RECOMMENDATIONS FOR FURTHER NEEDED ACTIVITIES IN THE FIELD OF FUNCTION AND YIELD CONTROL FOR LARGE SOLAR THERMAL SYSTEMS

TR 5.2.2

Institut für Solarenergieforschung GmbH (ISFH)

Klaus Vanoli, Carsten Lampe

Am Ohrberg 1
D-31860 Emmerthal
Tel. +49 (0) 5151/999-100, Fax -500;
www.isfh.de

Austrian Institute of Technology

Ivan Malenković

Version 2.1

Date: 28.05.2012

Final Document

Table of content

1 Introductory remarks

Based on the output of a number of previous projects (e.g. NEGST [1]), function and yield control (FYC) has been identified in the preparation phase of the QAiST project as an important technology to strengthen the market position of large solar thermal systems. In order to support further development of FYC in member EU countries, the following output on this topic was proposed in the original version of the QAiST project description:

1. Updating the market survey on available data on FYC based on previous work (projects NEGST, EAST-GSR, Q-Sol) by contacting major stakeholders in each participating country;
2. Exchange of technological descriptions and technical discussion of various FYC systems in a workshop;
3. Development of information material and technical guidelines respectively for installers and planners, which later could serve as a basis for a standard.

Already in the early project phase, however, it became clear that the number of existing market products and the experience in the operation of such systems is not sufficient to fulfil the objectives 2 and 3.

Therefore, it was concluded to change the goal of the project part concerning FYC and to further investigate the framework conditions for a successful technology development and to provide a set of recommendations to establish a basis for a broader public discussion on the topic.

2 State of the art analysis

2.1 Currently available methods and products

An overview of the currently available methods and products for FYC, which are known by the actively contributing participants of QAiST Subtask 5.2, is given in technical report **TR5.2.1**. Within this overview, the two special aspects of “Function Control” and “Yield Control” are treated separately; and this overview is limited to these two aspects. Methods and products with purely monitoring capabilities are not considered therein, although there is an increasing number of devices which are providing an abundant stream of measured data. For a discussion of the differences between the aspects of FYC and monitoring, reference is made to Chapter 2.4.

2.2 Technical limitations of the technology

Using new terms/definitions proposed in Chapter 2.4, the technologies of “Function Control” and “Yield Control” are still in a very limited state. This

remark holds as well for the number of concepts/devices as for their capabilities to detect and localise possible malfunctions and/or low-yield situations. The question of malfunction diagnosis has only been addressed in very recent research projects. From the investor's point of view, there is no clear picture of "error-detection-capability" for a product called "FYC device".

Although many solar thermal systems are being under constant surveillance, it has to be stated, that most monitoring activities are undertaken within research oriented activities with a dominating expertise and interest for detailed scientific analysis and evaluation.

Contrarily, the domain of future FYC technology requires the conception and development of low-cost FYC devices which are automatically working as fault detection devices or as solar yield rating units, with minimalistic measurement equipment and highly complex FYC algorithms, in a wide variety of individual solar systems.

Thus, future R&D activities should not only focus on FYC high-end solutions suitable for very large solar thermal installations, but also conceive FYC concepts for the collector area range between 20 and 100 m², which are operable by the concerned heating technicians without detailed scientific background. And further in the future, FYC-solutions are also needed for the small systems of the individual house installations.

2.3 Standardisation: VDI Guideline 2169 - function control and solar yield rating for solar thermal systems

In Germany, the VDI Guideline 2169 [2] on FYC has been developed since summer 2004. It aims at presenting to planners and installers both the actual possibilities of function and yield control, as well as the requirements which have to be satisfied for its correct operation. Furthermore, this guideline provides information to investors and system operators about the measures which they can take for supervising their systems. Presumably, this guideline on function and yield control is the first of its kind world-wide. However, due to the unforeseen postponement of its publication after the end of the QAiST project, it could not be discussed within the QAiST project consortium. Nevertheless, other European countries can try to benefit from these unique German experiences in future national and European FYC activities and related efforts towards standardisation.

As outlined in Chapter 4, VDI 2169 could serve as a starting point for further international FYC work, which of course has to consider a much wider scope than just the German view by integrating other countries' requirements due to their specific types and concepts of solar thermal systems and applications.

2.4 FYC definitions, guidelines and standards

2.4.1 Need for new terms and definitions

There is a need for new, clarifying definitions, in order to avoid frequent ambiguities in the use of common technical terms. For example, there is a fundamental difference between monitoring and FYC:

- **Monitoring** refers to either a detailed technical / scientific analysis of solar thermal systems over a given time period or in the frame of field-test;

- **Function and Yield Control** concepts consist of both the simplified and, hopefully, low-cost measurement devices associated with FYC algorithms. These algorithms have to provide either a functional analysis of the system's actual operation mode or they provide the calculation of the anticipated / expected yield under the actual conditions of meteorology and load.

Another example of double use of technical terms is the term **controller** or **controlling**. These terms are used, on one hand side, for a device which triggers switching off or on of pumps and fans or opening or closing of valves according to the predefined control concept and certain measured values. On the other side, they are used within the context of verifying either the functional and / or the energetic behaviour of the solar system being checked.

2.4.2 New terminology in VDI 2169

The only exact definition of the term FYC until now is contained in the draft version of the German Guideline VDI 2169. The publication of the final document has been announced for summer 2012. For the first time, there is a differentiation between the terms ”function control” and ”solar yield rating”, with manual and automated methodologies and techniques existing for both terms.

Automated function control designates a method for generating a set of warnings for well-defined system malfunctions or functional failures, using both the existing sensors of the system's controls, as well as typical behaviour of the specific system and its components. This definition in VDI 2169 is meant to be a minimum requirement for Function Control devices. Of course, optional additional sensors could provide for improved error detection.

The new term solar yield rating is energetically defined as the (preferably simultaneous) operation of:

- data acquisition;
- data evaluation to determine the measured yield;
- solar system simulation to determine the expected yield for actual climate conditions and load;
- comparison of measured and expected yield for yield rating.

The concept of solar yield rating permits both the detection of system malfunctions and errors during the planning or installation phases, as well as a continuous verification of the actual solar yield.

3 Preconditions for further development of the FYC technology

Two main barriers for a take-up of the technology have been identified by the experts:

- a harmonised European approach to the FYC topic, including clear definitions, requirements and standardised procedures is currently lacking;
- needs and views of all stakeholders regarding the technology and its possible impact have not yet been clearly articulated and understood by the majority.

This means that, in order to advance further with the development and implementation of FYC, several essential prerequisites have to be met. Most important is the fact that the procedure of harmonization concerns two different domains:

- the purely **technical** domain of FYC concepts, including FYC devices and FYC algorithms on the one hand side, and
- the "**social**" or "**human**" aspect, where both the market players as well as the FYC experts are involved on their respective, specific levels on the other.

Only a common view on these topics can tap the enormous potential of reliably operating and energy-efficiently working solar thermal installations and this can be maintained on the long run only by permanent FYC supervision.

Technical requirements

On the technical level, an effort is still required to push more FYC concepts from the R&D level to market ready FYC systems. Building-up own FYC experience by all participants involved in that process is needed.

It is essential to keep in mind the difference between monitoring and function and yield control when developing new methods and products, as described in the previous chapter. FYC requires easy to install and to handle, integrated and low-cost (compared to the overall investment and operating costs of the solar thermal systems) units which can be installed and operated by technicians.

More hands-on experience by all stakeholders has to be built-up regarding different FYC concepts, especially with systems which are readily available for market introduction. Only through real environment operation, long-time experience in different countries under different set of conditions and requirements can the process of harmonisation be facilitated.

Furthermore, that strategy offers a huge chance to train and qualify the concerned installers, planners and technicians of the systems operator, in order to come to a much faster detection and elimination of system malfunctions.

Along with the technology development, the discussion on further national and international standards has to support the process. The final goal of such development would be to establish quality assessment regulations for installed large solar thermal *systems* (analogously to component related quality labels like e.g. Solar Keymark or similar schemes).

The overall aim of such a development process should not be restricted to only solar yield rating, but should perform a long-term comparison of measured and predicted end energy use. And as an additional advantage, the conventional energy producing units and their distribution systems would be part of that qualification procedure.

Non-technical requirements

The needs and views of all stakeholders have to be taken into consideration when developing FYC systems. The benefits, concerns and workloads with respect to FYC associated to each player have to be understood and taken into account.

The workload associated to this development scenario can only be achieved by a joint effort of relevant market players in the field of large solar system installations:

- investors and their organisations;
- manufacturing industry and their associations (both component and system);
- providers and developers of FYC solutions for large solar thermal systems;
- systems operators / contractors;
- planners and installers for large solar thermal systems.

Additionally, this process has to be supported by well suited funding concepts and associated quality criteria requirements. This means that

- decision makers from policy, regulatory frameworks, subsidies etc. and
- regulatory framework representatives and standardisation bodies (e.g. CEN, national standardisation bodies)

have also to be included in the process.

The work towards a harmonized technical approach on FYC will require some time and minimum conditions in order to be successful, namely the contribution of adequate number of experts, good country representation, strong stakeholder involvement as well as relevant own practical FYC experience in the field, which is in the view of the authors a condition sine qua non!

To be successful on the EU level in a foreseeable period of time, it has to be further promoted by the relevant advisory bodies to the commission and to be endorsed in the upcoming research agenda as an important topic for the support of advocated EU energy policy goals. To succeed in this, the relevant benefits (e.g. increase in renewable energy usage) have to be promoted by all interested parties.

Finally, for a broad implementation of the technology, a regulatory framework (e.g. energy labelling) has to be established on the EU level.

4 Recommendations for further FYC promotion

In order to overcome the actual situation in the field of FYC, the following path towards both the future development of the FYC technology in its various aspects, as well as a future FYC guideline or FYC standard is proposed, based on the initiation of a wide variety of projects both on regional, national and/or international level:

- It is recommended to study the existing FYC know-how of VDI Guideline 2169 on FYC, which will soon be available in German and English and to analyse possible use in the different EU member states.
- Parallel to this process, various projects should be initiated in order to learn from the existing FYC concepts and / or FYC devices by installing and operating them in own solar thermal systems of the individual partners in the project. This would bring the required actors (investors, installers, planners, scientific partners – institutes, test labs) into the position of rapidly gaining own FYC experience in

the field of solar thermal systems' analysis and failure detection / failure removal.

- The experiences gained in the individual installations should be shared among different projects and the experts involved in order to increase the build-up of FYC know-how in a wide variety of solar thermal systems and applications.
- Due to numerous examples, everyone practically dealing with FYC will detect operating faults, malfunctions, and low-yield situations, which are in many cases originate in human errors rather than just technical problems to be fixed. Therefore, special care should be given to the delicate situation of detecting other people's errors and faults, because within this process nobody has to be blamed under any circumstance. But the aspect of learning from each other's installation and / or operation failures, system malfunctions, or associated low-yield situations is a very crucial point in this process of learning by doing, i.e. detecting and removing errors. Positive experience has been made by communicating these findings only once the deficits have been localized, understood and eliminated / repaired.
- A very positive side-effect of such projects could be stimulated by associating FYC learning programmes to related, specialized professional training courses for installers, planners and technicians. Furthermore, the future availability of low-cost FYC devices in thermal energy systems could be integrated into the basic professional training of future generations of (solar) heating technicians, and other practitioners, which so far have never had access to the measured behaviour of the systems which they built.
- While operating the FYC equipment available today, there will certainly be observations about its shortcomings, needed amendments, undetected failures or other problems, which are all very valuable for the process of future improving the FYC technology actually available.
- During this process, new projects for the development of new FYC concepts / new FYC approaches should be initiated.
- Up to this point, the projects could be on regional, national and / or EU wide / IEA wide level.
- However, on the international level, the practical and theoretical FYC experience gathered by a great number of FYC experts will enable the establishment of an international drafting committee for the elaboration of an international FYC guideline / FYC standard.

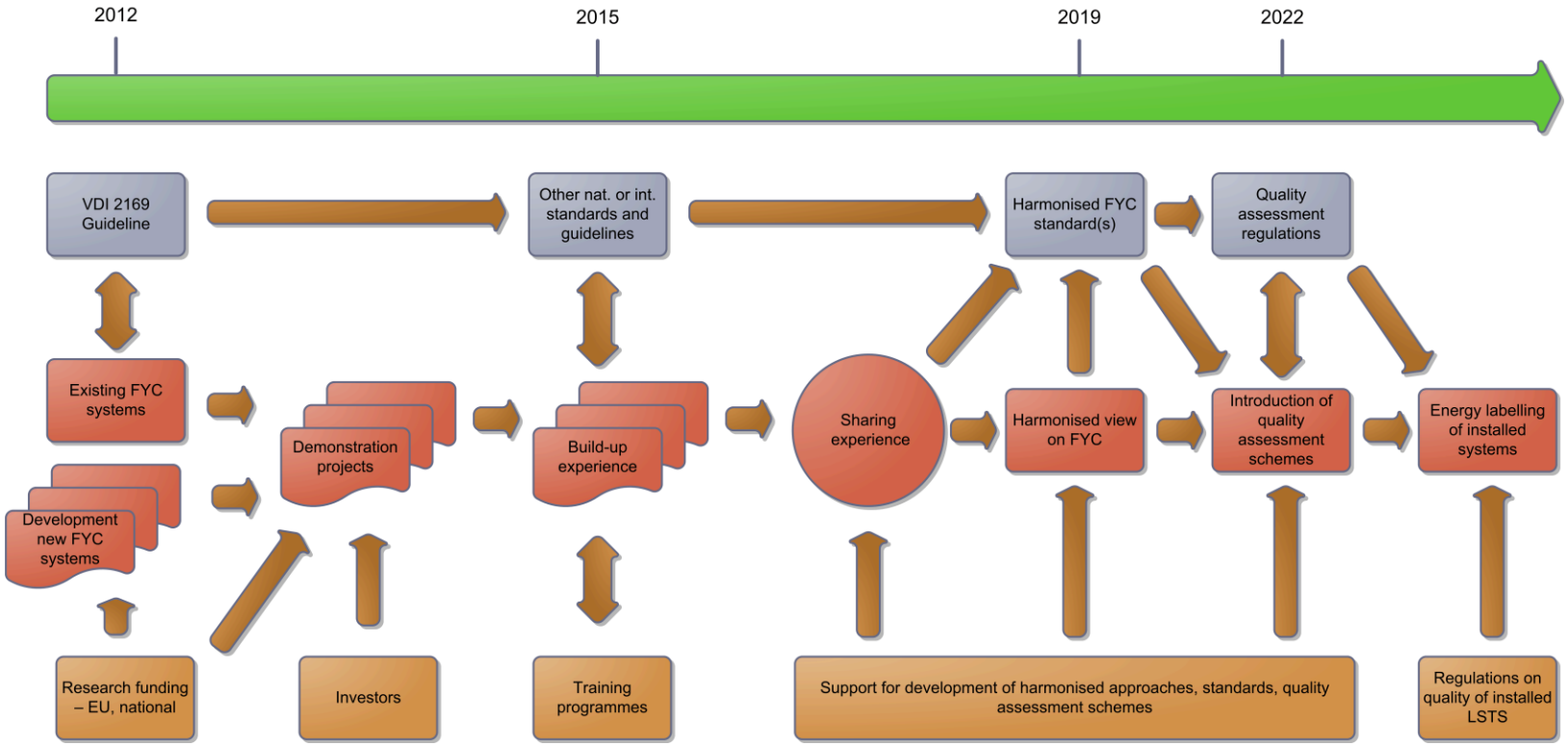
Possible association of members of funding authorities to this standardisation work will help to prepare possible future considerations /

requirements regarding quality criteria in the field of market stimulating mechanisms.

Working along these lines could help to reach the tremendous benefits of continuously and efficiently working systems. Clear goals for the technology are necessary to define the technical and other boundary conditions for efficiency verification and long-term monitoring of the installed systems. An example for a successful development and implementation of quality assurance schemes is the testing and certification of solar thermal collectors. Therefore, a similar course for installed systems could be taken.

In the following graph, the recommendations are summarised into a proposed timeline and actions that would have to be taken in parallel on the following three levels for a successful, comprehensive implementation of the FYC technology:

- standardisation level;
- technical level;
- non-technical level, which refers mainly to the role of the EU, but also includes the investors and training programmes.


2012
2015
2019
2022
VDI 2169 Guideline
Other nat. or int. standards and guidelines
Harmonised FYC standard(s)
Quality assessment regulations
Existing FYC systems
Demonstration projects
Build-up experience
Sharing experience
Harmonised view on FYC
Introduction of quality assessment schemes
Energy labelling of installed systems
Development new FYC systems
Research funding – EU, national
Investors
Training programmes
Support for development of harmonised approaches, standards, quality assessment schemes
Regulations on quality of installed LSTS

References

[1] Schindl, J., 2006, REPORT WP2.D1 - Survey on barriers and chances of large solar thermal systems. Report of the European FP6 NEGST project. Downloaded on 30.11.2011 from http://www.swt-technologie.de/NEGST2_D1.PDF

[2] VDI, 2011, VDI 2169 „Funktionskontrolle und Ertragsbewertung bei solarthermischen Anlagen“, Gründruck, VDI-Gesellschaft Bauen und Gebäudetechnik (Hrsg), Beuth Verlag, Berlin