 100% of final guarantee over course of 5 years
Site initial conditions	Shaded homes not taken into account	Correction for shading applied	Agreed on correction for shading	
Meteorological reference conditions	TRY De Bilt, De Bilt	TRY De Bilt, De Bilt	TRY De Bilt, Leeuwarden	TRY De Bilt, nearby meteostation
Limitations	Because of poor failure detection void if failure happens and stays unnoticed		If soiling ⇢ 5%, correction will be applied	
Determination normalised yield	No correction for failure; agreement void if failure occurs	Correction for period of system outage	Correction for period of system outage	Missing yield in periods of failure estimated on basis of insolation in that period
Failure detection	No good failure detection			
Finances	No financial part	Payment up to 10% of investment if Y-normalised ⇠ 0.95*Y-guaranteed	Payment up to 10% of investment if Y-normalised ⇠ 0.95*Y-guaranteed	Payment up to 20% of investment if Y-normalised ⇠ 0.95*Y-guaranteed. Compensation price of fl 0,79 per missing kWh
Dispute settling		Independent expert	Independent expert	

Tabel 5. Overview GRS-PV contract features in the different projects

6.1.3 Nieuwland, Amersfoort

Within the Nieuwland 1 MW PV project a performance guarantee was asked from the PV-suppliers as the final part of an extensive quality control program. In Nieuwland, 500 homes, a kindergarten, three school buildings and a sports hall have been equipped with PV. Within this project a lot of work was done on the technical part of a performance guarantee.

The same conversion method was employed for comparison of predicted yearly yield and measured yearly yield as was employed in the model GRS-contract (see Article 8 of the model-contract). This method is as simple as possible, leaving as little room as possible for discussion afterward. An error analysis was made to examine with what kind of accuracy this method could be employed.

For the Dutch situation, it turned out that this comparison could be made with an accuracy of 5-6%. This accuracy can vary somewhat, depending on the distance between the PV-system and the nearby meteorological station. These results have been reported earlier.

With two turn-key PV-suppliers in the 1 MW project negotiations on a performance guarantee have been carried out. In the Nieuwland project, the negotiations on the performance guarantees came after the contract for the general delivery was made, which affected the nature of the contract. The performance guarantee contract made with one supplier (Shell Solar) could be described as a formal system check rather than a real performance guarantee. This entails that a formal procedure is followed to check the performance of one system that is considered to be representative of all systems in a given housing block, but there is no financial repercussion if the performance requirement is not met. Before signing the document an issue concerning shading of some of the houses came up. This had not been addressed explicitly in the document.

Of one of those sections where Shell Solar was the supplier the performance guarantee has now finished. The measured yearly yield exceeded the guaranteed yearly yield and no repairs needed to be done.

In case of the second supplier (BP Solar) the negotiations for the protocol had finished, but delays were encountered in signing the document. When it finally came to signing the document, the supplier argued for a revision, because in the mean time it had turned out that a newly developed inverter had some problems, the chimneys nearby the PV-systems had turned out to be higher than planned, and so on.

Also, even though all houses are monitored individually, these data are collected through smart cards that are collected every half year. This frequency is not enough for GRS-purposes and required a change in the earlier draft of the protocol.

From the Nieuwland project the following can be concluded:

- it took a lot of work to establish the accuracy of the technical procedure. This was necessary to get more confidence in the procedure and to convince the suppliers of the validity of the procedure.
- It took a lot of work to finalise the details. This clearly shows the importance of having a guideline for a GRS-protocol that deals with all the details and gives options for dealing with varying issues.
- There should be a monitoring system and - procedure that fulfils GRS-requirements (availability, reliability, and accuracy).

6.1.4 CO_2-balance homes, Leeuwarden

GRS-contract negotiations between Ecofys and Solarned, Dutch supplier of BP-Solar modules, started in December 1999 and were almost finalised in February 2000. The GRS-contract was part of an overall contract of the Dutch utility Frigem, which is now part of Essent. The whole contract as a whole (including the GRS-part) was signed a few months later.

The main differences between the contract for the CO_2-balance homes and the model contract are itemised below. The items that were not covered in the CO_2-balance homes-contract were:

- Article 7, limitations, were not stated explicitly, but a general remark was made (see below).
- Article 8, determination of yield, was covered, but the way of dealing with system outages (Article 8.2) was different. In the Essent contract, system outages are not taken into account in the GRS-period. The advantage of this is that no assumptions need to be made on the theoretical yield during the outage period, but the disadvantage is that if such outages occur frequently, the GRS-period may be too short to determine the yearly yield accurately enough. There is no restriction in the total length of the outage periods.

Items that were covered more explicitly in the CO_2-balance homes contract than in the GRS-model contract were:

- Much more detailed agreements were made on the delivery of monitoring data to the PV-supplier. In the GRS-contract, it is assumed that the PV-supplier takes care of failure detection and monitoring the system. In the CO_2-balance homes (and in many other PV-projects in the Netherlands), this is not the case. The PV-client takes care of monitoring. On the other hand, the PV-supplier should be responsible for interpreting the data and determining whether something is wrong with the system or not. This gives a necessity for making detailed agreements on delivery (frequency and timeliness) and quality (accuracy, reliability of collecting all data) of monitoring data.
- In addition, this last issue adds another limitation to the responsibility of the supplier: if the PV-client does not supply the data, does not

supply them in a timely manner or if the monitoring systems fails and a fault occurs in this period, it will be detected too late and the PV-supplier cannot be held accountable for loss that occurred in this period.

- Because the PV-supplier does not have a daily update of system performance, an additional article was put in to ensure that the PV-client will warn the supplier as soon as possible if they have notice that the system is not working correctly.
- There are limitations to the responsibility of the PV-supplier. These limitations are not itemised, as is done in the model contract (Article 7). Instead, if the supplier considers a given yield loss not to be his responsibility, the burden of proof lies with the supplier to show this.
- After each outage period, PV-supplier and PV-client have to agree on which days do not count (i.e. they have to agree and the starting and ending date of the outage period). This has to be documented in a logbook.
- It is stated that if soiling is more than 5% and the PV-supplier can show this, this will be taken into account in corrections afterward.
- At the end of the GRS-period one of the parties will have to make a report (on the outcome, calculations, which outage days etc.) and both parties have to agree on it.
- In Article 9 of the draft contract it says that the PV-supplier is responsible for failure detection. What is not stated, is that a supplier should have time to react and correct a fault. It is questionable whether the PV-supplier should be held accountable for the yield loss occurring in the first few days after a fault has been reported. The model contract does not deal with required reaction times for PV-suppliers. In the CO_2-balance homes contract it has been agreed that the PV-supplier gets time to react.

From the CO_2-balance homes project the following can be concluded:

- It took a lot of work to establish all the details in the contract. Special attention was put into making clear and separate (in a legal sense) the responsibilities of the PV-supplier and of the PV-client.
- A GRS-contract deals with technical, organisational, financial and legal issues. This clearly shows the importance of having a guideline for a GRS-protocol that deals with all the details and gives options for dealing with varying issues. This ensures that the people who draw the contract have an easier job and require less input from specialists in these issues with every new contract they make.
- There should be a monitoring system and - procedure that fulfils GRS-requirements on availability, reliability and accuracy. The model GRS-contract should explicitly state any of these requirements or should refer to a document where this has been laid down. This is at present

not the case. Current monitoring guidelines do not fit the specific GRS-requirements.

- A GRS-contract makes it necessary to keep some kind of logbook to record unusual events, system outages and the like. This is necessary to avoid confusion and disagreement between parties.

6.1.5 PV-Annen

The contract for PV-Annen (a 188 kWp ground based array on the terrain of a water company) is quite similar to CO_2-balance homes. A notable difference is that there is a five year period taken as GRS-period. The required yield increases from 95% in the first year to 100% of the final yield guarantee in the fifth year. Missing yield in a given year can be compensated by surplus yield in another year.

6.1.6 GRS Conclusions Concerning The Netherlands

Four GRS-PV contracts have been negotiated with two different PV-suppliers within three different projects. Because of the timing the contracts used in these projects were not made according to the exact format of the model contract. However, in three of the four cases, most of the issues are dealt with in a similar manner, with some notable exceptions. It was noted that in all cases, the monitoring situation was more complicated than assumed in the model contract, which made additional articles necessary.

The conclusions from the experiences with these projects are the following:

- A GRS-contract deals with technical, organisational, financial and legal issues. This clearly shows the importance of having a guideline for a GRS-protocol that deals with all the details and gives options for dealing with varying issues. This ensures that the people who draw the contract have an easier job and require less input from specialists in these issues with every new contract they make.
- There should be a monitoring system and – procedure that fulfils GRS-requirements on availability, reliability and accuracy. The model GRS-contract should explicitly state these requirements or should refer to a document where this has been laid down. This is at present not the case. Current monitoring guidelines do not fit the specific GRS-requirements.
- A GRS-contract makes it necessary to keep some kind of logbook to record unusual events, system outages and the like. This is necessary to avoid confusion and disagreement between parties.

In one of the projects a contract has ended successfully. For another system the performance guarantee period has started recently. The other two systems still have to be commissioned before the performance guarantee period can start. A real test of a contract would be when the performance guarantee would not be met. This has not happened yet. To fully test the model contract, (1) contracts would have to be made according to the proposed format, (2) they would have to be carried out until the end of the performance guarantee period and evaluated and (3) enough tests should be done so that some projects are included in which the performance guarantee turns out not to be met. This will really put the protocol to the proof.

It is proposed to further test and refine the protocol in a follow-up project. The result of this project and the follow-up project can be brought in to a proposal for a European guideline. The time it takes to establish has clearly shown that standardisation of performance guarantee contracts is necessary.

6.2 France

6.2.1 The GRS context in France

Grid connected photovoltaic installations, in operation or under construction, are very rare in France today. This is due to the absence of a preferential sales price. The principal constructions are :

- 150 installations linked to the 'Phébus' project that have been built since 1992, or are in construction. Most of these installations are small PV generators from 1 to 2 kWp in private houses. The electricity generated is injected into the grid by means of an EDF electricity meter. Therefore, the sale price is the same as the electricity price billed to the client by EDF. This system, tolerated by EDF, has been made official by the Ministry for Industry. The installed power production is less than 500 kWp.
- A few important installations that have been built or are planned (a total of 500 kWp planned) within the framework of the European programme 'Hip-Hip'. In this case, the buying price is also expected to be the same as the electricity sale price practiced by EDF.

It has been decided that the buying price could be raised significantly to help the PV industry. The corresponding overcost would then be covered by a special fund. The ways in which this will be applied have still not been fixed, inspite of the announcements that have been put off several times.

Nevertheless, things are changing slowly : interesting buying price has been announced last December for wind energy.

6.2.2 Prospects for GRS-PV in France

In this context, it is difficult to define the details for a GRS-PV precisely. The existing projects are still mainly actions of communication for the clients involved, without consideration for the financial balance.

The potential contractors are interested by the GRS concept but their principal problem is to have a clearly defined electricity buying price in order to contact their clients on a sound basis. Opinions vary as to the interest of the GRS concept during the market take-off phase : certain consider that it would be more interesting in a second phase of market growth, when sufficient numbers of visible installations have been built.

Owing to our experience of the thermal GRS, we have contacts with certain large groups or institutions who are also potential clients for PV systems. Thermal GRS is considered to be an important factor for the decision makers when buying a thermal solar installation. A similar effect can be expected for PV. However, the importance of the thermal GRS is partialy due to the bad technical and economic image of thermal solar owing to the examples of inefficient installations in the past. This doubtful background doesn't exist for photovoltaic systems and it is possible that GRS-PV is less "necessary" for certain clients.

It seems that there is a real interest for GRS-PV in France, but a precise estimation cannot be made before reasonable economic conditions concerning the buying price for PV electricity are established and applied. Therefore, the following notes are liable to change in relation to future decisions.

6.2.3 Professionnal contacts in France

In order to gain some replies from french market players professionals have been interviewed for the evaluation of the GRS contract:

- Total Energie, Mr. StéphaneRegazzoni, 69890 La Tour de Salvagny
- Apex BP Solar, Mr. Pierre Courtois, 34270 St. Mathieu de Tréviers
- Solelec Caraïbes, Mr. Alain Vial-Collet, Christian Jonathan, 97122 Baie-Mahault

These are the principal French constructors selling PV systems. A synthesis of their remarks and recommendatons has been included in the following chapters and in the articles and comments of the model contract.

6.2.4 Methodology and presentation

We have considered the role that could be played by the GRS-PV as a tool for market development. So we have centered our analysis on different elements of the GRS-PV in relation to their effect on potential commercial activity. Furthermore, the following factors have been taken into consideration :

- the experience gained from Thermal-GRS
- the technical and financial constraints linked to the GRS
- the present opinions of the potential market suppliers
- the characteristics expected by the potential clients for PV installations

It must be remembered yet again that the finalisation of the GRS-PV in France cannot be effective before that the economic conditions for grid connected photovoltaic plants are defined and applied .

6.2.5 GRS Conclusions Concerning France

The precise definition of a grid connected GRS-PV protocol is not possible at present in France. The economic conditions needed to build a significant number of installations are not fulfilled. It is impossible to define the corresponding market. This problem should soon be solved and it will be possible to make real progress. The potential suppliers are interested in the GRS concept, but not during the start up phase of the market.

The following points seem to be important for finalizing the GRS, at least in France :

- The interest as well as the technical and economic feasibility of a GRS contract for grid connected photovoltaic installations is agreed.
- The final definition of the GRS should take the potential clients opinion into consideration.
- The GRS contract causes costs, largely independent of the installation size. If an installation is too small it cannot be covered. It would seem, on the basis of the present procedures and on the expected buying prices, the level at which it could be applied is about 10 kWp. A guarantee for small installations would require another approach which needs to be defined.
- It seems essential that the GRS-PV must be recognized as a real guarantee. All the clauses that encourage the client to think that the supplier is limiting his responsibilities should be avoided.
- The pay back time seems to be the most pertinent criteria for the client. It is essential that he has the feeling that the GRS effectively guarantees this pay back time, except in an extreme case. All the articles should be considered and written with this in mind.

- Consequently, the following ideas and formulations which effect the pay back time, in reality or in appearance, penalise (1 & 2) or are risky (3) for the success of the GRS :
  1) the guarantee depends on the weather
  2) the reimbursement is limited to 20% of the investment
  3) it isn't the real production that is considered but a corrected production.
- The fixed reduction principle (about 20%) on the theoretical estimation (which doesn't generally interest the client) could eliminate these clauses. After our experience, the client, almost always prefers a pay back time a little longer but really guaranteed, to a pay back time a little shorter with a guarantee under conditions.
- The GRS implies, like all guarantees, a risk for the supplier. The level of the acceptable risk must be defined (this implies real case studies) with reference to statistics and the market. If the risk isn't acceptable, there must not be a guarantee. But if a guarantee is proposed, it must appear valid to the client. Otherwise, one has no impact on the market, or much worse, if the client has the feeling that he has been cheated, one penalizes the market over the long term .
- Finally, as soon as the first installations are ready (see also chapter 2.3 Intoduction), we will try to apply a french version of this contract, i.e. including the above remarks and proposals, collected from the main professionnals.

6.3 Germany

The new renewable energy law (EEG) of April 2000 finally focussed the discussion in Germany on kWh not on kWp. With a fixed feed in price of 0,99 DM/kWh the generated energy is the most important point.

Clients and their interests are changing. In addition new players enter the market. Solar suppliers have to consider these changes. Guaranteed results are a powerful marketing tool under these circumstances.

But even before the EEG some type of guarantees were used in different projects.

6.3.1 Green Tariff

One of the biggest utilities in Germany, the Rheinisch-Westfälische-Elektrizitätswerke AG (RWE), started a green tariff project in 1997. Customers could pay additional 0,20 DM/kWh for a certain number of kWh. RWE gave the same amount of money and built wind, water and photovoltaic energy systems with it.

In order to ensure the energy yield for the customers, a lot of measures within a quality control program were started. RWE tried to get state of the art technology and installations. The experts of the Fraunhofer Institute Solar Energy Systems advised and supported the quality control program.

6.3.1.1 Shading Analysis

Normally optimal locations were selected for building the PV systems. Critical locations with partial shading were analysed. By using simulation software the best positioning of the PV generators was investigated.

6.3.1.2 Component Tests

Some of the most important components like modules and inverters were tested at the Fraunhofer ISE. One manufacturer improved his inverters within this project.

6.3.1.3 Commissioning

When commissioning the systems detailed STC power measurements were done to control the delivered power of the systems. Most of the systems did not reach the nominal power.

6.3.1.4 Monitoring

All of the systems were equipped with a monitoring system which records data and is able to send automatic alarms in case of failures. The data is collected and analysed in a central database.

6.3.1.5 Guaranteed Results

There was no guarantee of kWh, but the suppliers had to guarantee a certain STC power. As most systems did not reach the nominal power (see commisioning), some suppliers had to accept penalties.

6.3.2 PV on Estate Houses

The PV system was integrated in the roofs of 80 estate houses in Bremen. It was a demonstration project by the local utility and a housing company. Although there were no penalties fixed in contracts also a lot of measures were taken to ensure the quality of the system.

6.3.2.1 Shading Analysis

The partial shading of the first row of houses was analysed after the first year of operation to investigate the resulting energy loss.

6.3.2.2 Component Tests

Some of the modules were tested before mounting. A detailed analysis concerning electromagnetic compatibility in the houses was done.

6.3.2.3 Commissioning

Also STC power measurements were done to control the delivered power of the system.

6.3.2.4 Monitoring

The system was equipped with a monitoring system. Data was recorded and analysed by the utility itself and reported to the European Commision.

6.3.2.5 Guaranteed Results

There was no guarantee of kWh or kWp. The system power was checked by module tests and STC measurements. No penalties were fixed.

6.3.3 Jointly Owned PV System

A 100 kWp system in Ulm was organised as a jointly owned project. The supplier was a PV expert himself. He also was and is responsible for installation, operation and maintenance of the system. Therefore he was able to give a guarantee of kWhs over 15 years.

6.3.3.1 Monitoring

The systems is equipped with a monitoring system which records data and is able to send automatic alarms in case of failures.

6.3.3.2 Guaranteed Results

As in Ulm there were higher feed in prices for photovoltaics of 1,89 DM/kWh, he also would have to pay 1,89 DM for each kWh less produced. Of course he is working hard to reach the guaranteed production.

6.3.4 Industry PV Project

For a industry company a 50 kWp system was designed to produce 50 % of their energy consumption. In this case not only kWh but also peak power reduction and marketing aspects were important points.

Design and installation was done by a partner solar company. Commissioning was done internal only.

6.3.4.1 Monitoring

The solar system is equipped with a monitoring system, which records data and is now able to send automatic alarms in case of failures.

6.3.4.2 Guaranteed Results

The system produced more than 50 % of the consumption in the first year. But in the third year some failures were detected to late and caused energy losses of 20 %. Therefore the monitoring system was improved to send automatic messages.

With the EEG the peak power reduction was stopped and all of the generated energy is fed into the grid.

6.3.5 Overview

Project	Site Cond.	Contract	Commis.	GRS-Test	Penalty	Post GRS
RWE (green tarif)	- optimal conditions - no simulation - shading analysis if necessary	STC power	- STC measurement - commis-sioning by expert - component tests	- no results ≈ 800 kWh/kWp	- based on kWp STC	- monitoring - expert advise
Estate Houses (Demon-stration)	- optimal conditions - partial shading. - analysed after first year	STC power	- STC measurement - commis-sioning by expert - component tests - EMV analysis	- no result ≈ 750 kWh/kWp	no	- EU monitoring - string analysis for failure detection is missing
Jointly owned	analysed, expert knowledge available	perfor-mance guarantee	internal	15 years	1,89 DM / kWh	- automatic monitoring (PV-Control)
Industry	- design by experience - optimal orientation. - little shading	50 % of energy consum-ption	internal	1 year	no	- no - minus 20 % in 3rd year

Tabel 6. Overview Projects Germany

6.3.6 GRS Conclusions Concerning Germany

The evaluated projects show that already some types of guarantees are used and in some cases even penalties are foreseen. Usually this were still power guarantees. With the renewable energy law and higher feed in prices this is changing rapidly.

Clients and investors ask for safe basis for financial calculations and so they need safe numbers from the suppliers.

Estimating a higher yield with GRS, e. g. 900 kWh/kWp instead of 800kWh/kWp, and a feed in price of 0,50 Euro per kWh, shows also the possible budget for the measures which are necessary for GRS:

better results, means 800 900 kWh/kWp*year because of GRS	1 % of costs (7.500 EURO/kWp)	5 % of costs (7.500 EURO/kWp)	better results over 20 years
1 kW ⇢ 50 EURO/y	75,-- EURO	375,-- EURO	1.000,-- EURO
5 kW ⇢ 250 EURO/y	375,-- EURO	1.875,-- EURO	5.000,-- EURO
10 kW ⇢ 500 EURO/y	750,-- EURO	3.750,-- EURO	10.000,-- EURO
20 kW ⇢ 1.000 EURO/y	1.500,-- EURO	7.500,-- EURO	20.000,-- EURO
50 kW ⇢ 2.500 EURO/y	7.500,-- EURO	18.750,-- EURO	50.000,-- EURO
100 kW ⇢ 5.000 EURO/y	15.000,-- EURO	37.500,-- EURO	100.000,-- EURO

Tabel 7. Possible Budgets for GRS Measures

The table above shows that for systems bigger than about 20 kW there is a possible budget which makes it possible to finance additional GRS measures. So these systems are the most interesting ones for the introduction of GRS.

7 Conclusions

Situation is different in each country. With higher prices per kWh guaranteed results get more and more important. The next chapters show the process of developing a model contract.

By providing a framework for a GRS-PV contract, the project results will facilitate the use of performance guarantees by the PV turn key supplier. GRS^{PV} will lead to improved quality for the PV systems and ensures that clear agreements are made on operation and maintenance of the system.

Also, the transfer of the model contract to an accepted quality standard is considered. With a proven contractual framework and the further utilisation of GRS^{PV} the confidence of potential investors and thus the PV market will be increased.

8 Draft GRS Contract

8.1 Development of Draft Contract

8.1.1 Definition of The Type of Guarantee

The first point of the kick off meeting in Augsburg was to define the most suitable type of guarantee on which the project should be focused. Of course a lot of different guarantees are possible. Material is often covered by the manufacturer but also giving maintenance guarantees (e. g. exchange time of inverter after failure) would increase confidence in PV technology.

After also discussing some other possible types like interest rate on investment, it was decided to concentrate on a type of performance guarantee. , because, for the grid-connected PV-market in Europe this is the most important deliverable for a PV-system.

It is the generated energy what counts for the customer. So it is much better to move from promised kWp to proofed kWh. In addition it is easier to check the energy yield of a year than to measure the STC power in the field.

8.1.2 Definition of Possible Applications

The next step was to gather the possible applications of GRS in each country regarding also the results of the project evaluations (see chapter2.1).

Especially applications with higher refunds are very interesting. So there are the cost effective refunds, the green tariff projects and other green pricing contracts. With the new renewable energy law in Germany all systems above 20 kWp are very interesting.

GRS can also be applied to conventional calls for tender and turn key projects.

8.1.3 Definition of Benefits From GRS^{PV}

It increases confidence in PV technology for investors, utilities and especially for new customers. Therefore the market can be enlarged significantly.

Customers will get much more transparency for their buying decision, the life cycle cost analysis and the evaluation of offers.

It is a kind of consumer protection as technical actors will be responsible for their promised values.

Installers can use it as a powerful marketing tool. They will be able to deliver higher quality.

With the focus on system performance, not on STC power, system quality will be improved.

GRS will function as a standardisation tool.

8.1.4 Definition of Barriers for GRS^{PV}

Providing guarantees will cause additional costs and therefore additional efforts for sellers. Maybe the PV industry will not support the introduction of GRS. There may be fear of long term agreements.

Maybe awareness will be raised, that PV is risky, difficult, and dangerous.

Those who should give the guarantee have to be integrated.

Besides there is always the problem who decides in case of a conflict in interpretation of the GRS-contract.

8.1.5 Indicators For A Successful Project

The conclusion of the first meeting was to agree on indicators for a successful project.

A successful result of the project would be a practical contract (procedure) which is useable and becomes accepted as a standard by all market players (manufacturers, installers, customers).

Also some experiences in introducing GRS in example projects should be gained.

8.1.6 Influencing Parameters for a Performance Guarantee

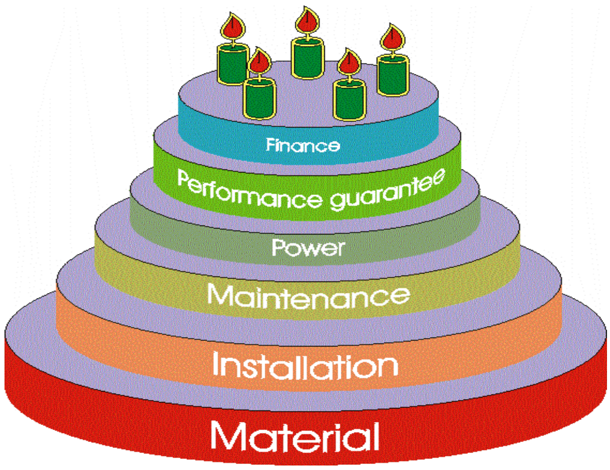
The parameters that influence the performance guarantee are:

- Measurement of Energy Yield
- Site Condition, Initial Condition, Design
- Meteorological Reference
- Fault Monitoring
- Maintenance
- Restriction of Liability, External Limitation
- Financial Consequences
- Post Contract Measures
- Internal quality insurance
- Shared risk , backup risk

These parameter have to be considered for the establishment of the draft contract. Based on these influencing parameters existing projects have been evaluated (see chapter 2.1). In addition the extra costs for a performance guarantee have been discussed.

8.1.7 Definition of Guarantee Levels

The different levels of a guarantee can be seen in fig. 8. As indicated by the cake the different levels of guarantee depend on each other. If you want to get to a higher level. All levels below have to be fulfilled.



Picture 8. Guarantee levels of GRSPV

All kind of guarantees are based on components and lifetime guarantees. Of course a state of the art installation of the system is needed. Operating a system well requires maintenance. Contracts right now are based on the installed STC power. The customers needs a global performance guarantee. Last step is a direct financial agreement between supplier and customer.

Also the different time scales in guarantees have to be considered. (e. g. broken module frames are not covered by a 10 year power guarantee if the mechanical guarantee lasts only 5 years)

8.2 Evaluation of Existing projects

The evaluation of various projects in different countries is described in chapter in detail.

The results and the feedback directly influenced the further development of the contract.

8.2.1 Additional Costs

PV Turn key suppliers have to spend more time on obtaining an accurate yield estimate. This is done in the tendering and offering phase, where it is not even sure yet that they will get the order.

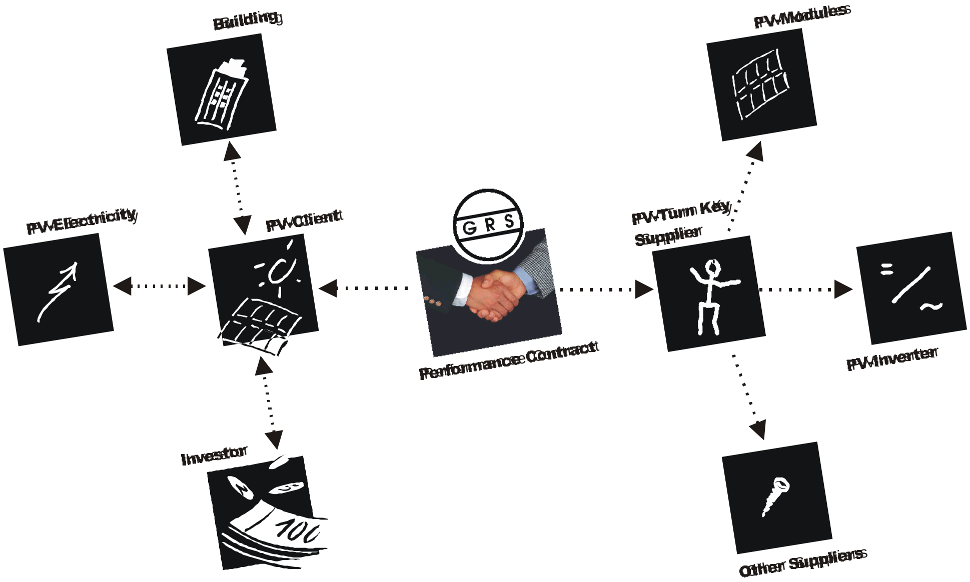
A maintenance contract should be part of the overall supply contract. This is currently not the standard.

Operation after commissioning is usually the task of the PV client, but in a GRS contract the suppliers have to keeping track of the performance of the system. This is not their core business.

To have bank guarantee for the whole GRS period is not usual for PV suppliers now and therefore is a very severe financial constraint.

In case of a yield loss money has to be paid back.

8.2.2 Project relationships



Picture 9. GRS^{PV} project relationships

The graph shows the main relations within the GRS Contract. The GRS contract will help to standardize the relations between the PV-Client and the PV-Turn-Key-Supplier.

Based on this background the structure and the content of the draft contract has been developed. It is separated in a short contract and additional comments. There some help is given to adapt the contract to the individual needs. (see appendix)

8.3 The Model Contract

The following chapter contains the articles and comments of the model contract (see also appendix). The comments (in frames) are to explain the model contract and to show different possible variations. The underlined phrases have to be adapted to the special project. The aim was a contract that was understandable and cost effective in the realization. Therefore some simplifications were made. The comments point out the resulting uncertainties and risks.

This version is published (in german) by the solar magazine “Photon”.

8.3.1 Article 1 Object of the Contract

The object of this contract is the Supplier’s guarantee of the energy yield of the photovoltaic system on the roof of the example building. It is mounted on the roof and contains 500 modules of type 1 and 2 inverters in the technical room.

Here the location, the nominal power and the offer or the purchase contract for the PV system should also be mentioned.

8.3.2 Article 2 Aim of the Contract

The aim of this contract is to ensure the performance and the quality of the PV system by the Supplier’s guarantee of the energy yield. At the same time, the guarantee is delineated into the risks for which the Client is responsible and those for which the Supplier is responsible.

8.3.3 Article 3 Duration of the Contract

The duration of the contract is 15 months. It begins with the full commissioning of the system and is divided into two parts.

A three-month test period starts when the Client commissions the system. Within this period the Supplier is authorized to change installation errors and defective components at his own cost.

The one-year GRS guarantee period directly follows the test period. The energy yield $Y_{MEASURED}$ generated in this guarantee period will be used to check the guarantee.

If there is a lower yield, the Client may decide whether or not to give the Supplier a second chance to prove the guaranteed energy yield after the expiration of the guarantee period.

It is strongly recommended that a one-year period be used to prove the guaranteed energy yield because of seasonal meteorological influences.

On the other hand, a period longer than one year seems not to be useful, as the Supplier has only to prove that his PV system is capable of delivering the guaranteed energy yield. The long-term risk should be born by the PV client.

A maintenance contract is recommended after the guarantee period.

8.3.4 Article 4 Definition of the Guaranteed Energy Yield

The Supplier guarantees the Client a reference energy yield $Y_{GUARANTEE}$ of 20,400 kWh per year, in words twenty thousand four hundred kilowatt-hours.

This guaranteed reference energy yield is compared to the measured energy yield of the PV system, which is measured by the utility's kWh-meter in the grid connection room.

The kWh-meter reading at the start and at the end of the one-year guarantee period is to be set down in writing by the contract partners. The difference between these two readings is the measured energy yield $Y_{MEASURED}$.

For the comparison of the reference energy yield $Y_{GUARANTEE}$ with the measured energy yield $Y_{MEASURED}$, the initial site conditions, defined in Article 5, the meteorological reference conditions, defined in Article 6, the limitations, clarified in Article 7 and the correction methods presented in Article 8 have to be considered.

The energy yield should be stated as a fixed, absolute amount of energy. Values such as the final yield per installed kWp are not useful, because then the discussion on the installed power starts again.

For an optimal energy yield over the whole payback period, other guarantees are also important such as

- Maximum delay time for delivery of exchange parts (inverters, modules)
- Availability of exchange equipment
- Fixed prices for exchange parts

8.3.5 Article 5 Initial Site Conditions

The following initial site conditions are accepted by both contract partners:

- The PV system will be placed on the roof of the building, building owner, building address. The roof has an area of XX square meters, is tilted XX degrees and orientated XX degrees from south to east.
- The PV system will be mounted on the roof with a declination of XX degrees and an orientation of XX degrees (180°=south). There is no space for additional modules.
- There are no restrictions in the local air quality (e.g. dust and soot).
- There is no shading caused by houses, trees, antennas, chimneys or superstructures.

- Connection to the grid is provided in the technical room in the basement of the building. The kWh meter of the utility is also placed there.
- The Client is not aware of any deficiencies in the quality or availability of the grid.
- The inverters will also be placed in the technical room. There are no restrictions such as high temperatures, humidity or too much dust.
- The Client is responsible for providing a sufficient air exchange rate in the inverter room (e. g. by tilting a window at all times). The air exchange rate is considered to be insufficient when the temperature of the room rises above 35 °C.

See also drawing no. 345 2178 of 23rd of May 1999 which is part of this contract.

The most essential examples for initial site conditions are given in the model contract:

- Area, orientation and declination of the module plane
- Local climatic conditions (dust, soot, ...)
- Evaluation of local shading conditions is strongly recommended, even if there is no shading. This helps to determine changes in the shading conditions. Also the method used (software?) should be documented.
- Grid quality should also be fixed in general useful terms and existing regulations. Maybe you can get some information from the utility.
- Inverter climate influences the system performance, so it has to be documented.
- Location of grid connection and kWh-meter should be documented.

8.3.6 Article 6 Definition of the Meteorological Reference

Basis for the guarantee of the reference energy yield is the long-term annual average of the global solar insolation in the horizontal plane at the national weather service weather station at Solartown Airport.

The long-term average of the global solar insolation in the horizontal plane at this weather station is 1209 kWh/(m_*year).

The use of an independent external source for the weather conditions helps to ease the contract and to save costs. One should keep in mind that local climate conditions could be different between the reference station and the PV system location. The Supplier has to consider that when calculating his guaranteed yield.

Explanations of the method for calculating the guaranteed yield and which parameters are taken into consideration increase the reputability of the offer and compensate for a fake *the more, the better* competition.

Influences of changes of yearly insolation are different on horizontal and tilted planes. This difference is not considered in the model contract.

The suggested method aims to keep the contract as simple and cost effective as possible. Some uncertainties are accepted.

New meteorological references such as monthly weather maps and satellite data evaluations could also be agreed on as a local reference for the insolation data.

8.3.7 Article 7 Limitations

The Client is responsible for outages of the grid, misuse by the Client (e. g. manual turn-off of the system) and actions by third parties (vandalism and theft).

The same holds true for damages by force majeur (e. g. hail, storms, floods, etc.) and overvoltage (lightning, among others). The basis is a state-of-the-art installation, according to standards and regulations. This is accepted by the commissioning of the system by the Client.

Failure of the utility company's kWh-meter is the responsibility of the Client.

Changes of the initial site conditions (see Article 5) are also the responsibility of the PV Client.

Unauthorized changes to the system by the Client or a third party (intentional or negligent) can lead to a reduction in the guaranteed yield. In this case the Supplier is justified in terminating the contract prematurely. The Supplier has the right of decision. In the case of a void contract, the GRS period is finished and the guarantee is declared fulfilled.

The Supplier is responsible for dirt (dust, plants, birds, ...) and damages caused by animals such as rats, squirrels and so on. Yield losses resulting from such conditions are the full responsibility of the Supplier.

The PV turnkey Supplier has to provide measures and instruments to detect lower yields, errors and changes of reference conditions and to report them to the Client at once.

The Supplier is responsible for operation, monitoring and maintenance during the GRS period. This article determines for which circumstances the Supplier is not responsible.

8.3.8 Article 8 Correction Methods

For the comparison of the measured energy yield $Y_{MEASURED}$ with the guaranteed energy yield $Y_{GUARANTEE}$, the variation of insolation, system outages and changing shading conditions have to be taken into account:

With this correction method, the normalized yield is determined as:

$$Y_{NORMALIZED} = Y_{MEASURED} + Y_{CORR\_SOLAR} + Y_{CORR\_OUT} + Y_{CORR\_SHADING}$$

where

$Y_{NORMALIZED}$:	Amount of energy after adding the correction factors to the measured yield. This value is decisive for the financial aspects.
$Y_{MEASURED}$:	The kWh-meter reading at the start and the end of the one-year guarantee period must be recorded. The difference be- tween these two readings is the measured energy yield $Y_{MEASURED}$.
Y_{CORR_SOLAR}:	Amount of energy to be added to the measured energy yield, caused by variation of the global solar radiation at the mete orological reference station.
Y_{CORR_OUT}:	Correction value to be added to the measured energy yield, caused by system outages
$Y_{CORR\_SHADING}$:	Correction value to be added to the measured energy yield, caused by the new shading object. Only positive values are valid.

Only the following correction methods are valid:

8.3.8.1 Variations in the solar insolation

The differences in the solar insolation during the guaranteed period compared with the long-term average value of the meteorological reference station affects the measured energy yield by:

$$Y_{CORR\_SOLAR} = 1 - \frac{H_{ACT}}{H_{REF}} * Y_{GUARANTEED}$$

Y_{CORR_SOLAR}:	Amount of energy to be added to the measured energy yield, caused by variation of the global solar radiation at the meteorological reference station.
H_{ACT}:	Global solar radiation in the horizontal plane for the guarantee period at the meteorological reference station.
H_{REF} :	Long-term average of the global solar insolation in the horizontal plane at the meteorological reference station.

$Y_{GUARANTEED}$: Guaranteed energy yield

Values for H_{ACT} and H_{REF} are taken from the reference weather station defined in Article 6.

In the case that the measured energy yield does not meet the guaranteed energy yield and there is a lack of more than 10% of the reference weather data (weather station failure), the data basis is insufficient. Y_{CORR_SOLAR} is set to “0”since a correction according to insolation variation is not possible.

The Supplier has the right to decide if he wants to establish the guaranteed energy yield in a second guarantee period.

8.3.8.2 System outages

In the case of outages that are not the responsibility of the Client or the Supplier as defined in Article 7, the following correction is used:

$$Y_{CORR\_OUT} = Y_{AVERAGE} * t_{DAY\_OUT}$$

Y_{CORR_OUT}: Correction value to be added to the measured energy yield, caused by system outages

$Y_{AVERAGE}$: Average daily energy yield measured during 2 weeks before and 2 weeks after the system outage

t_{DAY_OUT} : Number of days with system outages

8.3.8.3 Changes in the reference shading conditions

The ending of shading which existed in the beginning is not taken into account for correction of the energy yield. Only additional, new shadings are considered. In this case the following correction method will be used:

$$Y_{CORR\_SHADING} = 1 - \frac{H_{NEW\_SHADING}}{H_{REF\_SHADING}} * Y_{GUARANTEED}$$

$Y_{CORR\_SHADING}$: Correction value to be added to the measured energy yield, caused by the new shading object. Only positive values are valid.

$H_{NEW\_SHADING}$: Global radiation at reference station <u>in the horizontal plane</u> with respect to the new horizontal line

$H_{REF\_SHADING}$: Global radiation at the reference station <u>in the horizontal plane</u> with respect to the horizontal line defined in Article 5.

$Y_{GUARANTEED}$: Guaranteed energy yield

To keep the contract simple and understandable, simplified correction methods are also used.

No corrections other than those mentioned are valid.

8.3.8.4 Solar radiation

The yearly solar insolation varies in the range of +/- 10% in comparison to the long-term average.

If the actual insolation H_{ACT} is bigger than the reference value H_{REF}, it leads to a negative factor. The measured yield $Y_{MEASURED}$ will be decreased.

If H_{ACT} is less than the reference value H_{REF}, the measured yield $Y_{MEASURED}$ has to be increased. This implies a lack of insolation. The yield would have been higher with the reference insolation.

Differences in this variation between horizontal and tilted areas will be further evaluated. Maybe meteorological software (e.g. meteonorm) can be used for recalculating the reference values.

Once again, please think of the possible local climate differences between the reference station and the local PV system.

8.3.8.5 System outages

This correction is for system outages for which neither the PV client nor the PV turnkey supplier can be blamed.

The possible energy yield is replaced by the average yield 2 weeks before and 2 weeks after the system outage.

The outage of the utility meter can also be handled like this.

Long-term outages, especially in summer, cannot be taken into account by this method. Generally, the system should run during a minimum of 70 – 80 % of the annual insolation.

The responsibility for detecting outages and recording yields is strictly with the Supplier. He decides on suitable measures to monitor the system. These measures should become part of the PV system even after the guaranteed period, so the PV Client can effectively monitor the system by himself.

8.3.8.6 Shading conditions

For this calculation, software tools like meteonorm are recommended. The type of the software should also already be agreed on in the contract. The reference shading has to be determined before signing the contract. The method used should also be used when shading conditions have changed.

When shading decreases, no correction is made.

The suggested method is based on yearly sums. If the change happens during the GRS one-year period, you need a time relation, so monthly reference insolation values are necessary. The calculation can be made using the agreed-upon software instruments.

8.3.9 Article 9 Failure Detection

The Supplier is responsible for detecting failures, yield losses and changes in the reference conditions.

The duration of restrictions which are not the responsibility of the Supplier (see Article 7) has to be registered and the values must be correspondingly corrected.

The Supplier is permitted free access to the system and is allowed to install a monitoring system. The Client provides space, a 230 V AC socket and an analogue telephone connection (branch connection). Connection fees which can be proven by the Client are to be paid by the Supplier.

The Supplier is responsible for detecting failure, lower yields and restrictions. It is his decision as to which means (manual readings, automatic logging, ...) and what checking period (daily, weekly, monthly) he uses. But there are some suggestions which should be considered:

Failure detection should be based on daily values, at least. Choosing weekly or monthly periods may cause reaction times that are too long to fulfil the guarantee.

Normally, daily values are only available by using automatic logging equipment.

The monitoring of subsystems such as DC/AC strings is recommended in order to avoid yield losses, too.

In case of a failure, an automatic alarm or message should be generated. This can be useful on site, either optical or acoustical. For remote alarms, different cost-effective ways are available using fax, SMS or email.

In every case the aim is very short reaction times in order to keep the outage as short as possible.

8.3.10 Article 10 Finances

The normalized yield $Y_{NORMALIZED}$ results from the measured energy yield $Y_{MEASURED}$ and the corrections mentioned in Article 8. If the normalized yield is less than the guaranteed yield $Y_{GUARANTEED}$ in Article 6, the Supplier shall pay an amount F to the Client.

This amount F is determined as follows:

$$F = \frac{Y_{GUARANTEED} - Y_{NORMALIZED}}{Y_{GUARANTEED}} * I$$

F:	Guarantee payment, amount of money to be paid by the Supplier in case of a reduced yield.
$Y_{GUARANTEED}$:	Guaranteed energy yield
$Y_{NORMALIZED}$:	Guaranteed energy yield after corrections
I:	Investment, system costs

Investment in this sense means the entire system costs as stated in the purchase contract. The guarantee payment is a maximum of 20 % of the investment.

In case of a higher yield (after correction) the Supplier receives 50 % of the higher feeding in remuneration for the guarantee period (1 year). All payments are payable 60 days after receiving the corresponding bill.

The determination of F used is simple, too. Here, different variations are possible:

8.3.10.1 Tolerance

Usual are tolerance ranges where no payment is forced, e.g., if the corrected yield $Y_{NORMALIZED}$ is higher than 95 % of $Y_{GUARANTEED}$. Thus measurement uncertainties can be balanced out, too.

8.3.10.2 Bonus

There can also be a bonus if the PV system generates more than the guaranteed yield. But the bonus should be fixed to a maximum of 5-10% of the investment.

8.3.10.3 Safeguarding the payment

The payment could be safeguarded by a bank guarantee. Usual with public orders is amounts of 5 % of the investment.

8.3.10.4 Enlargement of the system

If there is additional space available, the enlargement of the system can be also agreed on, instead of any payment.

8.3.10.5 Limitation of payment

The maximum payment can be fixed as shown in the model contract.

8.3.11 Article 11 Dispute Settlement

In case a dispute between Client and Supplier arises during the execution of this contract, an accepted independent expert from the local Chamber of

Industry and Commerce will be brought in to decide on the matter. The cost for the independent expert will be paid partly by both parties.

Both parties have the right to resort to the general courts of law.

Aim of the contract is a standardisation and a clarification of the relationships between Client and Supplier. In case of any dispute, both sides should already have agreed upon an independent expert in order to avoid legal actions.

Besides naming the independent expert, the division of the costs should be also fixed.

Each contract partner still has the possibility to start legal actions to avoid limitations.

8.3.12 Article 12 Annexes

The annexes forming an integral part of this contract are:

- Call for tender
- Supplier's offer
- Purchase contract
- Shading documentation
- Commissioning report
- Documentation and operating hints
- Maintenance procedure

Important information (call for tender, offer, commissioning protocol, documentation, ...) should be a part of the contract. This ensures a safer basis in case of adispute.

8.3.13 Article 13 Concluding Remarks

Changes and additions to this contract have to be in writing and signed. The legal venue is the city of the Client.

If any part of this contract is or becomes invalid, the validity of the remainder is not affected. The contract parties will act in such a way as to reach the aim aspired to and to abolish the invalidity. The invalid part will be replaced by a formulation which is closest to the original aim of the contract parties.

8.4 Introduction of GRS^{PV} Model Projects

It was planned to test the first GRS contracts on 2 projects in France. The new laboratory for the IMP in Perpignan (15 kWp) and about 30 installations of 1 to 2 kWp in Guadaloupe. But the french indecision concerning the sales price for the electricity produced has had the following effects.

The construction of the laboratory is now almost finished, but it is more than 2 years late. The first PV module was installed in January 2001 and the rest is still to come.

The installations in Guadaloupe were built during the winter 2000-2001, but they are not covered by a production contract. The main interest given by the supplier (Solelec) for their installations is the protection against the grid network cuts, as a battery is integrated into the system. The fact that this system is still being tested and that the energy balance is uncertain, has made Solelec decide not to propose any kind of guarantee for the moment.

In the Netherlands four GRS-PV contracts have been negotiated with two different PV-suppliers within three different projects. Because of the unfamiliarity with the subject it took a lot of time to finalise all the details in the contracts. It was noted that in all cases, the monitoring situation was more complicated than assumed in the model contract, which made additional articles necessary. Because of the timing the contracts used in these projects were not made according to the exact format of the model contract. However, in three of the four cases, most of the issues are dealt with in a similar manner, with some notable exceptions.

In one of the projects a contract has ended successfully. For another system the performance guarantee period has started recently. The other two systems still have to be commissioned before the performance guarantee period can start.

There were and are already projects with extended guarantees in Switzerland. This is strongly forced by the solar stock exchange. You need a safe business plan for any project, because your profit is in year 18 and 19.

Giving 2 years warranty on material and 5 years on hidden defects is almost usual. Sometimes a final billing of 10% is paid after 2 years of checking the performance. To make such guarantees safe also the supplier (or manufacturer) has to sign the contracts, not only the installer.

Also in Germany it was planed to test the GRS model contract in two special projects. One roof mounted system and one soundbarrier with integrated photovoltaics.

The client of the roof mounted system signed the contract without a performance guarantee, so the supplier wasn’t forced to offer one furthermore.

In the soundbarrier project a lot of problems and delays occurred. The system is still not errected, but the model contract was included in the call for tender. So the final project GRS contract will be an adaption of it.

Big market players like BP Solar and Shell Solar are planning to offer their customers guaranteed results of their systems. They are preparing the tools and measures they need for that. Even insurances for yield losses are already available.

Over 50 PV suppliers and clients got the model contract from the Photon magazine. They were asked for an anonymous copy of any realised contract. This feedback will help to further develop the GRS model contract.

8.5 Tools for GRS

8.5.1 Capturing initial site conditions

360°-degree panoramic view of the site for the solar PV installation prior to installation helps planners and contractors to agree on similar determination of site conditions. Such pictures can be taken with an ordinary camera and a support tool such as PanoramaMaster, and then correspondingly stitched together with a software such as HorizON 2.0

After completion of the project, a 360°-degree panoramic view of the site can help to capture the current situation. Should rising trees or new build buildings block the sun and potentially lower the yield, the initial situation can easily be proven.

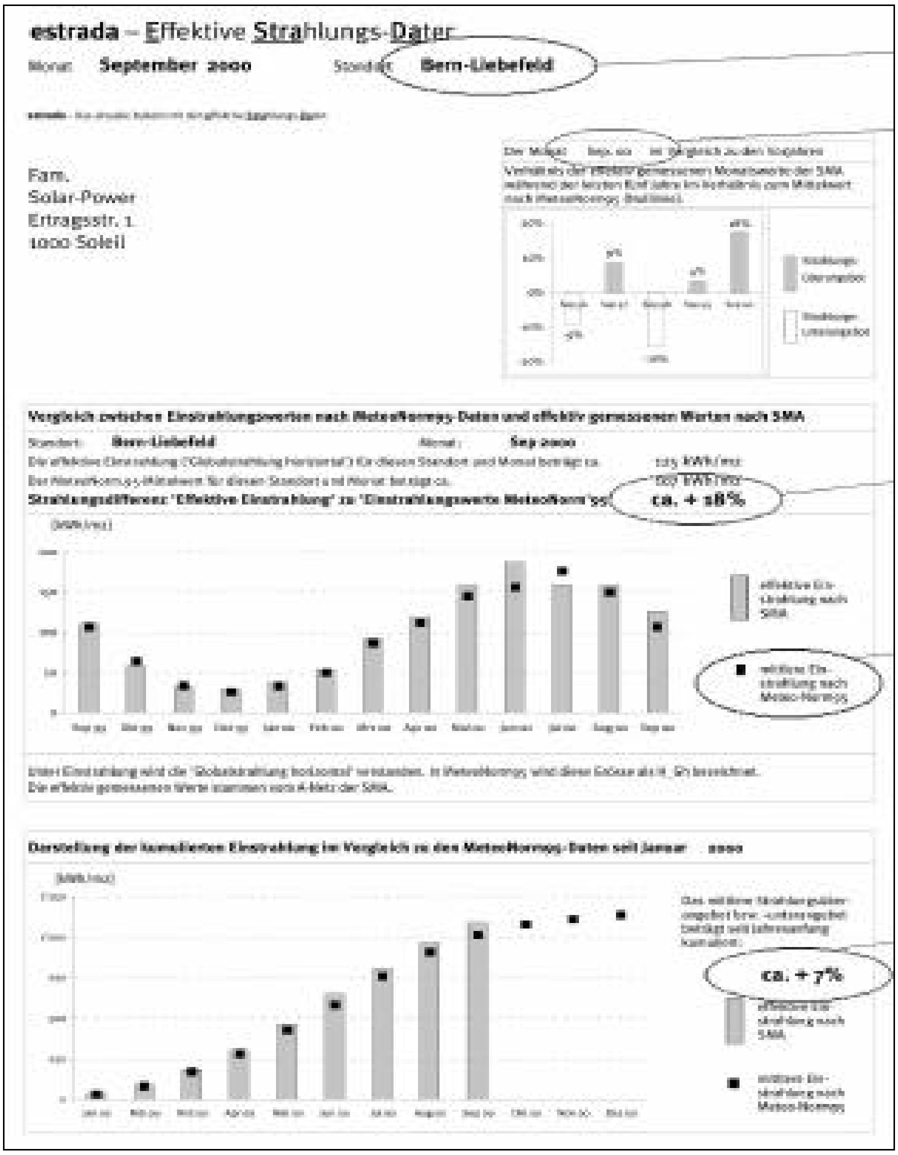
Picture 10. The camera tool HorizON (left) and software HorizON (center & right) capture intial site condions with ease and accuracy

8.5.2 Reference Data

A useful tool for checking the system performance are insolation evaluations like the monthly bulletin ESTRADA (Effektive STRAhlungs-DAten, German for "effective solar insulation data") in Switzerland, which shows the solar insolation on actual weather data. In regards to GRS, the ESTRADA bulletin works for both the PV client and the PV contractor as an independent source of reference for GRS (available at www.energieburo.ch).

In Germany insolation maps of magazines like Photon are useful. In some cases also data from the national weather service are available.

Using new evaluations of satellite data (PV-Sat) or email and internet (WEB-direct) are additional possibilities for analysing system yields.



Picture 11.Example of the independent monthly bulletin ESTRADA Monitoring

8.5.3 Monitoring

Quick responding monitoring and alarming of the system is essential to keep the down time of the system and with it the possible financial losses due to penalties low. There are a few monitoring systems on the market which are suitable for GRS purposes.

9 Changes in the working plan

No changes had to be made concerning the working plan. For the introduction and the test of the contract in real projects more time or a follow up project would be very useful. A real test of the contract would be when the performance guarantee would not be met. This has not happened.

To fully test the model contract, (1) contracts would have to be made according to the proposed format, (2) they would have to be carried out until the end of the performance guarantee period and evaluated and (3) enough tests should be done so that some projects are included in which the performance guarantee turns out not to be met. This will really put the protocol to the proof.

It is proposed to further test and refine the protocol in a follow-up project. The result of this project and the follow-up project can be brought in to a proposal for a European guideline. The time it takes to establish has clearly shown that standardisation of performance guarantee contracts is necessary.

10 Dissemination

The project has been presented in public as follows:

- GRS workshop in Switzerland at Basel, January 2000
- 15th Photovoltaik Symposium, Staffelstein, March 2000
- 16th European Photovoltaic Conference and Exhibition, Glasgow, May 2000
- ALTENER conference, Toulouse, October 2000
- Presentation for the Dutch 'monitoring working group PV', autumn 2000
- Articles in Photon magazine, autumn 2000, (the model contract is available at Photon for customers)

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Christian Meier