

**Summary
of**

R&D - Project 201 95 311/01:

**" Feasibility Studies for new Eco-labels in compliance with ISO 14024
for the Product Group:
Thermal Solar Systems "**

Compiled by

Dipl.-Ing. Volker Handke (IZT)

Dr.-Ing. Uwe Hartmann (DGS)

Dipl.-Pol. Michael Knoll

Dipl.-Ing. Philipp Spitzmüller

**IZT Institute for Futures Studies and Technology Assessment gGmbH
German Organisation for Solar Energy e.V. Landesverband Berlin-Brandenburg**

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Contents Page

1. Objective, and approach in the project.....3

2. Results of the market research, analysis of environmental impact and the product requirements.....3

2.1 Market research 3

2.2 Product range as well as definition of scope and area of application 4

2.3 Environmental Impact 5

2.4 Potential and appraisal for product optimization..... 6

2.4.1 Avoidance of dangerous substances..... 6

2.4.2 Reducing material input..... 6

2.4.3 Reduction of energy consumption 6

2.4.4 Reduction of material emissions 7

2.5 Defining ecological requirements for fitness for use and product quality..... 7

2.6 Applicable standards for the award process 7

2.6.1 Process of environmental labeling 7

2.6.2 Product related standards..... 7

3. Area of application and product requirements.....7

3.1 Area of application 7

3.2 Product requirements..... 7

3.2.1 Avoidance of dangerous substances..... 8

3.2.2 Plating systems..... 8

3.2.3 Recyclable design 9

3.3 Cumulative energy input (KEA) and energy pay-off period 9

3.4 Product information..... 10

4. Perspective10

1. Objective, and approach in the project

The Institute for Future Studies and Technology Assessment (IZT) and the German Solar Energy Society, Berlin Brandenburg Section e.V. (DGS) were commissioned by the Federal Environmental Agency (FEA), to conduct a feasibility study for a new environmental seal for the product group: „Thermal Solar Systems“.

The processing took place according to EN ISO 14024 „Environmental Labeling Type I– Principles and Procedures“ and encompasses two requirements: Firstly the revision of the eco-label for solar collectors RAL-UZ 73 taking into account developments which have taken place in the solar sector since the allocation as well as checking to what extent it is ecologically meaningful and how feasible it is within the framework of the eco-label to set a boundary between galvanic and non-galvanic plating processes of the absorber. Secondly, a check should be conducted to establish to what extent it is meaningful and feasible to extend the current eco-label for solar collectors to full component solar thermal systems.

Besides the feasibility study, which aims at producing a range of products, a consultation with the interested parties and an overview of the market and innovational developments, as well as the environmental impacts, proposals for ecological product requirements were to be developed.

First, the current situation regarding the use of the eco-label „Blue Angel“, the application of the different plating systems and the spreading of full component solar thermal systems was classified within the framework of a market research. At the same time the fundamental environmental impact by solar thermal products and possible strategies for their reduction and product optimization were determined. On the basis of the results of this market research, as well as the determined environmental impacts and the product optimizations a decision for establishing the area of application (scope) was finally made. On the basis of the results of this survey, as well as with the aid of interviews with particularly relevant representatives from industry and federations the product selection was made in close coordination with the expert guidance from the Federal Environmental Agency (FEA).

Subsequently, the development of criteria for the product requirement took place according to principles of award for the new eco-label in the product range: solar thermal collectors. The consultation with the interested parties, as specified in the process environmental labeling according to ISO 14024, was carried out in the context of an expert discussion. In this discussion, the developed product requirements were presented and examined with regard to their acceptance and feasibility. The findings of the expert discussion finally served the advancement and concretization of the product requirements, their proofs and their formal integration into the principles of awardbases of award.

2. Results of the market research, analysis of environmental impact and the product requirements

2.1 Market research

In order to be able to compile new requirements for the „Blue Angel“ it is essential to possess sound knowledge of the current market „solar thermal systems and components“. Thus a market research, which was subdivided into 3 parts was carried out:

- 1) the wide range of plating types for absorbers available on the German market and their marketshare
- 2) Market distribution of and penetration by the „Blue Angel
- 3) Market share of so-called full component systems (factory made systems)

Absorber Plating

The research was concerned with providing evidence with figures of the increasing use of non-galvanic plates and the respective decrease in plating on the basis of chromium.

Results on collector surfaces sold in 2001 [m²]:

<i>Black Chrome</i>	<i>TiNOX</i>	<i>Sunselect</i>	<i>Other</i>	<i>Total investigations</i>
139.430	277.190	247.250	110.930	774.800
18 %	36%	32%	14%	100%

Illustration 2 -1: Market distribution of the plating systems

Altogether in 2001 in Germany, approx. 900 000 m² of glassed collector surface was traded on the market. 86 % of this surface was investigated and estimated. The remaining part could not be investigated, since a considerable number of companies were not willing to disclose their data.

The result of the investigation shows that, the collectors which use non-galvanic plates have a market share of over 50 % while those collectors which work on chrome basis have only 15 % market share. Their application is limited to niche products e.g. large collectors and economical collectors.

Market distribution of and penetration by the „Blue Angel“

More than 50 % of the collectors introduced onto the market between 1997 and 2001 carried the eco-label. In relation to the collector area, and in consideration of the most frequently used absorber plating types, the market penetration is as follows:

Plating type	Share with eco-label
Black chrome	74,8 %
TiNOX	69,3 %
Sunselect	87,7 %
Total Investigation	82 %

Therefore, the eco-label is well represented in the mostly used absorber plates as well as on the entire market.

Market share of so-called full component systems (factory made solar systems)

In order to investigate a possible extension of the eco-label to so-called full component systems, this market section was closely examined. This is however notably more difficult since although on one hand definitions of complete systems are by now clearly available with respect to standardization, the market still remains by and large non-uniform. It can be established that the sale of full component systems has notably increased in recent years, the extension of the eco-label is however not considered reasonable because of the still less structured market and also because of the still unclear future certification policy of companies with respect to EN-Standards.

2.2 Product range as well as definition of scope and area of application

The definition of the scope and application area presupposes a product range and the establishment of the characteristic product function in order to deal with containment of the product group as well as guarantying the comparison of the products of this group to be labeled (cp. ISO 14024).

For the amended eco-label in the sector thermal solar systems, support through the EN-Standards is plausible. However, the survey on associations and manufacturers showed that the EN-Standards for prefabricated respectively customized systems will only play a subsidiary role in the next 5 years in Germany. Therefore it is recommended to keep relating the eco-label only to solar collectors.

2.3 Environmental Impact

In order to determine the environmental impact of solar thermal energy systems, the entire life cycle was taken into consideration. During the **production process**, the production related emissions in sewage and air, waste development and energy consumption are of special interest, whereby special attention should be given to galvanic and non-galvanic processes for plating of selective absorber surfaces. During usage the product emissions become the focus of attention in form of leakages, evaporations as well as consumption of materials and supplies and spare parts and finally, the energy requirement for the pump and the control. During and after recycling the environmental impacts in form of the arising waste quantities, their material properties and the recyclability are the points of interest.

For the analysis and assessment of environmental impacts, different eco-balance methods are readily available. They differ from each other in the level of aggregation of the used indicators among other things. Within the scope of the feasibility study, three methods (EcoIndicator, ProBas-Datenbank, KEA) were compared in their relevance to the environment and with respect to their practicability for the awarding process, on the basis of determined material input of four selected collectors (two flat plate collectors and two vacuum tube collectors). The EcoIndicator 99 represents a highly aggregated system, which serves a damage oriented method that matches an absolute measure, so-called EcoPoints (Pt) to each material, which in turn represent cumulative environmental impact and the associated damage. The ProBas data base on the other hand, allows for very detailed quantifiable declarations with respect to inputs in the environmental media i.e. air and water as well as of the arising waste and of the resource consumption.

Despite the different methodical concepts for determining the environmental impact, concurrent results have to be stated. This way, the environmental impact of the materials used in solar thermal systems indicate a direct mass dependency with all three assessment systems. It follows that materials with the most mass have the greatest impact on the environment

The treatment of the environmental impact according to the EcoIndicator 99 Method produces a corroborated and operationalizable index but does not take into account declarations on the underlying areas of influence of the environmental impacts. On the other hand, detailed quantitative declarations on the environmental impacts in the different environmental media (ProBas) require weighted evaluations of the individual environmental impacts, as well as a declaration on the significance of the effects and damages. Both seem less practicable with respect to the eco-label.

Therefore, the cumulative energy input (KEA) was selected as a reference system for the determination of the environmental impacts. This is particularly so since solar thermal energy represents a technology for energy transformation and a large proportion of environmental problems is linked to energy use. Furthermore, the quantities of energy related to the product and its materials are relatively easy to determine, to aggregate to an index and consequently easy to use in the decision making process as a transparent factor for orientation. In addition, the KEA-values of energy transformation systems can be used for the calculation system-dependent energy pay-off times. A further advantage is the methodical robustness on the basis of the establishment of terms, definitions and calculation methods in the VDI directive 4600 (German engineer association).

However, it must be pointed out that a restriction exists on products with a high environmental impact (e.g. because of their toxicity) but with only a low energy requirement (e.g. because of their characterization as by-products), since they can only be inadequately covered, assessed and represented.

The environmental impacts through solar thermal systems and their components are caused by substance active materials used. Namely, the metals copper, aluminum and steel cause the most substantial environmental impacts with respect to the energy input, the production related CO₂-emissions, the transportation related waste in form of excavation waste, as well as the consumption of non-regenerative scarce resources in form of ores. Glass too deserves mention, which as a mass intensive material particularly induces discharges into water bodies in form of inorganic salts, besides its energy requirements and the CO₂-emissions during its production.

A determination of the environmental impact by the plating systems of the selective absorber surfaces and their judgment must be deepened. On one hand, reliable data on the production process is not available

and on the other hand the final judgment of the long-term durability and the recyclability of the plating systems is still open.

2.4 Potential and appraisal for product optimization

On the basis of the determined environmental impacts environmentally oriented optimization potentials were revealed.

2.4.1 Avoidance of dangerous substances

Through European standards and the present eco-label several applications of dangerous substances have already been excluded. The remaining need for optimization for the avoidance of dangerous substances in the heat transfer fluid and in the insulating material is little.

Basically, the object of strategies for the avoidance of substances with demonstrably significant eco- and human toxic effect remain however the heavy metals, lead and chromium VI contained in solar thermal products. For chromium VI which is used in the galvanic plating of selective absorber surfaces there are tried and tested substitution alternatives in form of the non-galvanic plating processes. The avoidance of the toxic heavy metal chromium VI through substitution of the galvanic plating systems appears denoted, in view of the prioritized Prevention Requirement for waste according to § 4 KrWG/AbfG (.....), although metal recycling of the galvanic wastes is possible

For lead, which is the conventional component in plumbing applications for the connection of pipes there is still no substitute up to this day.

2.4.2 Reducing material input

A reduction of the material input can take place through an increase in resource productivity. Basic starting points are provided by the extension of the **service life**, **the choice of material**, and **recycling**.

The extension of the service life, as a strategy for a product of domestic technology with an average economic life span of approx. 20 years has only little potential.

Material preference or material discrimination is seldom clearly possible. In addition, the functionality has to be taken into consideration. An environmentally oriented comparison of rock wool and polyurethane – hard foam as insulating material proves to be relatively more distinct. Rock wool must be favored.

An approach for developing the recycling potential is represented by the composition of the components according to recycling paths (e.g. copper, steel, aluminum, glass). A result of this is the constructional design requirement, to use material as much as possible as a single substance or at least to use material so as to facilitate subsequent separation into the constituent single substances. Basically, material use in the solar thermal industry is already characterized by relatively pure substance, metal and mineral materials with distinctive recycling alternatives on a considerably high utilization level.

Besides the recycling level, the environmentally oriented choice of material offers a starting point for product optimization. Orientation towards environmentally friendly selection of materials is provided by the approach of material specific environmental indicators.

2.4.3 Reduction of energy consumption

With respect to the reduction of energy consumption during operation, the energy efficiency of the pump is decisive. Here, the optimization potential lies with the use of rotary pumps controlled through rotational speed. More decisive are the energy inputs for the production process. Since solar thermal systems serve energy transformation and thereby provide the energy as heat, the entire energy relationship is afforded a key position. A considerable optimization potential is represented by the minimization of the pay-off periods. The energy pay-off period is however an expression of the relationship of expended quantity of energy to provided quantity of energy of the entire system. This way, two basically different strategies can be followed for its minimization. The minimization of the expended energy through a respective choice of material on one hand and the maximization of the provided quantities of energy on the other hand.

2.4.4 Reduction of material emissions

Leakages, gas emissions and in the broadest sense spare parts too and raw materials are considered as material emissions. Leakages in the collector cycle and the accompanying discharge from heat transfer fluid are to be disregarded, except in the shrinking self-construction sector.

On the other hand, gas emissions are of particular relevance. Though the gas emission of dangerous substances from insulating material is rather low, gaseous emissions are nevertheless possible at high temperatures and in the initial years of use of the system, particularly from the lead containing solder. Because of lack of substitutes the optimization potential appears rather low. The same applies for spare parts.

Also to be regarded as raw material is the refilling of the heat transfer fluid and the adjustment of the additive concentration accompanying the maintenance. Since however this concerns an inevitable handling of a substance there is currently no realistic potential for optimization evident.

2.5 Defining ecological requirements for fitness for use and product quality

The ecological requirements for fitness for use and product quality of solar collectors respectively full component solar systems can mainly be brought into a relationship with the faultless operation of the components respectively of the whole system.

Chiefly the installer comes into contact with these requirements. The bottom line for a satisfactory operation is the knowledge and competence of the installer, the usability and design of the product as well as the assembly and operation instructions for the installation and operation of the product.

With respect to the whole solar system further aspects regarding product usability, which concern the operation of the solar system of the user have to be taken into account. In particular, the user friendliness of the control has to be pointed out here.

2.6 Applicable standards for the award process

2.6.1 Process of environmental labeling

The **EN ISO 14024** establishes principles and processes which are applicable for the development of Type I environmental labeling programs including selection of product categories, environmental criteria and characteristic functions of the products to be examined and for the judgment and proof of the conformity.

2.6.2 Product related standards

In recent years, European standards for solar collectors, full component solar systems and hot water accumulators have been developed. These define the minimum requirements on the products and test methods for their verification as well as methods for the determination of the performance. The standards relevant for the feasibility study are

EN 12975-1/-2/: Thermal solar systems and their components – Solar collectors –,

EN 12976-1 /-2 Thermal solar systems and their components – Factory made systems

ENV 12977-1/-2/-3 Thermal solar systems and their components – Custom built systems

3. Area of application and product requirements

3.1 Area of application

In the context of the amendment of the eco label “blue angel” for solar thermal technologies the area of application for RAL UZ 73 is suggested to remain with solar collectors, as discussed in chapter 2.2.

3.2 Production requirements

In order to attain an as near complete assessment of the products during their entire product life cycle as possible, it is recommended that the fabrication of the solar collectors be taken into account in the principles of award. Compliance with the present environmental policies is recommended as the minimum requirement for production plants which manufacture solar collectors. For those production plants which are registered according to the EMAS regulation, or those with an environmental management system complying with ISO 14001, these requirements are regarded as fulfilled.

3.2.1 Avoidance of dangerous substances

Since, with respect to the dangerous substances in solar collectors, only marginal changes are notable, which are additionally, chiefly of a legal and administrative nature the appraisal of dangerous ingredients takes place in compliance with the present principles of award of the RAL UZ 73 (german eco-label for solar collectors).

It is recommended that the dangerous ingredients to be avoided contained in the gas emission from the insulating material at stagnation temperatures must be defined through the labeling according to the respective applicable version of the regulation, GefStVO (german regulation for hazardous substances...???), as well as through the labeling "hazardous for the environment" according to the respective applicable EU-Directive 67/548/EWG.

The heat transfer medium is not to be regarded as a constituent of the solar collector. According to the EN 12975 the manufacturer's recommendation with respect to the heat transfer medium to be used is presupposed. For this kind of recommended heat transfer medium the definition of the hazardous ingredients is proposed, likewise through a label according to the regulation GefStVO (...) as well as the respective applicable EU-Directive 67/548/EWG(see above). In addition, consideration of the classification into the water hazard level 2 or 3 will still however be recommended according to the applicable version of the VwVwS (...).

3.2.2 Plating systems

The plating is traditionally applied as galvanic black chrome. Of late, there has been however the introduction of non-galvanic physical coating processes which are increasingly establishing themselves on the market.

Contrary to reports in literature, there is a marginal difference between the energy input and the water consumption in the studied cases. Significant differences are however notable particularly for the sectors air emissions and sewage.

According to KrWG (...), waste avoidance should be prioritized. From this perspective, avoiding the arising of metal-containing galvanic sludge from the black chrome plating process should be given priority too.

The air emissions from the galvanic plating processes are of considerable relevance from the perspective of industrial safety.

The extremely thin layers of the non-galvanic systems basically represent low material output. This factor is therefore contributory to sound resource utilization.

Regarding the long-term action of the radiative properties there is practical experience with black chromium plating which denotes to considerable durability. For more modern plating processes (PVD, Sputter, PECVD) there are likewise measurement results which denote to considerable durability. Practical experience is nevertheless still not available.

With respect to the use of hexavalent chromium in the „black chromium“ plating process considerable implications result from the European Environmental Protection Law. According to the Directive 67/548/EWG hexavalent Chromium compounds, with the exception of a few, are considered a part of the hazardous substances. In accordance with the principles of the EU, the act of bringing dangerous substances into circulation underlies a principal Avoidance Requirement. This Avoidance Require-

ment has been rendered more precisely in different Directives and Bills of Directives (RL 94/62/EG, WEEE 2000/0158/EG, ROHS 2000/0159/EG).

The occurrence of hexavalent chromium by ore-purification during the producing process of metallic chromium, as applied in the process of physical absorber plating, disapproves a fundamental ban of black chromium.

Following these arguments the minimum requirement is suggested to comply with the limit values for hexavalent chromium according to TA-Luft (...), appendix 40 of AbwV (...) and TRGS 900 (...).

However air emissions and sewage, the occurrence of galvanic sludge and hexavalent chromium immersion at workspaces deliver sufficient arguments to ban black chromium in the principles of award. At least these are the reasons we recommend the complete ban of platings using hexavalent chromium.

3.2.3 Recyclable design

For the principles of award, consideration of the recyclability of the construct of the solar collectors has been proposed. The subsequently recommended constructional criteria are aligned to the VDI-Directive 2243. As proof thereof, a written declaration on the compliance with the first principles of recyclable design as well as the use and the submission of a checklist available in the attachment of the principles of award will be proposed.

Since there still remains no established screenings of solar collector constructs it is recommended to insert the check list in the principles of award solely for informative purposes. Should the requirements for a recyclable construct, as described in the check lists, not be met the applicant will be required to account for these deviations from the requirements.

Further, product requirements will be recommended with respect to the retraction and labeling of the collectors. It is proposed to incorporate a binding declaration on the retraction of the collector and of the inputted materials there into the basis of awarding. In addition, disassembly and reutilization instructions should be incorporated as well within the scope of the requirements on the product information.

3.3 Cumulative energy input (KEA) and energy pay-off period

For determining KEA for production the mass balances of the four reference collectors have been used. In addition, the mass balances of a further 12 collectors have been used. The KEA for production, transport, installation, operation and maintenance will be taken into account. Along the different stages of the product life cycle the energy input for production outweighs all other energy inputs amounting to approx. 80%. On the other hand merely 0,4% to 0,9% of the total energy input is accountable to the production of the selective plates of the absorber surfaces.

A more decisive and newer factor for the modified requirements within the scope of the eco-label for solar collectors is the energy pay-off period. This will be generated from the solar yield respectively the economization of conventional energy (f_{sav}) and from the KEA-Value. The use of the energy pay-off period as a requirement in the scope of the modified eco-label leads, above all in ecological terms to a transparent and more comprehensible assessment, which is only attainable by through minimal complication. According to the area of application, the solar collector yield and not the system yield will be taken into consideration for the eco-label. The determination of the collector yield takes place with the application of the simulation program TRNSYS and with the aid of the deck „ITW-Standard Conditions“. In order to obtain the eco-label, the energy pay-off period must not fall below specified threshold values.

As a threshold value for vacuumized collectors, an energy pay-off period of 9 months has been suggested, for non-vacuumized collectors 5 months.

3.4 Product information

Since solar thermal systems relate to technical products with a high economic life span and which require permanent information relating to disassembly, reutilization and disposal, for an environmentally sound handling as well as in compliance with informational obligations according to EN 12975, the inclusion of comprehensive product information in the requirements for the basis of award have been suggested. This product information needs to cover brief, clear and precisely formulated instructions relating to safety, installation, operation, maintenance, disassembly and recycling respectively disposal and must be backed by understandable and ostensible graphs.

4. Perspective

The occasion for the amendment of the RAL UZ 73 was the criticism on the current scope, besides the adjustment to the developments in the branch. This was not oriented to the real demanded, purchased and finally installed solar thermal systems, but only to the component solar collector. This criticism is therefore justifiable, as on the one hand for reasons of maximal completeness of an assessment as well as in view of the environmental impact and the energy efficiency, the entire system, solar thermal system is decisive.

The current proposal for amendment of the RAL UZ 73 as well is limited to the awarding of the symbol (label) for the solar collector. The reasons for this are first, methodical complications for a selective product definition, but lie nevertheless primarily in the lack of acceptance of the still recent EU Standards. It is however to be presupposed that the use of the Standards will become inevitable for the manufacturer in 3-5 years. Therefore, it remains reserved for a future feasibility study to develop the environmental labeling of solar thermal systems under these altered conditions.

On the basis of the energy pay-off period, the amended RAL UZ 73 already has an indicator which too is designed for an environmentally oriented assessment of complete systems.