# Impact Assessment Solar Thermal Energy

Final Report

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# Abbreviations

| | |
|---|---|
| ADA | Austrian Development Agency |
| ADC | Austrian Development Cooperation |
| CoC | Centres of Competences |
| $CO_2$ | Carbon Dioxide |
| DAC | Development Assistance Committee of the OECD |
| DCA | Austrian Development Cooperation Act |
| EUR | Euro |
| GEF | Global Environment Facility |
| IEA-SHC | International Energy Agency – Solar Heating and Cooling Programme |
| IFC | International Finance Cooperation |
| IFI | International Financing Institutions |
| IRENA | International Renewable Energy Agency |
| $kW_{th}$ | Thermal capacity of 1 kilowatt |
| kWh | Kilowatt Hours |
| LAC | Latin America incl. the Caribbean |
| $m^2$ | Square meter |
| MDG | Millennium Development Goals |
| MENA | Middle East & North Africa |
| MWh | Megawatt Hours |
| SC | Solar Cooling |
| SD | Solar Dryers |
| SDG | Sustainable Development Goals |
| SHIP | Solar Heat for Industrial Processes |
| STE | Solar Thermal Energy |
| STS | Solar Thermal Systems |
| STTP | Solar Thermal Technology Platforms |
| STTRM | Solar Thermal Technology Road Maps |
| SSA | Sub-Sahara Africa |
| SWH | Solar Water Heaters |
| UNIDO | United Nations Industrial Development Organisation |

# 1 Introduction

## 1.1 Austrian Development Cooperation in energy and development

The Austrian Development Cooperation (ADC) supports since 2001 development projects in the field of solar thermal energy, whereby nearly all programmes and projects in this area do include a component on know-how transfer and capacity building, in the view of:

- implementation of technical improvement measures of facilities,
- establishment of demonstration projects,
- improvement of local (political, social, economic and technical) conditions,
- awareness building measures and/or
- development of business and financing models.

In addition, conservation of the environment is one of three prime aims set forth in the Austrian Development Cooperation Act (DCA). Climate protection is explicitly stipulated as one of four fields of action in the Austrian development-policy strategic guideline, Environment and development. Sustainable energy and climate protection are also a programmatic priority in the cooperation between the Federal Ministry of Finance and international financial institutions (IFI). As far as possible, ADC will consequently pay due attention to climate change issues.

The mission statement of the Austrian Development Policy 2016-2018 refers to one of the priorities being the "*Environment-friendly development, the sustainable use of natural resources and the protection of habitats in urban and rural areas.*".

Energy remains in the Nexus "Water-Energy-Food Security" one of the four key topics in the actual "Three-Year Programme on Austrian Development Policy".

## 1.2 Objectives of the impact study

The Austrian Development Agency (ADA) has contracted the consortium ConPlusUltra GmbH and PWC Advisory Services GmbH with the development of an "Impact Study on Solar Thermal Energy", with the objective to assess and analyse the direct and indirect long-term outcomes of project interventions supported by ADC in the field of solar thermal energy (in fact solar drying, heating and cooling).

The study objectives were to:

- Assess the causes, interactions and outcomes associated with the implementation of solar thermal projects
- analyse and conclude regarding the outcomes of involved instruments (cooperation with NGOs/NPOs[1] or private sector) as well as of the used approaches (e.g. improve capacity for private sector, realization of demonstration projects, other incentives) for the future design and steering of project interventions,
- assess the sustainability of immediate outcomes and of the change processes initiated,
- and address the circumstances that have contributed significantly to the success or failure of the various interventions.

The impact study was not designed as a classical evaluation that focused on details about outcomes and impacts of individual projects. Rather, the study envisaged to derive generalised findings describing the effects of the ADC's solar-thermal energy project interventions and outcomes as perceived by stakeholders (refer to scope in chapter 1.3).

[1] Non-governmental organizations/non-profit organizations

The results of the study are foreseen to be used both for institutional learning about the planning and steering of future projects and for informing the ministries involved and the Austrian public about the effectiveness of the interventions of ADC.

## 1.3 Scope

The impact study focused on projects that match the following criteria:

- Thematic focus on solar thermal energy *)
- Contract amount beyond EUR 100,000
- Project were directly supported by ADC
- Projects were finalised before Q1-2016

*) In technological terms, and in the context of this study, "solar thermal energy" (STE) refers to a form of energy and a technology for harnessing solar energy to generate thermal energy. Typical applications are solar water heaters (SWH) for hot water preparation and heating (space or process heat), solar drying processes (SD, e.g. for food products like fruits, grain, fish, medical and aromatic plants, cashew nut, cocoa, coffee and others), and include also solar-driven cooling systems (SC, e.g. for buildings). Any secondary transformation, e.g. from heat into electricity, or direct solar-electric applications (photovoltaics) are not considered in the frame of this impact assessment.

**For further reference in this study we therefore refer to the terms *solar-thermal energy* (short: STE) or *solar thermal systems* (STS), encompassing the individual technologies of solar water heaters (SWH), solar dryers (SD) and solar cooling (SC) being used in the project interventions assessed.**

The study team has been initially provided with a list of all projects and programmes in the context of STE that were supported by ADC.

The evaluation did not have a geographic focus but covered all geographical regions where STE projects were implemented.

## 1.4 Evaluation criteria

In principle, the structure and evaluation criteria of OECD DAC (Development Assistance Committee) were taken into consideration to answer key questions concerning the

- Relevance
- Effectiveness
- Efficiency
- Impacts
- Sustainability

of interventions supported by ADC and by assessing the wider impacts of solar thermal installations, and in case, no conclusions at the impact level were possible to draw, focus on the outcomes, by looking at exemplary projects realised in the past years.

Specific evaluation questions referring to the DAC criteria above have been provided by ADA. The list of questions can be found in Annex B.

# 2 Methodology

## 2.1 General Approach

The impact assessment is founded on different ***qualitative and quantitative methods for data collection and analysis***, in order to ensure a systematic data and information collection and a robustness of the results.

While *quantitative methods* produce data that can be aggregated and analysed to describe and predict relationships, *qualitative research* can help to probe and explain those relationships and to explain contextual differences in the quality of those relationships. Qualitative research is able to use social analytical frameworks to interpret observed patterns and trends.

## 2.2 Methods used for data collection and analysis

For the **collection of data,** the following methods were used:

- **Document analysis**

At the outset of the study all written documents available for the projects, such as: project concepts, project reports, internal project papers, evaluation reports, etc. were screened with a view to identify information on outcomes and impacts as well as respective gaps.

- **Logic modelling**

Based on this document analysis a generic intervention logic for STE projects logic was created. Document analysis is a key starting point for later instrument development and data collection.

- **Exploratory qualitative interviews**

Before the missions and the finalisation of the evaluation instruments (interview guidelines, questionnaire) some explorative qualitative interviews with ADA staff were conducted in order to obtain a better insight into the national contexts and the respective country strategies of ADA, and to identify possible contact persons and potential interview partners.

Based on the analysis of project documents, the generic logic model and the information obtained from the interviews, interview guidelines were developed.

- **Qualitative interviews with stakeholders**

During the site visits to Egypt, South-Africa, Namibia and Mozambique a **total number of 55 interviews** with project partners, trainees, universities, project developers and implementers, and policy makers in ministries and state agencies were conducted. Additional interviews were held via Skype with stakeholders from these countries and additionally with project partners working in Macedonia, Jamaica and Central America. All these interviews constituted a crucial element of the contribution analysis in that they, firstly, sought to identify evidence for the achievement of outcomes and, secondly, reviewed the plausibility of the assumed causal links between project outputs and outcomes.

- **Standardized survey**

In addition, and as a result of the discussion of the inception report with ADA staff, a short internet survey for training participants was developed with the aim to launch it in the countries visited during the missions, i.e. South Africa, Namibia and Mozambique as well as in Egypt. It was, however, only supported by the project partners in Namibia and Egypt. In total, the link to the questionnaire was sent out to 118 former training participants (87 from Namibia, 31 from Egypt). Twenty-four responses were received (20 %), eighteen of which were form Namibian participants.

- **Analysis of available literature and data**

Throughout the study and in parallel with the collection of primary data, relevant (grey) literature and data bases were identified and analysed, including information from international organisations, other development partners and donor-funded programmes, R&D institutions, national government/institution publications, national and international statistics and relevant country reports.

The findings of the evaluation are based on the analysis of the following data:

*Table 1: Data basis used for the evaluation*

| Method | Data | Details |
|---|---|---|
| Document analysis | > 60 project documents, interim and final progress as well as evaluation reports | List of documents available see Annex C |
| Exploratory qualitative interviews with Austrian stakeholders | Interviews with 10 stakeholders | Lists of interviewees see Annex D |
| Qualitative interviews with stakeholders in/ from project countries | Qualitative interviews with 47 stakeholders | List of interviewees see Annex E |
| Online survey | 24 completed questionnaires | Online questionnaire – see Annex F |
| Analysis of available literature and data | > 70 documents/ reports | List of references and literature – see Chapter 7 and Annex H |

For the **analysis of data**, the following methods were used:

- **Descriptive quantitative data analysis**

The *quantitative assessment* contained a mix of top-down analyses (e.g. country-level data) and project-specific bottom-up information, based on availability throughout the project cases provided for review, such as the following examples:

  - Energy related indicators: e.g. number of STE installations (capacity in $m^2$ and kW) for solar heaters, cooling and drying facilities; amount of thermal energy produced (heating/cooling); share of renewable energy in country energy mix; RE growth rates (especially STE but also complementary technologies like solar photovoltaics); development of GHG emissions on a country level.
  - Technology indicators: cost of STE installations, number and size of producers of STS or components in the countries, number of installation companies and certified installers
  - Socio-economic indicators: e.g. number of households/industries/service buildings using STE, in share of total % and in absolute terms; access rate to clean energy technologies and how it has changed over past years; data about household income; number of jobs created directly by projects in the area of STE; amount of financing available for STE installations.

- **Content analysis** was used for the analysis of qualitative interviews.
- **Descriptive statistics were** used for the analysis of the survey data.
- **Adapted causal loop diagrams** were used for the analysis of the factors influencing the market for solar thermal systems.

The contribution of the projects to the achievement of the goals of the ADC is determined by a **contribution analysis**.

For the initially planned *Comparative Qualitative Analysis (CQA)*, which should be used to assess the necessity and sufficiency of specific factors on the spread of solar thermal systems the evaluation did not have enough "cases".

# 3 Limitations of the impact study

The following factors account for certain limitations of the evaluation:

- **Sketchy outcome chains or lack thereof**

  Though several of the STE projects supported by the ADC submitted a logframe or a similar project matrix, none of the available project documents contains a detailed description of the underlying intervention logic at higher outcome levels or the related theory of change (ToC). While project outputs and immediate outcomes are usually described in detail, references to medium-term outcomes and most notably longer-term impacts are scarce and rather vague.

  ***Reasons:*** Most of the projects were contracted at a time, when logframes and/or a ToC were not obligatory. ***Consequences for the evaluation:*** Thus the "Generic intervention logic of solar thermal energy projects" (see Figure 1, chapter 4) which served as basis for the evaluation, is only a re-construction and the assumed outcome chains might not always entirely reflect the original intentions of the project implementers.

- **Considerable gap between outcome and impact level**

  The scarcity of clearly defined medium-term outcomes mentioned above also contributed to the big gap between outcomes and impacts. One of the challenges of evaluations is to assess the extent to which the changes triggered by a specific project have contributed to the achievement of the impacts envisaged. In the area of evaluation this gap is being referred to as "attribution gap", which is inherent to all outcome evaluations. If outcome chains have been formulated, this gap can be bridged by existing methods for impact assessment, i.e. counter-factual or theory-based approaches. If the outcome chains are not complete, as is the case for the STE projects supported by ADC, reliable and evidence-based statements about the contribution of projects to the achievement of impacts become impossible.

  ***Reasons:*** To avoid such a gap, which can be found in many development cooperation projects, more than the two outcome levels of the standard log frame format are necessary. However, STE projects were only required to have at least two outcome levels, i.e. there was no reason for them to define more.

  ***Consequences for the evaluation:*** Therefore, the evaluation focused on outcomes triggered by STE projects that could be traced using the methods described in chapter 2.2. Data on some impact indicators were collected and analysed, yet without being able to draw any decisive conclusion about the influence of STE projects on respective changes.

- **Continuation of projects after 2016**

  For two projects only, a project phase was finalised before Q1-2016 (*Soltrain* and Egypt), i.e. they were continued afterwards.

  ***Consequences for the evaluation:*** In these cases, a clear distinction between outcomes triggered by the phase/s within the scope of the evaluation and later project phases was not always possible.

- **Large-scale STE projects implemented simultaneously or shortly afterwards**

  In the context of international development cooperation, the STE projects supported by ADC are to be considered small-scale interventions. The effects achieved can thus easily be overlapped by bigger interventions implemented simultaneously or shortly afterwards.

  ***Consequences for the evaluation:*** In cases, where other large-scale STE projects of other donors or national programmes were implemented at the same time, for example in Albania (national solar thermal project implemented after ADC intervention with support from UNDP), Egypt (UNIDO-supported project "SHIP – Utilising Solar Energy in Thermal Industrial Processes") or South Africa (ESKOM rebate scheme for SWH), an attribution of outcomes to the ADC intervention was difficult and remains questionable.

- **Lack of qualitative data derived from interviews with local stakeholders**

  For three projects (Bolivia, CONA/El Salvador-Nicaragua-Guatemala and Albania) no interviews with local stakeholders could be conducted.

***Consequences for the evaluation:*** Findings related to these projects are only based on project documents and interviews with the Austrian lead partners.

- **Limited amount of quantitative data received through a standardised survey of training participants**

  The standardised online survey launched among training participants in Namibia and Egypt received only twenty-four responses, of which eighteen came from Namibian participants. The limited number of answers from Egyptian participants was certainly also due to a language problem. Since the survey had not been part of the original evaluation plan, available resources did not allow a translation into Arabic.

  ***Consequences for the evaluation:*** The small number of responses did not allow for computation of statistical significance. The reported results are therefore descriptive only and have more the character of anecdotal evidence.

- **Lack of statistical data to capture medium term and long-term outcomes**

  All STE projects were implemented at local level, whereas the majority of available statistical data refer to the national level. Thus, even if there were changes or developments of the selected impact indicators at local level, available data did not allow for their identification, i.e. they would not show in national statistics. Equally, changes at national level do not allow for conclusions at local level.

  ***Consequences for the evaluation:*** While it was possible to describe overall changes at the level of long term outcomes/impacts, due to their limited size the respective contribution of STE projects could not be determined.

- **Lack of baseline data and information at start of project intervention**

  Notably, for projects which started some ten to fifteen years ago, contextual data referring to the start of the project could not be reconstructed entirely by the evaluation. This concerns especially information on policies in place at the time of project development, statistical data on supply with and use of solar thermal systems, or data related to state of awareness issues and capacity.

  ***Consequences for the evaluation:*** it was not possible to entirely answer evaluation questions related to the alignment of projects with political priorities as well as the determination of exact state of change.

# 4 Generic intervention logic of solar thermal energy (STE) projects

The intervention logic of STE project presented in this chapter has been re-constructed on the basis of available project documents. It is not the only possible model for STE projects, but rather represents one of many possible options that could have been developed based on the available information.

Since this study does not focus on single projects, but on STE projects in general, the resulting logic model is to be considered as generic. It therefore could not incorporate all project outputs and outcomes mentioned in project documents but had to focus on the most important ones.

Its purpose is to summarise and bring together different causal pathways as envisaged by projects and to illustrate how the activities of a series of interventions in a combined approach can be understood to contribute to a chain of results (outputs, short/medium-term outcomes) that likely produce the ultimately intended impacts. Having said this, it is important to bear in mind that not all pathways are equally addressed by all projects.

It differentiates between three main outcome chains (direct outcomes) directed at different target groups:

1. Outcomes and impacts for end-consumers of solar thermal energy – these include the domestic sector, industry as well as social institutions;
2. Outcomes and impacts for businesses that produce, install and maintain solar thermal systems;
3. Outcomes and impacts for policy makers or the respective policy context;

**End-consumers:** The outcome chain for end-consumers is mainly triggered by the outputs depicted in the middle of the diagram, such as for example demonstration systems or test facilities, market research to determine consumer needs as well as events to inform consumers about solar systems. As a result, both their awareness of and their confidence in solar thermal systems should increase. However, the purchase of solar thermal systems requires financial resources, the access to which can be enhanced through financing models or favourable policies. Once end-consumers start to buy solar thermal systems the respective market can be expected to grow.

**Businesses**: The outcome chain for businesses that produce, install and maintain solar thermal systems is shown on the left-hand side of the diagram. It is triggered by capacity building activities for the target group. Increased knowledge and skills should enable the participants to increase the supply with affordable, high-quality solar thermal systems at local level. If at the same time the respective demand of end-consumers increases, the market for solar thermal systems will grow which in turn will contribute to the creation of new jobs.

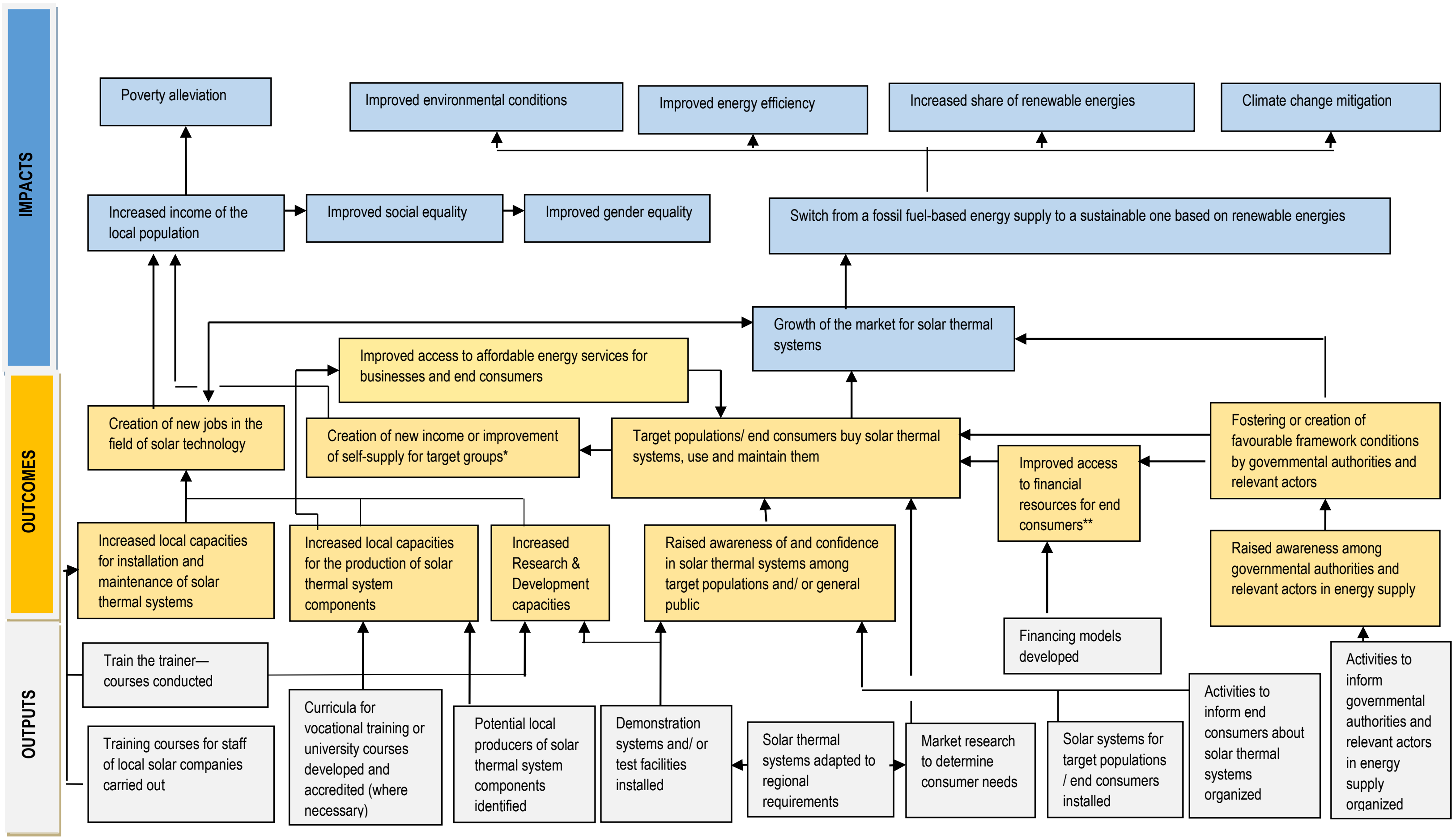
**Policy makers:** On the right-hand side a third outcome chain addresses policy makers. It is of special importance, because it also feeds into the outcome chain for end-consumers in the way that it creates the framework conditions necessary for an increased demand for solar thermal systems.

The logic model presented on the next page has two noticeable characteristics:

1. There is a huge gap between the short-term outcomes expected to be triggered by project activities/ outputs and the impacts to be achieved. This is one of the limitations of the impact study addressed under chapter 3.
2. There are only two “links” between the outcome and impact level, namely the “Growth of the market for solar thermal systems (STS)” and “Creation of new jobs, in the field of solar technology”, which are interlinked. Notably the growth of the market for STS can be considered a bottleneck, in that its achievement is a pre-condition for the achievement of higher-level outcomes/ impacts.

Also, the logic model does not contain any assumptions, i.e. additional conditions that have to be met in order to achieve the next level. They are missing, because the project documents used for the re-construction of the intervention logic did not refer to them. They are, however, addressed under chapter 5.1.

## Generic intervention logic of solar thermal energy projects




**: only applies to solar drying projects* ***: can also be a project input*

*Figure 1: Generic intervention logic of solar thermal energy projects*

# 5 Evaluation Findings

In this chapter, the evaluation findings are presented in detail. The evaluation report is structured according to the OECD/DAC criteria of **relevance, effectiveness, efficiency, sustainability and impact** as they are listed in the ToR. In addition, findings related to the design of projects and their underlying intervention logic are presented.

## 5.1 Project Design

### 5.1.1 Determinants of the market of solar thermal systems (STS)

Both, interviews with stakeholders during the missions, as well as the analysis of project documents and literature produced two important overall findings:

(1) Firstly, in principle many of the causal links between project outputs and immediate outcomes assumed by STE projects are plausible. For example, the trainings conducted did in most cases increase the knowledge and skills of participants and consequently increased the local capacities regarding the design, installation and maintenance of STS.

(2) But, secondly, this notwithstanding, in none of the countries a significant growth of the market for STS was observed.

To understand the underlying reasons a rough model of the determinants of the market for solar thermal systems, notably SWH and SC, was developed. It uses an adapted version of causal loop diagrams, an instrument that is often used for the analysis of complex contexts. Similar to the classical logic model it identifies causal links between different factors (shown as arrows), but in addition also includes the direction of the correlation.

The respective model is being presented below. Naturally, the factors included in the diagram represent only a small portion of all possible factors. Their selection was guided by their assumed relevance in the context of STE projects, which was derived from reports/literature and stakeholder interviews. Also, it is important to bear in mind that according to stakeholder interviews in many countries SWH systems were already in use. Therefore, it is not a model for the establishment of a market for a "new" product, but for entering an existent market dominated by similar products that are cheaper and of inferior quality with the aim to set up a market for high quality STS.

The model serves a heuristic purpose and therefore it neither aims at completeness, nor does it claim to be able to entirely capture the complexity of the STE market in all the different countries under concern.

The accompanying narrative description also includes needs of the three identified target groups related to each of the five "main factors" identified.

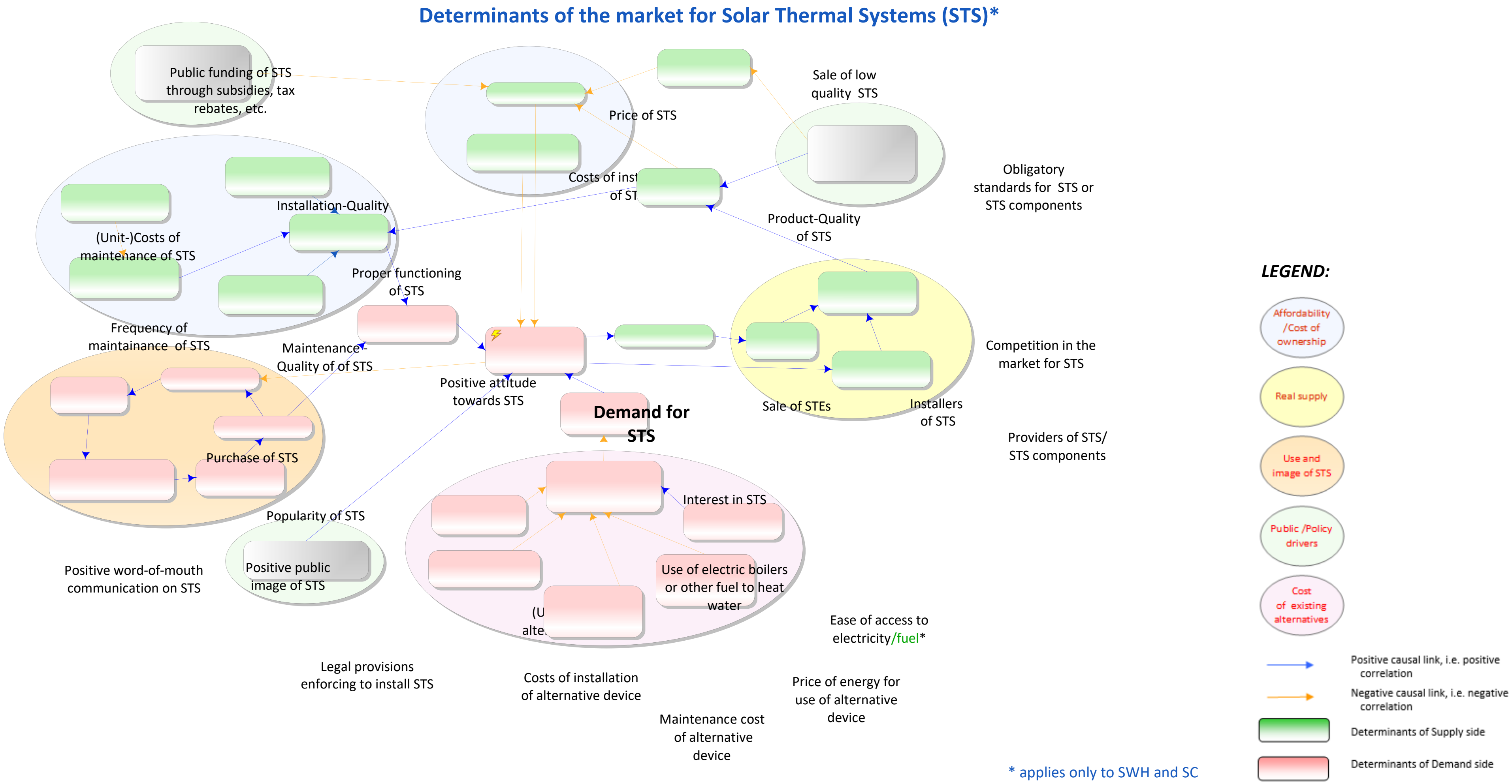



*Figure 2: Determinants of the market for Solar Thermal Systems*

**Description of the diagram**

Central element of the market for STS is the demand of the target groups which triggers the purchase/ sale of STS. It is being influenced by numerous factors which can be summarised under five "main" factors:

**1. Costs of alternatives (in the middle at the bottom):**

A solar thermal system is only one of several devices that can be used to heat water. Other options are the use of electric geysers or, in industry, oil or other fossil fuels. Whether or not the target groups of STE projects (private households, industry, social institutions) become interested in STS depends mainly on two factors: firstly, the ease of access to electricity or other fuels used for alternative devices and, secondly and most importantly, the overall costs for alternative devices such as electric geysers. If the latter are low, target groups will continue to use these cheaper devices, which decreases the demand for STS. Only if using an electric geyser or another device is not significantly cheaper than using an STS target groups will become interested in the latter.

***Related needs:***

- End-consumers: There are two needs related to this factor: firstly, the target groups' need for hot water or cooling and, secondly, the need for information about alternatives to existing devices.

**2. Costs of STS (in the middle and on the left-hand side on top)**

Secondly, there are the total costs for the purchase, installation and maintenance of the STS. Costs to purchase and install a STS directly influence the demand. However, due to the volatile economic situation in most of the project countries cost savings are only a decisive argument, if the costs related to investment and installation of STS are short-term amortizable. In addition, costs for maintenance occur which is the pre-condition for a proper functioning of the STS. These costs vary considerably depending on the quality of the STS, its installation and its maintenance. In fact, the solar thermal systems promoted by the ADC projects, do not only compete with alternative devices, but also with cheaper, low-quality systems.

***Related needs:***

- End-consumers need to be able to afford the purchase as well as the maintenance of STS, either because the respective costs are comparable to the costs of the devices they presently use or through specific financing models. They also need information about the importance of maintenance in order to make sure that they take care of it.
- Businesses that install and maintain STS need to have the knowledge and skills required for installation and maintenance STS.

**3. Use and image of STS**

The third factor that influences demand is the use of STS, the respective user experience and the resulting image of STS. It is probably the most important, because it is composed of several sub-factors that form a reinforcing causal loop. This factor best illustrates the challenges of establishing a market for a specific product, because it is both the pre-condition for and the consequence of the demand for this product. Or, in other words: the more people already use STS, the more people will become interested in it. Usually there is a tipping point, i.e. a point when a "trend" catches. According to "diffusion theory" the rate of adoption of a technology e.g. by using a specific device, can vary considerably. Its early adoption by opinion leaders can speed up the process considerably.

**Related needs:**

- End-consumers need to be able to learn about the positive experiences of other users of STS in order to be motivated to use the systems themselves. Once they use a STS, they need a positive user experience themselves to be willing to inform other potential users about the advantages of STS.

**4. Real supply**

The fourth factor relates to the supply side. In this regard it is important to notice that increased demand stimulates the supply side, but not vice-versa. Usually an increased demand for STS will increase the competition amongst both, installers as well as providers of STS, i.e. more actors will enter the field. At the beginning, such a competition usually takes place via pricing, which may initially lead to a reduction in product quality. However, in the long run competition can be expected to increase the quality of STS (as shown in the diagram).

**Related needs:**

- Businesses that provide, install and maintain STS need to have access to systems or components thereof with sufficient quality which they can sell, install and maintain at an affordable price for end-consumers. They also need a safe-guard against low-quality products, as for example quality standards. Quality refers to criteria such as durability/endurance of system components, overall design (including thermal efficiency of solar panels, integration into thermal processes of industrial applications or heating/cooling systems of buildings), and quality of installation (e.g. piping and fittings).

**5. Enabling environment (Public/ Policy drivers)**

The fifth factor summarises basically public/policy drivers that might influence market development. In the context of this non-exhaustive model the best options to influence the demand for STS are to decrease the price of STS via public funding, to preclude the use of alternative devices by making the use of STS obligatory and to protect the market from low-quality products through the introduction of obligatory quality standards.

**Related needs:**

- Policy makers need to know about the advantages of STS. They also need a policy framework that is compatible with an active support of the usage of STS. Finally, they need the necessary resources to effectively implement policies favourable of solar thermal energy as well as to control the implementation.

Overall it can be stated that in most of the target countries the market for STS is hardly subject to legal regulations and therefore demand driven. The latter is largely determined by the costs of purchasing, installing and maintaining a STS as compared to the costs of alternative devices. A positive attitude of end-consumers towards STS systems is another important factor that triggers demand. It is, amongst others, influenced by a positive public image of STS which in turn is fostered by positive user experiences that depend on well-functioning solar thermal systems. Suppliers (providers and installers of STS) can stimulate demand mostly by offering affordable systems and ensuring that these systems work, i.e. though product quality and the quality of installation and maintenance.

In the following, the evaluation findings are being summarised by answering a set of 23 evaluation questions (EQs) that have been proposed by the consultant team and agreed with Austrian Development Agency, based on the original evaluation questions provided with the ToR.

The responses to the evaluation questions below are structured accordingly into (1) main findings that constitute affirmations based on the information collected and (2) a short background analysis to support the arguments provided within the findings; the evaluation findings are being followed by the consultant's conclusions (summary assessment of performance) and recommendations (chapter 6).

## 5.2 Relevance

**EQ 1: To what extent were the interventions aligned with the ADC targets?**

*Main findings:*

Within this outcome evaluation, project interventions within the given ADC principles to support sustainable energy, and especially here with the focus on solar thermal energy (STE) interventions, are being taken into consideration and how interventions have contributed to achieving at least two of the three main ADC targets. Namely (1) the objective to reduce poverty, (2) the objective to achieve environmental protection and conservation of natural resources, and (3) peacebuilding (the latter not being considered by the authors to be an immediate and relevant aspect for this evaluation).

(1) **Contribution to reduce poverty:** Meanwhile, energy has become a key component of any sustainable development strategy. Ensuring adequate access to energy is essential if national development strategies, such as those for health, education, rural development and gender equality, altogether meant to reduce poverty, are to be successful. Of the three types of STE projects covered by this evaluation, i.e. solar water heating, solar drying and solar cooling, only the concept of solar drying projects directly addresses the reduction of poverty. They do so by ensuring an increased income for final project beneficiaries through the creation of new jobs. The case of SWH and SC projects is to be considered differently, because project activities and outputs provided do not directly address poor or low-income groups. A longer-term contribution to poverty reduction at household level cannot be precluded but would require a positive impact of the projects on the local economic development, for example through the creation of jobs. Similarly, in other sectors, e.g. in industry, services, small businesses or social entities, applications of STE cannot be directly linked to poverty reduction. The impact there is more indirectly, since security of energy supply and improved access to cheaper and cleaner energy technologies reduce operational costs in public entities and businesses and therefore increase the likeliness to poverty reduction in the way that a well-functioning social infrastructure and strengthened local businesses might impact on the poverty level at a macroeconomic level.

(2) **Achieving environmental protection and conservation of natural resources**: The use of solar thermal energy brings independence from fossil fuels and predicted price increases. In addition, STS can reduce the peak load of grid electricity, in turn, less electricity generated from coal or other fossil fuels benefits the environment and natural resources, since adverse effects of pollution and emissions, mainly carbon dioxide ($CO_2$), and other pollutants resulting from (incomplete) combustion of biomass or fossil and other (e.g. waste) fuels, are being mitigated. Moreover, electricity demand, in most countries produced in low efficient power plants and with high transmission and distribution losses, is also being replaced by clean energy from the sun. Awareness measures and capacity building programmes at educational institutions (mainly secondary and tertiary) create the basis for the increased use of environmentally friendly technology. Project-type interventions and business partnerships thus contributed to the achievement of Millennium Development Goals (MDGs[2]) No. 7 "Environmental Sustainability" and No. 8 "Building a Global Partnership for Development", as they did also for the newly formulated Sustainable Development Goals (SDGs[3]) that came into effect in 2016, especially SDG 7 "Ensuring access to affordable, reliable, sustainable and modern energy for all". By 2030, this target is to ensure universal access to modern energy services, lead to an increased share of renewable energies in the global energy mix and doubling the global rate of improvement in energy efficiency. STE provides a contribution to both aspects of this target as is being demonstrated by the pilot projects being supported by the project interventions (see also EQ related to *efficiency*, *impact* and *sustainability).*

Effects of the individual projects have been reconstructed based on project documents and intermediate and final reports as well as independent evaluations, to come to the conclusion that project interventions have

[2]MDGs are referred to here as they were the prevailing UN goals under which projects were considered and approved. The eight Millennium Development Goals (MDGs) – which range from halving extreme poverty rates to providing universal primary education, all by the target date of 2015 – formed a blueprint agreed to by all the world's countries and all the world's leading development institutions.

[3]https://www.un.org/sustainabledevelopment/sustainable-development-goals/

been relevant, considering the quantitative effects of fuel savings and carbon emissions being achieved– see further elaboration in EQ 21 & 22.

**EQ 2: To what extent were the interventions aligned with the specific targets in the energy field:** increase of the share of renewable energy, energy efficiency, improved access to affordable, modern and sustainable energy services?

*Main findings:*

The level of extent to which project interventions are contributing to the achievement of specific targets in the energy field is as follows:

- **Increase of share of renewable energy**

  It is obvious that availability of solar thermal energy is contributing to the achievement of the renewables' target. Altogether, 470 demonstration projects for STE have been installed and are (still) running (with the exception of a few facilities), covering solar water heaters and process heat, solar drying and cooling applications. The solar energy yield has been estimated at 6,850 MWh per year, energy being produced through the sun and replacing other primary sources of fuels (mainly electricity and fossil fuels). However, due to their overall small size and number compared to installations on a national scale the overall impact on contribution to increased share of renewables is minor. Project interventions can nevertheless be considered important *early-movers* in countries where penetration of renewable energies is to a large extent in a very early stage – at least what concerns the supply-side of STS provided in the market (i.e. focus on qualitative technology dissemination in the market).

- **Improved energy efficiency**

  Although IEA or World Bank had often put STE in the same drawer as energy efficiency, because it reduces the energy demand from power plants, replacement of fossil fuels or electricity by solar thermal energy is not an energy efficiency measure *per se*, if the installation does not consider also improving the specific demand for heating, cooling and hot water per unit of energy input. Energy efficiency in buildings usually goes hand in hand with reducing energy demand due to improving the building envelope or optimising user behaviour (e.g. decrease temperature level of a hot water system, increase room temperature in the case of cooling to avoid energy being used for cooling down), or in industrial processes, if specific production lines can produce the same (or even higher) output with less energy input.

  The fact is that *energy efficiency* is not mainstreamed yet in many countries. Projects like *Soltrain* or the business partnerships did consider energy efficiency aspects into their trainings and capacity building programmes, as well as integrated design for optimised supply of hot water, heating and cooling especially in larger facilities (social institutions, industries), but yet, energy efficiency approaches are not always sufficiently incorporated into project design also within projects focussing on renewable energies.

  Reports referring to the interventions have in neither case made specific reference to the level of energy efficiency before and after the project nor provided any quantitative indication of energy efficiency improvements linked to the project outputs and outcomes. It cannot be excluded that *actually* energy efficiency improvements linked to STE installations have taken place, but they cannot be reconstructed based on information available. Energy efficiency aspects have received attention in those cases where project partners have been emphasising the linkage between energy efficiency and application of renewable energy technologies in their project activities (e.g. within trainings or design of pilot installations) – but yet energy efficiency considerations are not considered from the beginning in all project interventions. ADC should consider this strong linkage wherever possible in the future, in line with striving to contribute to the achievement of the SDG7 target.

- **Improved access to affordable, modern and sustainable energy services**

  STE is not considered to be a cheap renewable energy source, since especially the larger installations in the commercial, industry and public sector need engineering capacity and integrated design, which makes the technology attractive only in the case the user pattern can be effectively optimised and sustained using solar energy. In those cases, where project interventions where targeting STS in households, interviews with several stakeholders revealed that readiness and acceptance rates to invest into a STS (including the readiness to have it regularly maintained) exist only in middle- and higher-income households. In fact, STS in the residential sector compete with cheap electric resistance heaters (geysers), although solar heaters are gradually penetrating some markets (e.g. with past government support in South Africa–with low-quality systems tough). In general, however, low-income families tend to refrain from hot water use if ability-to-pay is not existent.

Project interventions have proven to be relevant, as far as quality aspects and provision of sustainable energy services are concerned, since the major focus was to promote solar thermal systems that were long-lasting and operational beyond other basic hot water systems (with the proof that most of the systems installed with ADC support are still operating).

**EQ 3: How relevant were the interventions to the identified target groups' needs?**

*Main findings:*

The interventions implemented by STE projects addressing solar water heating (SWH) and solar cooling (SC) targeted mainly three different groups: (1) potential users/ end-consumers of STS (private households, industry and social institutions), (2) providers/ installers of STS and (3) policy makers/ governmental authorities. The solar drying project (SD) implemented in Guatemala, Nicaragua and El Salvador addressed farmers and agricultural co-operatives.

**Users/ end-consumers of STS**

As regards the needs of potential users/ end-consumers, the installation of demonstration systems in selected social institutions and SMEs provided the possibility to firstly, reduce the costs of STS for beneficiaries and, secondly, to inform other institutions/ companies about the advantages of STS.

However, one need of users/end-consumers that has not been addressed by SWH projects concerns the maintenance of STS. Project implementation on the ground revealed that users are not aware of the necessity to having a technical installation regularly "maintained", especially if a system like a solar thermal installation is backed up by electric resistant heating or other systems. The need for information on maintenance was also emphasised by interview partners who stated that awareness about maintenance requirements is generally low, notably in African countries. Also, system owners with a lower income or from social institutions often lack the means to finance regular maintenance.

Some SWH projects, such as for example *Soltrain*, also sought to address the need for affordable STS in the domestic sector by developing financing models. However, in general the needs of private households were not at the focus of project activities.

The SD project only targeted users of the solar drying systems. The project implementer (CONA) identified a need for efficient drying for farmers and farming co-operatives that grow coffee, herbs and fruits. In order to be able to sell their products also outside the local market with a view to increase the income they needed an affordable technology for conservation which was provided through solar air dryers.

**Providers/ installers of STS**

The interventions implemented by SWH and SC projects clearly addressed the needs of providers/ installers of STS in that they enabled them to acquire the necessary knowledge and skills. The involvement of Austrian companies ensured the access to high quality systems as well as the possibility to adapt the STS to local conditions. The majority of projects also provided for measures that supported the introduction of quality standards for STS and components thereof.

**Policy makers/ governmental authorities**

SWH and SC projects addressed the information needs of policy makers especially by offering specific workshops for this target group. With the exception of *Soltrain*, where the development of Solar Thermal Technology Roadmaps was foreseen in the second project phase, the need for a supportive policy framework that fosters the introduction of STS was not addressed by project activities from the beginning.

*Background information:*

In the context of the envisaged market growth for solar heating and solar cooling the evaluation identified several needs of the target groups. They are presented in the Table 2 below together with relevant project activities of SWH and SC projects. It should be noted, however, that not all of the planned activities were implemented successfully.

| Target group | Identified needs | Related project activities |
|---|---|---|
| **Private households** | • energy for hot water or heating and cooling | |
| | • information about alternatives to existing devices presently used for hot water, heating and cooling<br>• affordability of STS, their installation and maintenance<br>• information about the importance of maintenance in order to make sure that users take care of it.;<br>• information about the positive experiences of other users of STS in order to be motivated to use the systems themselves; | • production and distribution of leaflets, posters, online media, etc.<br>• introduction of financial incentives |
| **Industry/ Social institutions** | • energy for hot water or heating and cooling | • installation of demonstration systems |
| | • information about alternatives to existing devices presently used for hot water, heating and cooling | • production and distribution of leaflets, posters, presentation of STS at fairs, online media, etc. |
| | • affordability of STS, their installation and maintenance | • coverage of up to 50% of the costs of demonstration systems |
| | • information about the importance of maintenance in order to make sure that users take care of their installations;<br>• maintenance requirements included in demonstration projects | • project partners were supposed to ensure regular maintenance as a precondition for funding |
| | • information about the positive experiences of other users of STS in order to be motivated to use the systems themselves; | • production of catalogues/best practice publications |
| **Providers/ installers of STS** | • knowledge and skills necessary for proper planning, installation and maintenance of STS; | • training courses/ workshops at different levels;<br>• development of curricula for vocational training and university courses |
| | • access to systems or components thereof with sufficient quality which they can sell, install and maintain at an affordable price for end-consumers; | • adaptation of STS to local conditions/ requirements |
| | • a safe-guard against low-quality products, as for example quality standards. | • creation of national platforms for STE<br>• development of quality standards for STS |
| | • information about the advantages of STS; | • seminars/ workshops for policy makers; |

| Target group | Identified needs | Related project activities |
|---|---|---|
| **Policy makers/ governmental authorities** | • a policy framework that is compatible with an active support of the usage of STS;<br>• the necessary resources to effectively implement policies favourable of solar thermal energy as well as to control the implementation. | • development of Solar Thermal Technology Roadmaps |

*Table 2: Identified needs of STE target groups (Source: Stakeholder interviews and project proposals)*

As can be taken from the table above, the activities foreseen by SWH and SC projects covered very well the needs of providers and installers of STS. The needs of potential users of STS in industry and among social institutions were addressed, concerning the complexity of system integration, quality installation and maintenance requirements. However, the awareness concerning the assurance of regular maintenance works at STS remained limited and was often argued by public institutions with unavailability of necessary resources (personnel as well financial).

As regards the private sector, the major need refers to affordability of STE. Especially for lower-income groups the price for a SWH and its installation plays a major role. Accordingly, the final review of *Soltrain* phase 2 recommended to *"…avoid over-engineered systems in the favour of price, search for opportunities to lower costs in cooperation with local producers"*.[4]

However, though proposed STE projects referred occasionally to lower income households as a potential target group, this target focus has often been re-defined in the course of project implementation. The *Soltrain* project, for example, currently ongoing in its third project phase, has defined from the beginning industry and social institutions as main target groups. Nevertheless, the South African Solar Thermal Technology Roadmap (STTRM) indicates long-term priorities concerning the residential sector, as it foresees to install *"…high-pressure residential systems, gravity-fed residential systems, industrial/commercial/multi-family residential installations for solar heating and cooling, unglazed swimming pool collectors, and passive solar thermal (PST) heating /cooling of buildings…"*. Also, the market analysis conducted in Albania as part of the project implementation came to the conclusion *"…that the two groups with the highest incomes (normal and above normal) can afford the installation of 180,000 m² SWH systems between now and the year 2020."*

The information needs of policy makers were addressed by specific seminars/ workshops. The need for a policy framework was partly covered by the development of respective roadmaps, measures to support the implementation of policies favourable of STE were not foreseen.

**EQ 4: To what extent did the outcomes envisaged correspond with the declared priorities of partners/ partner governments?**

*Main findings:*

In many of the target countries of projects supported by ADC, policies or regulations are in place today, and have partly been in place during the projects' runtime, which are in certain aspects favourable to a growth of a local market for SWH systems (refer also to EQ 14). However, since several SWH projects were launched up to a decade ago, policies presently in place do not allow for drawing conclusions on the relevance of outcomes at the start of the projects.

Available information for **Albania, Macedonia** and **Egypt** indicates, that at the time the SWH projects started STE was not a declared priority of the respective governments. However, in **Albania**, the many initiatives that followed after the

[4] Final Review of the Project: "Southern African Solar Thermal Training and Demonstration Initiative SOLTRAIN II", March 2016

ADC funded intervention to develop STE, meanwhile reached a point where the energy policy includes specific goals for STE installations and where cities are considering implementing solar thermal obligations.[5], [6]

In **South Africa**, the implementation of the *Soltrain* project coincided with the Integrated Energy Strategy developed in 2010. However, within *Soltrain* (phase I and phase II), the government concerns in South Africa and the policies of the South African national electricity utility ESKOM, which focused on low-cost systems, that were supposed to be rolled out on a broad basis, have not been addressed.

In **Namibia**, the introduction of policies and regulations related to STE took place simultaneously and partly with the support of the *Soltrain* project.

In **Mozambique**, policies related to Off-Grid-Energy, notably the Policy for Renewable Energy adopted in 2011, focus on biofuels, solar PV and solar water heating.

Overall it can be stated that although at project start in many cases the outcomes envisaged by ADC projects did not correspond with declared priorities of partner governments, many of them were reflected by policies introduced later on.

*Details:*

In **Namibia,** the Ministry for Public Buildings has introduced a regulation that requires SWH installations in all new public buildings which is seen to have provided a push for the market. However, split responsibilities between several ministries also bring about some challenges in the programme's implementation, notably a lack of ministerial staff qualified to control it. The participation of several employees of the ministry in training provided by *Soltrain* and their increased knowledge on STE is perceived to have been very helpful.

Also, in Namibia, the Namibian Solar Thermal Technology Roadmap was developed jointly by the *Soltrain* project partner and the Ministry, similar in Mozambique, where the STTRM was endorsed by the Ministry of Science Technology and Education.

This notwithstanding, the main focus of Namibian energy policies in the period 2014-2017 has been on the introduction of a legislation on new Independent Power Producers (IPPs).

In **South Africa**, the Integrated Energy Strategy developed in 2010 and adopted in 2016 has focused on electricity. In terms of securing energy supply, photovoltaic represents an alternative to SWH which is often favoured (notable exception: City of Cape Town's municipal policy) and is currently also supported by an intervention of GIZ.

Beset by power outages and a long-term electricity supply shortfall, Eskom introduced a cash rebate for installing residential SWH in 2008. This rebate targeted the residential sector as it accounted for 35 % of electricity demand in peak hours. Almost all residential hot water in South Africa was at that time heated by electric resistance elements and the electricity use for this accounted for approximately 40 % of monthly electricity consumption for middle income households. The rebate programme set an ambitious target of 925,000 SWH installations by 2013 but was suspended in 2015 with only 102,000 rebate payments made, 11 % of the initial target. By any metric, achievement of 11 % of the target set, is poor, however, South Africa had an existing SWH industry in 2008, with growing volumes, albeit from a small base. Ultimately the SWH rebate programme managed to stimulate the supply-, but not the demand-side of the market, causing long-term damage to the SWH industry, including job losses for local manufacturing and supply/installations of STE systems.[7]

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[5]http://www.al.undp.org/content/albania/en/home/operations/projects/environment_and_energy/the-country-program-of-albania-under-the-global-solar-water-heat.html
[6]http://www.al.undp.org/content/albania/en/home/library/environment_energy/solar-thermal-obligations-for-public-buildings-in-the-municipali/
[7]Review of South Africa's Solar Water Heating Rebate Programme, Scientific Paper published by Unlimited Energy, Johannesburg & Stellenbosch University, Stellenbosch, South Africa

In 2013/14 a new building code was passed at national level which required that >50 % of hot water demand of residential houses (larger than 120 m²) must be provided from other sources than electrical heating (non-resistive), i.e. solar water heaters or heat pumps.

At local level, the City of Cape Town has an Energy 2040 target approved by City Council which includes the efficient use of SWH and heat pumps, with a target of 500,000 SWH installations in households by 2040. Until 2014 / 2015, approximately 46,000 installations have been made. The programme was not so successful in the beginning, as it was influenced by the bad (low quality) reputation of the ESKOM funding scheme. In recent years also the issue of water scarcity has become prominent, and therefore attempts to convince households about water saving measures have gained importance, which leads to a conflict of interest with the promotion of SWH. There is also a competition between PV and SWH, but City Council promotes SWH since the technology is perceived to be more advanced in overall system efficiency compared to PV systems. The policy also includes accreditation of service providers (ASPs): ASPs must adhere to a strict Code of Conduct established by the City when selling the solar water heater, including the installation, warranty and maintenance. They also have to meet the rigorous technical, business, ethical and service standards set by the City.

Furthermore, though the Department of Renewable Energy and SANEDI were involved in the discussion process, endorsement of the STTRM by the Department of Energy of South Africa is lagging behind and not expected to happen, because the roadmap was developed by a project and not the government itself.

## 5.3 Effectiveness

**EQ 5:** How have the specific interventions contributed to **increased local capacities for the installation and maintenance of solar thermal systems**? What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

STE projects supported by ADC have had in nearly all cases a focus on increasing local capacities for the installation and maintenance of solar thermal systems. Project interventions have initiated to build capacities and know-how of local stakeholders involved in the installation and maintenance of solar thermal systems in basically two ways:

- Supporting Vocational Education and Training (VET):
- Supporting higher-level education (universities)

and additionally, by general means of dissemination of good practice STE technology and maintenance related issues in the course of pilot project implementation but also general awareness measures on the level of policy-makers, financial institutions and general public.

**Vocational Education and Training**

The effectiveness of trainings can be considered quite high within the limited scope of participants addressed through the training programmes; major benefits were the mitigation of the lack of local capacity that has been mentioned to be one of the main barriers affecting the STE market development.

- Training modules and sessions have been developed and promoted together with national stakeholders and project partners, being in some countries universities, in some others national educational institutions (either ministries of education, or national vocational training institutes).
- Participation in trainings was encouraged by project partners with the result that trainings were well accepted and partly even overbooked. Projects like *Soltrain* in Southern Africa or the business partnership of *Sekem* in Egypt provided several rounds of trainings (in case of *Soltrain* over 2 project phases), to merge existing basic with new improved knowledge and skills, which provided value-added to the education systems in the countries. Meanwhile, in some countries like Namibia, the continuous improvement and development of VET courses on STE is based on local knowledge of trainers and instructors. Here, an updated curriculum with a

specialisation on SWH installations is expected to be out in 2018, after approval by the National Training Authority, which can be finally attributed to some extent to the successful activities of *Soltrain*.

- Project interventions have been able to address the topic of capacity building for STE among trainers (teachers, instructors) through dedicated "Train-the-Trainer" (TtT) courses and specialised training sessions for technicians, students, engineers as well as dissemination trainings for policy makers, NGOs/associations or financing institutions. Trainings were delivered in a combination of theoretical and practical contents, with a focus and ability to design, build, install and operate (maintain) solar thermal systems. In cases of projects like *Soltrain*, the practical training was enhanced by the availability of small-scale solar demonstration installations (either installed in the training centres/schools or educational trailers – see info box below). In Egypt, the local partners learned specifically about project design parameters and what kind of input are required, together with the introduction of calculation tools for conducting technical and economic feasibility studies.
- The content of VET programmes is largely defined by existing (or newly developed) curricula for particular courses and not so much determined by the job profile required by the labour market. While the job profile of a "solar-thermal engineer/technician" (or similar) is existing only in a few countries (e.g. Albania has received supported in the curriculum development through a Global UNDP-GEF funded program on Solar thermal energy, as a follow-up to the ADC-funded project; Namibia is currently approving a profile of a Solar Engineer, covering both, STE and PV, mainly with donor support from GIZ), some countries do have basic technical VET courses for plumbers, installers (or similar), but with no specific focus on renewable energy technologies or perhaps even solar thermal energy.
- What has been reported back during the stakeholder interviews was the fact that trainings provided within different project interventions were covering relevant (technology and operational-focussed) topics and were properly organised, however certification of these trainings was not anticipated beforehand, and therefore participants were not able to benefit from accredited trainings – a recommendation to be thought of in similar future activities.
- Also, to mention is the positive achievement towards the outstanding involvement and share of women in technical trainings, which was significantly higher in some countries, e.g. Namibia with more than 60 % female enrolment in VET courses. Information from other than *Soltrain* countries have not been available in detail.

**STE Capacity on University Level**

The main finding is that university education cannot be filling the gap of practical, "hands-on", trainings that is required to satisfy the immediate need for production, installation maintenance and business development of STS applications in most of the countries assessed. But the role of universities in building theoretical capacity and develop their capabilities with applied research and educating students is eminent.

1. Nevertheless, introducing academic courses on renewable energy technologies (with focus here on STE), such as promoted in Egypt, South-Africa, Namibia or Mozambique can be expected result in medium- to longer-term impacts on the number of graduates and specialists entering the market through om-the-job trainings. The role of universities in basic research and development of innovations and technology improvements is limited in some countries due to lack of financial and personal resources, although the academic institutions are important drivers and partners to lead and monitor the STS market development activities in countries like the one participating under *Soltrain*. However, in terms of technical, economical and marketing capacities these experts have mainly (or in some countries solely) finished VET schools or benefited from scholarships to foreign countries (mainly Europe and Northern America).
2. In addition, the role of universities and research institutions in capacity building and promotion of STE systems has been quite significant in some countries. *Soltrain* was built mainly on cooperation between research institutions and universities with a dedicated (renewable energy) technology focus. At each of the educational institutions at least one university level course on renewable energy in general with a special focus on solar thermal energy for students was developed and held over the considered project period. Furthermore, master theses considering a STE topic were accompanied at each educational institution as part of their academic duties und supervised by their staff. Job profiling workshops were organised, and draft unit standards based on competence-based education and training (CBET) approach have been developed.

*Background information:*

Skilled professionals and technicians are critical to renewable energy and especially solar-thermal technology deployment. While higher education is a prerequisite for developing research, technology and project development, policy and financial capabilities, vocational trainings and capacity building at technical level are essential to provide technical services in installation, operation and maintenance. Solar thermal installations require periodic inspections and routine maintenance to keep them operating efficiently and are therefore also demanding specific installation and servicing capacities, more than some other renewable energy technologies, like simple biomass or solar photovoltaic systems.

VET systems are usually institutionally integrated in the regular national educational system, at secondary level, upper and post-secondary as well as sometimes at tertiary level. In the countries assessed, different government bodies and ministries share supervisory responsibilities. Often, these are loosely (if at all) coordinated, unregulated and fragmented.

The challenges and therefore entry points for ADC-supported projects are (1) lacking suitable RE technology-focused curricula (specifically for STE), following the (2) lack of experience with STE, linked with the (3) lack of sufficient capacities of local installers and project developers.

The fact that training courses provided on STE topics have not been formally integrated in the national education system provided the demand for building up these capacities through ADC-supported interventions. Projects considered therefore mainly a focus on training (within existing national VET systems or isolated through the project activities) on practical (technical) skills and competences. Training in entrepreneurial skills, including economic or management skills were generally less common and did not have a significant focus within ADC funded projects.

The general gap between the skills required for the implementation of STE and those provided by initial education is arguably a substantial one. It can be noted that in many countries neither governmental nor private training institutions are in a good position to cover these skills requirements. In addition, there is a disconnect between the energy industry and the training institutions, perhaps leading to the conclusion that often, companies themselves (or associations, where they exist and have own experts with acquired skills) may be better positioned to provide technical trainings.

Activities to bring about the educational process are usually differentiated between *initial training* and *supplementary training*. This includes continuous training corresponding e.g. to further training of employees or an up-grading of existing skills as well as additional training for the upgrading of fresh graduates. For most developing countries, the provision of such vocational education and training provides a major challenge. Support to their own efforts is rendered to many governments by international donor partners, whose attention to VET has been increasing, not least because VET has been defined as one of eight priority areas in the African Union's Second Decade of Education (2006-2015).[8]

However, educational systems of developing countries and economies in transition are challenged to provide for sufficient number and/or sufficiently skilled people in new technology areas, such as renewable energy or solar thermal energy specifically, as demanded by the labour market.

On the university level, in Egypt, the Faculty of Engineering at the Heliopolis University of Cairo has started a bachelor course on “Renewable Energy” and has expanded it gradually to include the field of solar thermal energy including low, medium and high temperature applications. For this, the ADC-supported project (business partnership) provided capacity in developing the curriculum and specialist lecturers. As a part of the TtT approach, professors and teaching staff have initially participated in the solar technical training courses – including a hydraulic training, a product training and training at the two demonstration plants. In addition, a special introduction to monitoring & measurement equipment was provided, so that the demonstration installations can be measured and evaluated in the long term by the students of Heliopolis University in the course of their lessons. In the long run, user behaviour of the facilities was measured, to monitor the productivity, if necessary, adapt them to local conditions and to formulate new research questions. As part of the plant survey, research and development projects can be created, which is also of interest for the further cooperation of the new local company in Egypt.

[8] https://au.int/en/newsevents/27617/african-union-second-decade-education-africa-au-and-adea-launch-publications-skills

In the case of STE promotion and market development, in order to design and install advanced high quality solar thermal systems for social institutions, such as hospitals, schools, university or administration buildings, hotels, industrial applications or residential buildings, specialized courses for experts have been setup by ADC funded projects.

**EQ 6:** How have the specific interventions contributed to **increased local capabilities for the production of solar thermal systems components**? What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

Project interventions were mainly built around the target to improve the capacity to install, the quality, performance and lifetime of solar thermal systems; and not necessarily increase the capacity of local production. However, some projects focussed on local production capacities to be established.

In **Zimbabwe**, local production and installation of small SWH was established through the project intervention, with support of local partner companies, whereby the supply of technology components and supporting equipment was organised through local dealers/supply companies. The production of locally manufactured solar collectors as well as storage tanks had been supported, where the production and installation of collectors and storages underwent constant quality control by the leading project partner. All in all, 100 SWH installations were implemented between 2002 and 2004 (193 m², 135 $kW_{th}$).

In **South Africa**, *Soltrain* supported individual assistance to eight local producers and distributors of STE technologies with the objective to improve overall system design and local supply of solar-based thermal systems. Due to the negative development in the market resulting from the unsuccessfully implemented ESKOM rebate scheme (see also EQ 4), which was introduced to stimulate the uptake of STE technology, demand for STS fell drastically and so did a majority of suppliers/distributors vanish from the market. STS suppliers (including a few local producers) were competing for the same small market which was overrun by cheap STE systems imports, which as a conclusion turned down all production capacities in the country and most of the available supply and installation capacities as well. As of today, according to information provided in the interviews, no STS producer exists in South Africa. Stimulating the supply side therefore failed to stimulate the demand.

As an additional barrier for local producers and a consequence of the above, the South African Bureau of Standards (SABS) introduced the testing of the solar water heating system (as a whole) and not the testing of individual components. This makes it fairly expensive for local producers to get their products certified, and still hinders local production because it is not possible to change a single component (e.g. locally produced tanks or solar panels) after the system has been tested. If a single component is changed, the whole STS must be tested again.

In **Central America**, construction and commissioning of 50 basic solar drying units for wooden handicrafts and food, obtained good yields in the processing of the products dehydrated. However, the support was related to one project intervention finalised already in 2009, and no information has been available if local production of such drying units could be maintained or extended.

In order to be able to implement a solar thermal system in **Egypt** that meets a European quality standard, the solar thermal system was adapted to the local requirements. For this purpose, the climatic and regional characteristics of Egypt such as the climate zone (sand, salty air) and the water quality were considered and led to the specific design of a solar flat-plate collector for maritime and near-desert regions. This design developed by the Austrian solar panel producer *GREENoneTEC* is resistant to the salty sea air as well as to shifting sands. Heat pipes have been adapted as well to local conditions. All findings and results were documented and taken into account in the preparation of training documents. Particular attention was paid to the system cost. By using as many local products and services as possible, the costs should be kept as low as possible, so that the systems can be applied to local businesses (especially tourism, industry) or the broader population.

Building production capacities for STE installations and therefore serving the development of the supply side is one element of the market development, however, it is not the key element. Developing the supply market has to go hand in hand with increased demand for STE, which is a complex function between hot water demand[9], a technological solution (in our case through STE) and the assumption that potential buyers can or will afford the technology.

In conclusion, the project interventions did have some effects on increasing the capacity for local production of STS or components, however, they were not targeted to solely develop local production capacities through these interventions. In order to come up with locally developed or locally sourced STS or system components, increased efforts would be required in developing local research & development capacities, bringing in experienced know-how product and equipment suppliers and of course a favourable policy framework to ensure stable and foreseeable market conditions supporting the promotion of STE technology. Altogether, this goes beyond the scope that can be achieved through ADC-funded project interventions.

**EQ 7: How have the specific interventions contributed to increased capacities in research & development?** What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

Activities and outputs concerning enhancement of research & development (R&D) capacities were not considered a main focus of the SWH projects under evaluation in their planning, management, and reporting. Rather, they have been embedded in a framework that has primarily focused on training activities, deployment of demonstration systems, and awareness raising. In the project carried out in Egypt, R&D issues appear as an aspect of the multi-level training package deployed. In the *Soltrain* project, goals related to data collection and monitoring and to the build-up of an institutional structure that can be considered favourable for the unfolding of solar technology have additionally been addressed in some of the project's target countries.

In the majority of STE projects, except for Albania, Jamaica and Central America, local universities were project partners and were supported/targeted by train-the-trainer activities as well as by the deployment of high-quality solar technology systems. The latter could not only support training, but also be used for research activities in that they enabled students of the university to study at the demonstration system by ways of measuring and monitoring the system's performance.

As concrete outcome of the support provided by SWH projects in most of the involved universities the specific field of solar technology has been included into a study course.

Also, the continuous collection of data and monitoring of the demonstration systems installed increased significantly the data base on the performance of SWH under different conditions, which can be expected to not only increase the quality of respective statistics/ databases, but also can be used as basis for new innovations in the field of solar thermal systems.

This notwithstanding, genuine information on research & development capacity as it is typically used by professional evaluations in the field of research, technical development and innovation (RTDI), such as number of publications or patents directly related to the SWH projects, is not available. However, during stakeholder interviews it has been mentioned, that university staff in Namibia, South Africa and Egypt has been involved in research studies and published respective papers, which were also presented at international conferences. PhD thesis which are also accepted as an indicator of research output have not been submitted yet at the universities involved.

Also, Centres of Competence (CoCs) have been created at partner universities in Namibia, South Africa and Mozambique. However, the exact contribution of the CoCs to an increase of RTDI is difficult to assess, because their main focus seems to lay on carrying out training programmes.

Overall, for the time being the available evidence does not suggest a significant increase of R&D capacities triggered by ADC projects.

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[9] Especially in developing countries, where the primary needs of continuously operating tap water is not ensured to all clients, the commodity 'hot water' is of less priority.

*Background information:*

- At Heliopolis University in Egypt, the engineering curricula of 2018 comprise a course in Solar Thermal Energy Systems and a course in Solar Energy in Buildings at the Department of Electromechanical Engineering. 2 lecturers and 2 tutors are allocated to each course. The course in Solar Thermal Energy Systems is mandatory in the Energy Engineering Programme, while the course in Solar Energy in Buildings is an elective course. Both courses also are elective courses in the Water Engineering Programme, and Solar Energy in Buildings is also an elective course in the Architecture Engineering Programme.10The university also runs a Centre of Excellence for Education for Sustainable Development.
- In South Africa, *Soltrain* training content has been integrated in one module of the MSc programme on renewable energy offered by the Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University, and has been taken up through students' projects. A testing facility that has been installed during *Soltrain I* and enhanced during *Soltrain II* has mainly been used for Master Theses of students.
- In Namibia, *Soltrain* content is currently integrated at the university only at the undergraduate level. The Namibia University of Science and Technology (NUST) is developing the curriculum for a Master of Engineering Degree in Sustainable Energy Systems, where solar thermal technologies will be part of the courses.
- In Zimbabwe there is a new MSc course covering *Soltrain* training content.

Also, the continuous collection of data and monitoring of the demonstration systems installed increased significantly the data base on the performance of SWH under different conditions, which can be expected to not only increase the quality of respective statistics/ databases, but also can be used as basis for new innovations in the field of solar thermal systems. For example, in South Africa CRSES invested (partly with *Soltrain* support) in new monitoring equipment (4 sets) that are installed at STS for about 1 year and then moved to other project sites. Respective results are mainly being used for R&D purposes."

Centres of Competence (CoCs) that have been created at partner universities in Namibia, South Africa and Mozambique. These have been conceptualised as hubs of expertise with view to training and education. However, CoCs are in the contemporary RTDI policy and expert discourse understood to represent a type of organisation which structurally anchors the cooperation between research and economy (companies, technology application). This concept is not spelled out in *Soltrain* project planning and documentation. It can however be taken from interviews that the universities and research centres were CoCs were established are in contact with industry. In Macedonia, the CoC is in place with the Macedonian Solar Thermal Energy Association, which was already partner in two FP-7 research projects.

The exact contribution of the CoCs to an increase of RTDI is difficult to assess, because their main focus seems to lay on carrying out training programmes. However, in contemporary approaches to RTDI capacity and performance in Europe, the US, or Australia, research and development carried out in the industry and leading to innovations are of pre-eminent interest, shoulder to shoulder with RTDI capacity inside academia. Vocational trainings are usually not considered aspects of R&D capacity in contemporary RTDI policy and evaluation.

**EQ 8: How have the specific interventions contributed to raised awareness of and confidence in solar thermal systems among the target populations or the general public?** What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

In none of the countries data regarding the level of awareness of potential users/ end-consumers of solar thermal systems and their benefits is available, neither on local nor national level. Thus, interviews with stakeholder of five countries (Egypt, Namibia, Macedonia, Mozambique and South Africa) provided the only information source. According to them the awareness regarding the availability of STS is lowest among private households and medium to high among

[10] http://www.hu.edu.eg/wp-content/uploads/2016/07/engineering.pdfaccessed on 15 May 2018.

industry and governmental stakeholders. Country-wise, the awareness of target groups is assessed highest in Namibia and lowest in Mozambique.

However, a high awareness of the existence of solar thermal systems does not necessarily imply a high awareness of their advantages. Especially in countries where STS were already in use at the start of the ADC projects, such as for example in Egypt, Namibia or South Africa, STS often had a bad reputation/image due to the low quality of the STS available in the market at that time.

Overall, the nature/ format of awareness raising activities implemented by the projects, which did not include the systematic use of new electronic media (e.g. social media channels), makes it questionable whether a raise of awareness, notably of the general public, could be achieved with a limited amount of financial resources. Awareness raising measures need to be fledged by continuous programmes for dissemination of STE with defined target groups and under the auspices of the relevant government stakeholders to be effective in the long term. None of the projects implemented with ADA support were in the position to launch these awareness programmes. But as regards feedback of policy makers/ governmental stakeholders, interviews indicated increased awareness of participants of workshops/ seminars targeted at this target group.

## *Background information:*

As an immediate effect of the project activities, targeted users should have developed an increased awareness of the advantages of STS which should lead to an increased purchase of STS, the source of this affordable energy. To this end, a variety of awareness raising activities were implemented, such as for example the production of leaflets or posters or case study booklets, or, as for example in Albania, the participation in the national trade fair “Albanian Elite Industries” with a solar energy stand in 2008.

The general observation made is that at the start of the projects STE was already used, mainly in households, in several countries, e.g. in Egypt, Namibia or South Africa. This means that at least a minimum level of awareness has been in place, though only rudimentary as regards the benefits of high-quality STE systems. Businesses or social institutions have been hardly considering STE installations since they were considered costly and difficult to integrate into existing heating/hot water systems. However, the first penetration came with cheap SWH systems (very often from Chinese brands) that have entered these mostly unregulated markets at low cost or were supported by national funding schemes (as e.g. in the case of South Africa). These cheap systems often had quality problems as they were badly installed by a largely untrained workforce. Maintenance can equally be taken to have been problematic since not solved for by system providers or clients willing to take care of maintenance issues. Technical problems were thus common, and many systems stopped functioning in a short period of time. This severely affected the reputation/image of SWH among the general population. Trust and confidence in the SWH systems had to be rebuilt.

Asked about the overall image of STE in the target countries, stakeholder interviewed during missions assess it as fairly good or neutral. Also, in South Africa and Namibia it has improved over the last years. However, due to the small number of respondents the ratings below rather have the character of anecdotal evidence, and no evidence is available that STE projects have contributed to this development.

Stakeholders interviewed during the missions assess the present level of awareness as follows:

**How would you assess the general awareness regarding the availability of solar thermal systems in your country among…*(1= Little, 2= Medium, 3= High)***

| Target group | Egypt | Namibia | Macedonia | Mozambique | South Africa |
|---|---|---|---|---|---|
| Private households | 1 | 2,25 | 1 | 1,5 | 2,2 |
| Industry | 2 | 2 | 2 | 1 | 2,2 |
| Government stakeholders | 3 | 2,75 | 2 | 1 | 1,8 |
| *No. of respondents* | *1* | *4* | *1* | *2* | *5* |

*Table 3: Survey among interview participants regarding general awareness. Source: Stakeholder interviews*

**EQ 9:** How have the specific interventions contributed to **improved access to financial resources for end consumers of solar thermal systems**? What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

ADC provided dedicated co-funding for STS and is being considered an important early-stage donor in the countries considered within this evaluation, for the following reasons:

- Solar thermal demonstration projects would not have been installed without this external funding source, due to unavailable other sources of financing. In general, investment projects were meant to demonstrate the solar thermal technology in different settings, mainly within social institutions (covering schools, kindergartens, hospitals, vocational training centres, universities, student dorms, retirement homes or public administration buildings), private service buildings (e.g. airports, office buildings) businesses of different sectors (e.g. breweries, private business incubators), and to a smaller extent also within residential homes (multi-family, single-family houses).
- The contribution foreseen by ADC was through a setup that ensured efficient use of funding sources through a non-repayable grant covering a share of the installation costs. In the case of *Soltrain,* the funding was ensured through a developed subsidy scheme and several calls for project applications covering up to 50 % of eligible investment costs for solar hot water systems, in some other projects smaller demonstration cases e.g. for solar dryers or SHW systems up to 100 % with a requirement by the beneficiaries to provide the remainder as own contribution (either from own sources or financing through other means, like state funds or commercial bank financing). The overall investment volumes instigated and compared to the overall volume of STE installations in the countries were though marginal (compare with Figure 2 and Figure 3 in Annex G), equivalent to the low absolute subsidy amount ADC was able to provide.
- Within business partnerships, ADC support was typically covering only the preparatory costs for market studies, setting up business cooperation, trainings of local staff/experts, conducting feasibility studies and developing financing concepts or financial appraisals. Exceptional is the case of Jamaica, where the grant support provided by ADC in the amount of ca. 200,000 EUR within the business partnership between an Austrian-based STE project developer and a local company was able to leverage about 8 million EUR of investments into solar cooling plants – not only in Jamaica, but also for an additional project development in Aruba and another investment in Nicaragua. Other financing approaches that were tested in Jamaica, such as the development of ESCO-based models using solar cooling at airports in Montego Bay and Kingston did not materialise.
- One of the main outcomes of the project interventions that made a difference was that they helped to realise STE systems with high quality and state-of-the-art technology in early markets and under conditions that required specific awareness support and know-how development that had not been available before. The longer-term impact is thus linked to use the positive experience and attitudes of project stakeholders towards developing capacities further and enhance policy and market instruments for further upscaling of the STE technology, which includes the financing component.
- As a major finding from a business partnership implemented in Jamaica, private sector investments require several stages in the development of the financial appraisal and improving the access to financing sources: (a) gather experience in the negotiation with different financing institutions, including development and commercial banks, in the setup and structuring of larger-scale investment projects, (b) developing and implementing alternative financing solutions (e.g. soft loans, blended financing schemes), and finally (c) development of flagship projects, which are relevant for mitigating the financial risk (one of the major arguments for structuring project finance).
- The finance available for renewable energy projects provided by banks is related to market conditions in the country or market, and in the case of developing countries is usually challenged by high interest rates and high collateral requirements. Project partners and stakeholders do often express the need to have financial mechanisms available that will better address the challenges of the specific technology and target groups it is to address. Engagement with development banks to raise the interest and awareness of local commercial

banks to finance new technologies with dedicated credit lines[11] would enhance the local capacity to provide attractive financing conditions to households and private businesses and are thus required in many developing countries or transition economies. Very often, banks are reluctant to overcome their low sensitivity as they argue about technology and operation risks during financial appraisal. In the case of household systems this is less of an argument (considering the type and size of SWH usually installed) compared with businesses or industry, where design and process integration are major aspects to be considered at the project development stage and driving factors for lowering financial risks.

- The finding concerning public sector institutions is that they rely on ordinary budget provisions (for new investments as well as covering operational and maintenance costs) or grant financing unless being integrated into an appropriate financing scheme (e.g. set up of a revolving fund, introduction of national subsidy schemes, or tax-based instruments only to name a few typical instruments). Such schemes can be practically not realised without grant financing from a donor, development partner, or development banks. ADA can support governments in developing appropriate market and policy instruments, however, would require to specifically engage in a longer-term policy dialogue, which for ADA is usually limited by time and financial resources available.

*Background information:*

Although economic aspects may not be considered the main barriers for promotion of STE technologies, however, they are among the most critical ones to be considered in the overall evaluation of the perceived technological and market risks. Especially the level of energy prices (mainly electricity but also other fuels) and required STE system costs impact the investment decision made by end users. The benefits of solar-thermal energy utilisation are in some countries outbalanced by the cheap electricity costs, and due to little experiences and awareness about solar energy also resulting in low incentives to switch to this kind of clean energy. However, when comparing STE based on their overall lifecycle costs, i.e. considering not only the investment costs for the system, but also the lifetime operational and maintenance costs (therefore including opportunity costs for alternative energy sources to produce the same output of hot water, heating or cooling as well as costs for regular inspections, maintenance works or replacement of spare parts), the solar thermal systems become much more attractive.

There is a need of assessing the costs of the heat produced by solar thermal systems over their life time in order to compare different designs and technological solutions with one another.

The levelized cost of heat (LCOH), a measure based on the concept of levelized cost of energy, which is widespread in the electrical power sector, provides a suitable benchmark to assess the unit cost of heat provided through STS, however, it was not possible to assess these benchmarks for the demonstration projects here (or even compare them), since data has not been available, or projects have not made assessment of these LCOH.

The value added of ADC supported projects lies therefore in the creation of awareness among decision makers (governmental stakeholders, association, NGOs, businesses etc.) and training of installers and users to holistically understand the advantages that this renewable energy technology does provide, from an operational but also financial point of view.

But overall, the financial barrier remains very often a key handicap for all identified target groups, i.e. residential households, public institutions as well as private businesses, however, from different perspectives. Social institutions represent an extremely difficult target group. There are usually no funds available for co-financing due to the extremely tense financial situation (e.g. in case public support is undergoing regular cuts), which resulted in financial hardships to ensure co-financing of demo systems in some cases.

[11]The European Bank for Reconstruction and Development (EBRD) provides a successful model case to sensitivise local banks in approaching renewable energy and energy efficiency financing, through so called “Sustainable Energy Financing Facilities” (SEFFs), a donor-supported program extended to local financing institutions and their clients in more than 15 countries of their operation (see link for further information).

**EQ 10: How have the specific interventions contributed to the purchase, use, and continuous maintenance of solar thermal systems by target groups or end consumers?** What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

## *Main findings:*

There are statistical reviews published on the national level that show the development of the STE market for the past years. One of the major sources is the annual review of the *Solar Heating & Cooling Programme of the International Energy Agency* (IEA SHC[12]), publishing global market development trends and detailed market figures (with national statistics concerning STS) once per year. However, since these statistics refer to the national level, no conclusions can be drawn as regards the influence of STE projects, most of which acted at a local level. Equally, due to a lack of information it cannot be assessed to what extent STS have been purchased as an attributable effect of the project interventions, during their runtime or beyond.

The only direct effects of the projects concerning the purchase of STS can be attributed to the design and deployment of the demonstration systems. Here, the beneficiaries of demonstration systems were expected to contribute to the installation costs in the magnitude of approximately 50 % of total costs.

Regarding the use of STS, findings in evaluation question 23 (sustainability) indicate that the > 99 % of STE installations being supported through ADC interventions are still in use after many years, some of them more than fifteen years.

## *Background information:*

According to the model developed in the course of this evaluation to determine the main factors determining the development of the market for SWH, the purchase and use of SWHs by end-consumers is crucial, because it initiates a reinforcing causal loop that eventually feeds back and increases demand.

What can be said, however, is that all SWH projects focused on the supply side rather than on the demand side. In all countries where SWH projects were implemented, emphasis was put on high technical quality of SWH systems that are appropriately adjusted to local requirements on the grounds of high expertise that was brought in by the project partners. In Egypt, the requirements were identified in the initial stage of the project, and a dedicated system was designed that also took on board components that were, or became, available from local producers. For the rest of the project's runtime, continuous monitoring of this system's performance formed integral part of the training and capacity building concept. In Southern Africa, seven different STS that were already existing in the target countries were tested at the onset of the project, and the shaping of consequent activities was at least in part derived from the results of these tests. The projects' main activities further on formed a bundle of measures and steps focused on the deployment and promotion of high quality SWH systems, and on dedicated trainings on competences related to high quality SWH systems, within the overall framework of the capacity building approach.

In contrast to the chosen approach, both project reports as well as stakeholders interviewed confirm that the price of SWH is the decisive criterion for the purchasing decision of the majority of potential users of SWH in the target countries. SWH are in competition with electrical geysers which are considerably cheaper as regards the up-front costs of installation, but cause electricity costs throughout their lifetime. However, in countries where electricity is still very cheap, which for example is the case in Egypt, South Africa, Mozambique – the argument of savings on the electricity bill therefore does not have substantial weight for many potential buyers, notably in the business sector.

The high up-front costs of installation gain in importance, due to the lack of appropriate financing schemes for the installation of STS by households or SMEs (with the notable exception of Namibia).

*"Self-financing cannot provide the necessary means for overriding these barriers. Market penetration of most of the renewable energy technologies has been very slow due to a lack of proper innovative financing schemes, among other reasons. Furthermore, Investors and funding Institutions find it difficult to reimburse their investments in renewable energy due to the specific characters of these projects and their associated risks. The high initial cost of such technologies*

[12] Publications available at http://www.iea-shc.org/solar-heat-worldwide

*combined with the risks that the user should undertake create the need of promoting and applying modern financial schemes."* (Source: *Soltrain* County Market Reports, February 2010, p.11). Though this need has been recognised in project proposals, so far none have been developed.

**EQ 11: How have the specific interventions contributed to the creation of new jobs in the field of solar thermal technology?** What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

Based on project reports and interviews with the project partners, it is estimated that for solar drying projects per two basic units (= 4 m² solar air collector) one job in production (i.e. drying of food) are directly created. In addition, it is estimated that each job in production creates two jobs in distribution. The CONA project implemented in El Salvador, Guatemala and Nicaragua installed a total of approximately 430 basic units. Thus, based on the formula above, around 600 local jobs were created.

Different from SD projects which envisaged as their major outcome the creation of jobs for the target group, according to project stakeholders job creation was none of the short- or medium-term objectives of STE projects. Rather, they aimed at creating an enabling environment for the use of solar thermal energy that stimulates the demand for STE and, accordingly, to a growth of the respective market. Consequently, information on job creation is scarce and sketchy for STE projects and available information has rather the character of anecdotal evidence.

*Background information:*

In **Egypt**, the company Intersolar Egypt was founded in 2015, with all three partners having been trained on STE technology within the TtT training programme of the ADC funded. Presently, they have 10 employees working for them.

In **Namibia**, at least 2 companies have been founded as a result of the *Soltrain* project: TBS (single entrepreneur) is mainly active in SWH installations in the National Housing Programme, which has also been supported by *Soltrain* demonstration systems. Light systems is primarily active in Photovoltaics but also covers SWH in its portfolio. The company SOLSQUARE already existed before the *Soltrain* project but has been growing. Presently, they have a team of 26 working in Namibia and quite recently established a new team in South Africa.

Despite *Soltrain*, in **Mozambique** there is still hardly any local capacity in the area of provision and installation of STS available. While a market for SWH systems that would allow companies to thrive is virtually non-existent, a few companies are active in the import of foreign system and the installation of these systems. Most of these companies are operating out of South Africa.

In **South Africa**, the general picture conveyed by stakeholders is that existing business is not creating substantial revenue. As a result of the ESKOM rebate scheme 2008-2010, the SWH industry that had already been present in the country has substantially declined. SWH industry is facing severe challenges since as regards the re-building of the market, the growth of existing companies, or the creation of new business. Nevertheless, South Africa hosts the core part of the industry in the entire region, with South African companies also operating in the neighbouring countries, and some of these also being active in the manufacturing of components.

An estimated number of approx. 50 manufacturers, suppliers, and/or installers was active, and was also considered sufficient, since the market did not expect big growth rates from the very beginning. The history of one major company can serve as an example: The company has become active in the market in 2008 after the energy crisis and in the context of the ESKOM rebate scheme and started business with good prospects. Between 2008-2012 mainly SWH for domestic systems were installed. *Soltrain* has improved the knowledge of the company, staff and the owner have participated in several trainings. The company grew steadily until 2016 to more than 60 staff. However, since additional financial resources were required, the company entered into a merger with another company. This development was not sustainable and resulted in a crash, staff was consequently reduced to 8. *Soltrain* has not triggered a growth of the company. Rather, the programme has helped to grow the business at a time where subsidy went down and has at least helped to stabilize the business in a difficult period. There are 3 to 4 other companies left that were comparable in size and activity.

In addition, the STE projects also created local jobs through the implementation of project activities such as for example the installation of demonstration systems. For *Soltrain* it is estimated that approximately 47 new temporary jobs were created during the installation of demonstration systems.

**EQ 12: How have the specific interventions contributed to the creation of new income or improvement of self-supply for target groups?** What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

The creation of new income was only explicitly envisaged by the Central American solar drying project, but also here no concrete evidence is available. It is, however, highly plausible that each of the approximately 600 jobs newly created also induced new income. For the SWH projects, the only information related to income was obtained through the survey. Roughly 28 % of the Namibian respondents indicated that after the training they had been able to increase their personal income "Very much" or "To a certain extent". Due to the low number of respondents this has, however, rather the character of anecdotal evidence.

**EQ13:** How have the specific interventions **contributed to raised awareness among governmental authorities and relevant actors in energy supply**? What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

ADC projects have provided contribution towards raising awareness of governmental stakeholders, yet with limitations given by their size, focus, outreach and funding possibilities, or simply because the project duration being too short (considering the fact that a two-year project is not able to change the level of awareness of a whole country without being sustained by continued and complementary activities thereafter).

The anticipated outcome by projects supported by ADC, namely that awareness among governmental authorities and relevant actors has been raised, can be confirmed by the strong feedback received from stakeholder interviews at least towards one specific output: series of information workshops organised were well attended and raised considerable interest in STE. More related to the outcome is the statement that *"information provided gave a new insight on how development of new STE technology should be approached"* – high-quality products do have a longer lifetime expectancy, are more expensive, however do repay within the operating lifetime, and need capacitated staff and continuous maintenance to ensure that ST facilities are operating well.

The key messages that were drawn from interviews among governmental stakeholders are:

- Quality application of STE can bring a lot of benefits in accessing and using energy for individual purposes (hot water preparation, heating and cooling of processes and buildings, drying of food and other purposes) and different target groups (households, industry/businesses, public sector) at lower lifetime costs, compared to other (e.g. low-quality, fossil-fuel based) technologies.
- But effective promotion of STE among beneficiaries and general public will need constantly dedicated resources (personnel and budget sources to carry out awareness campaigns), to be able to make an impact in the countries. Although stakeholders have mostly supported this statement, yet the lack of resources is prevailing.
- Another feedback was that project interventions have been found to be very relevant amongst solar thermal professionals but have less addressed policy makers. This seems only partly true, since initiatives like *Soltrain* or the business partnership in Egypt have engaged with governmental stakeholders from the beginning by inviting selected stakeholders to awareness trainings, workshops or conferences. What comes closer to reality

is, however, that still a low level of awareness among most policy makers and public administration representatives prevails. In this respect the project sizes have been altogether too small to put effectively weight on decision-makers and over a continuous time (in a longer-term). Awareness creation has been focussing on the major benefits that STE have for different target groups (see first bullet point above) and for specific purposes (e.g. higher comfort with less environmental impact and cost), but continuous efforts are required by the governments to sustain these activities on their own. This argument can be sustained by the fact that most countries have meanwhile recognised the need for a sustainable energy transition as part of their country's overall policy targets, which requires commitment on the implementation level. Yet, none of the countries being assessed here have political "solar champions" among themselves.

*Background information:*

Lack of awareness on all levels (social institutions, policy, administration, financing sector, et al.) are one of the main obstacles to the broad implementation of renewable energy technologies in general, and of STE in particular. Project interventions have contributed to mitigate the information and knowledge barrier, by introducing comprehensive awareness activities. Apart from capacity building activities, which covered mainly series of trainings for the key target groups which produce, install, implement and operate solar thermal systems, awareness raising activities were dedicated towards information provision to the public and key stakeholder groups (residential building owners, industry, education, policy, administration, social institutions, and the financing sector) about the possibilities of the use of solar thermal systems.

Awareness raising activities for representatives of governmental authorities (ministries, agencies) have been covered by a majority of project interventions, having in mind that policy makers and administration staff play a major role in preparing the ground for a sustainable development of the solar thermal technology – by providing a policy framework that incentivises a greater STE use in the markets and by introducing appropriate support mechanisms and incentives for target groups to decide using STE within their premises. Awareness is therefore an important precondition to learn about and understand the STE technology basics and benefits for their greater use.

Project-based outputs consisted of organised information events, study tours, trade fairs and information materials produced, such as booklets with demonstration projects, leaflets, online media presence etc to inform about STE technology, disseminate results and achievements and keep the information present at the national levels.

An example of how projects have tried to ensure long-term commitment by policy makers was the development of *"Solar Thermal Technology Roadmaps (STTRMs)"* (*Soltrain*) in Southern African countries with the purpose to prepare guides to decision makers about the local development of solar energy technologies and their deployment taking into consideration relevant policies and initiatives. Although not all countries had these STTRMs endorsed by the relevant governmental institution, they have been able to "keep the information alive" towards decision makers and provide food for thoughts in the future.

**EQ 14:** How have the specific interventions **contributed to the fostering or creation of favourable framework conditions by governmental authorities and relevant actors**? What has made a difference, and which external factors did play a role, positive or negative? In how far could these factors be influenced by ADA or project partners?

*Main findings:*

For the evaluation of outcomes and impacts of ADC-supported projects it has to be differentiated – what where the initial activities foreseen in the project interventions, defined by the individual intervention logic, and what has actually been achieved (intentionally or unintentionally) in the context of the actual developments taking place country-by-country during that time. From an ex-post point of view, it became obvious that most of the implemented projects were influenced by political developments taking place in their specific country or region that were closely linked to the policy framework, such as specific promotion activities or incentive programmes that were introduced in the given time.

Project interventions have been able to stimulate government interest, they have partly achieved important contributions and steps towards building framework conditions around STE introduction and promotion, but in general their initial intention was not to develop single pieces of policies or legislation for the deployment of STE, that's why they cannot be attributed to the envisaged outcomes of these projects.

Nevertheless, and although the direct impact of policy work might have been rather small, for example, projects like *Soltrain* contributed visibly to on-going procedures and individual aspects of improving framework conditions in target countries:

- Provided inputs for the new energy strategy in Mozambique which distinguishes between PV and SWH systems, resulting in the plan to install solar water heaters in rural hospitals, like it was done with PV systems.
- In South Africa, *Soltrain* information was used as input to the formulation of National Building Regulations for Energy Efficiency (moreover the South African National Standards SANS 10400XA and SANS204). These regulations mandated for new buildings to have at least 50 % of their hot water supply provided by other means than conventional electric water heaters (therefore also opening the opportunity for STE).
- In Namibia, strengthening of the relationship took place between the Ministry of Mines and Energy (MME) and the National Housing Enterprise (NHE) in the implementation of the 2007 cabinet's directive instructing that solar hot water heaters were to be installed in government buildings and supporting NamPower's electricity demand side management efforts. To develop a flagship site for the *Soltrain* project in Windhoek that can be used as a showcase for promotion of solar hot water among policymakers and project financers, the project has provided the grounds for the Government to ensure the installation of 62 solar water heaters within their low-cost housing programme in Windhoek. This has been a collaborative effort led by the Namibia Energy Institute at the Namibia University of Science and Technology (NUST), together with the MME and the NHE.
- Solar Thermal Technology Platforms (STTPs) and Solar Thermal Technology Roadmaps (STTRMs) together with Centres of Competence (CoCs) were defined as crucial project elements to achieve outreach and regional collaboration. Although the national STTPs succeeded in producing the STTMs in Mozambique, Namibia, and South Africa, the process of gaining momentum thereafter was still slow. Difficult economic and political conditions were most likely impacting negatively on the level of participation by industry in South Africa. There has been progress in Namibia and Mozambique in terms of political will to support the STTRMs in their country. However, the budget to cover implementation could not be secured at least in the short term, without resulting in low likeliness that STTRMs will result in a sustainable process for developing further STE projects. The STTP was introduced as a new concept and stakeholders had to learn how to fully exploit the potential of this type of communication platform.
- In Zimbabwe, within the project "Solar Energy for Zimbabwe – Phase II" (1865-01/2001), a subsidy scheme for medium-scale solar water heaters for the institutional sector and for small solar waters heaters for the residential sector was developed in order to incentivise the market. The subsidy scheme followed the criteria: (i) open for all private persons and institutions with a health-, social- or educational background, (ii) customers can choose the producer/manufacturer and installer of the solar water heater, and (iii) clear criteria concerning the selection criteria (for subsidy). The handling of the subsidy applications was done by the local project

partner in Harare. All solar thermal systems for the institutional sector, which were proposed for funding, were also approved by the Austrian Embassy in Harare. The Embassy checked the applications if they are in line with the sanctioning criteria set up by the European Union.

Other projects, such as the business partnership implemented in Egypt, also contributed to the development of a policy framework for STE.

- In Egypt, representatives of the New Urban Communities Authority (NUCA) have been invited to technical trainings conducted within the project and created such commitment of decision makers at this authority that it resulted in a decree by the Minister of Housing New Urban Communities shaped with the support of the business partnership project that would consider the installation of STE in new housing developments (residential and touristic infrastructure financed out of governmental budgets).
- Another result from the project in Egypt (and also in Albania), materialising far after the project finalisation, was the approval of a national standard for solar thermal systems, which was in discussion and supported by project partners in their collaboration with governmental institutions (initially in the business partnership, and then in a follow-up project which resulted in a strategic partnership implemented until 2017), however were only put in place about 6 years after. Initially, the New & Renewable Energy Authority (NREA) intended to adopt European standards (*Solar Keymark Standards*) without comment, but this was averted during the duration of the project with intensive stakeholder engagement, as for example the Egyptian market does not have the same solar glass quality available as Keymark certification would require. However, there is no request yet to suppliers to have their products tested against the standard and certified, since it is only a requirement to provide certified solar systems within public procurement tenders – and so far, there are no tenders issued (though may change in the future, when NUCA will realise their plans to have STE installed in new housing programmes).

All in all, it is important to note that project interventions prepared the grounds by establishing (or partly extending) reliable relations with governmental officials or professionals in key positions during trainings and dissemination activities, however, in terms of evaluating the overall effectiveness of interventions, more activities would be required in all countries on a continuous basis, which respond to the respective needs to have suitable policies and framework conditions for STE market development in place. This follows basically the conclusion of EQ 13 concerning awareness raised where there is evidence that continued support towards establishing clear commitment from governments and implementation of national policy frameworks and programmes that have been partly initiated through project outputs is required.

**EQ 15: How effective was the chosen approach (ADA instrument) regarding the achievement of the outcomes/impacts envisaged?**

*Main findings:*

STE project funded by ADC were implemented in two different formats: project-type interventions and business partnerships.

As regards their approach, STE *project-type interventions* more or less followed a similar approach, i.e. they were based on a similar intervention logic. Regarding measures addressing the target groups they consisted of three main components: (i) capacity building, (ii) awareness raising and (iii) realisation of demonstration projects. Having said this, it should be noted, that although there is a similar approach, the *project-type interventions* have not been based on a systematic project model approach.

In the case of *business partnerships*, the projects in Jamaica and Bolivia (two out of three projects assessed in this study) followed a different logic. They were focused on either developing a feasibility assessment for improving the market for ST products (Bolivia) or on the development of a financial business model (Jamaica), by engaging private-sector developers with financial institutions (development and commercial banks). This partnership was in its specific approach also very successful since it resulted in several realised investment projects leveraging ADC with other funds significantly (refer also to EQ 16, Table 4).

The *business partnership* programme therefore focuses – more than *project-type interventions* – on the specific needs of Austrian (or EU) businesses in developing collaborations with local partners and other local stakeholders for the setup of joint ventures, cooperatives or other forms of long-term business engagement. Business partnerships can thus very specifically mitigate market and financial barriers in development cooperation and sensitize companies to search for possibilities of opening up new markets or engaging with local partners.

A distinctive feature relevant to both types of projects implemented was the composition of project partners. They included Non-Profit-Organisations (NPOs), private businesses (project developers, technology suppliers and/or industrial enterprises), universities and other institutions. With regard to the success of project implementation no significant differences could be identified as regarding different types of project partners. What seemed to make a difference, though, is the degree of local embeddedness of the respective project leader. For project leaders with a permanent or long-term presence or strong network in the target countries it seemed to be easier to ensure continuous contact with relevant stakeholders and thus to ensure local ownership.

Capacity building usually addressed both, the individual as well as the institutional level, in the way that it combined training for the target group(s) with subsequent measures to integrate the training content in existing educational structures. Aim of the trainings was an increased knowledge and skills of participants. However, what distinguishes the approach of SWH and SC projects from the classical approach was that it required from final beneficiaries to buy a STS before being able to make use of the services offered by training participants. As shown by this evaluation this twist can easily exclude low income segments of society if the necessary investment is too high. The appropriateness of this approach therefore depends on the longer-term objectives of the projects. It works with regard to environmental objectives, but not for socioeconomic goals.

Awareness raising among target groups, too, can be considered a common approach of outcome-oriented projects. It is basically about providing people with relevant information they are presently lacking and especially important if target groups do not have access to information. It is, however, important to bear in mind that the level of information does not directly impact on behaviour. If a project aims at changing the behaviour of a target group, awareness raising is a necessary, but not sufficient measure.

## 5.4 Efficiency

**EQ 16: Which resources were invested in order to reach the interventions' results?**

*Main findings:*

ADA projects considered within this study have been provided funding for the implementation in the amount of approx. 4.5 million EUR, covering a period of about 15 years (basically between 2001 until 2016). The average annual budget covered by ADC funds over that period was therefore about 300,000 EUR.

Thereof, the share of subsidy being used for supporting demonstration projects was in the range of about 1.4 million EUR (or slightly more than 30 % of the grant funds available). However, 3 out of the 8 projects were implemented as a business partnership, where ADC provided up to 50 % of the costs as a subsidy to the project implementer (businesses from Austria or other EU countries), whereas the remainder must be co-financed out of the businesses' own sources. Table 4 provides an overview on subsidy rates, numbers of demonstration projects, their size and specific investment costs.

*Table 4: Project level demonstration projects realised within project interventions*

| Cost of STE systems at project level | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project | Country | ADC subsidy (€) | Co-financing (€) | Subsidy rate % | Project installations [$m^2$] | [kWth] | No. of installations | ADC subsidy €/kW | Specific Investment €/kW |
| 1865-01/2001 | Zimbabwe | 10 340 | - | 100% | 293 | 205 | 108 | 50 | 50 |
| 1865-02/2005 | Zimbabwe | 106 424 | 51 646 | 67% | 402 | 281 | 58 | 378 | 562 |
| 2608-00/2009 2608-00/2012 | Zimbabwe | 61 735 | 118 261 | 34% | 331 | 232 | 19 | 266 | 776 |
| | Mozambique | 16 560 | 18 542 | 47% | 41 | 29 | 2 | 571 | 1 210 |
| | Namibia | 64 481 | 79 285 | 45% | 229 | 160 | 71 | 403 | 899 |
| | South Africa | 244 912 | 596 440 | 29% | 1 326 | 928 | 85 | 264 | 907 |
| | Lesotho | 27 316 | 33 078 | 45% | 81 | 56 | 10 | 485 | 1 072 |
| 2550-02/2011 | Egypt *) | 24 000 | - | 100% | 29 | 20 | 1 | 1200 | 1 200 |
| 2444-00/2006 | Jamaica, Aruba, Nicaragua *) | 200 000 | 7 000 000 | 1% | 5 936 | 4 155 | 3 | 48 | 1 699 |
| 2550-06/2009 | Bolivia *) | 36 600 | 130 000 | 22% | 71 | 50 | 50 | 732 | 3 332 |
| 2444-00/2006 | Nicaragua | 157 584 | 77 616 | 67% | 140 | 112 | 18 | 1 407 | 2 100 |
| | Guatemala | 236 376 | 116 424 | 67% | 210 | 168 | 6 | 1 407 | 2 100 |
| | El Salvador | 202 608 | 99 792 | 67% | 180 | 144 | 18 | 1 407 | 2 100 |
| 8047-00/2004 | Macedonia | 21 240 | 49 660 | 30% | 153 | 107 | 11 | 199 | 663 |
| 7991-00/2002 | Albania | 10 020 | 3 941 | 72% | 36 | 25 | 10 | 401 | 558 |
| | **Total** | **1 420 196** | **8 374 685** | **14% 32% **)** | **9 457** | **6 673** | **470** | **213 474 **)** | **1 135 982 **)** |

Source: *Soltrain* Solar Thermal Demonstration Systems in Southern Africa (2015);
Demo Systems Funding_Overview_Budget_SOLTRAIN 1.xlsx & Demo Systems Funding_Overview_Budget_SOLTRAIN 2_20160530.xlsx
Other Projects: Project final reports and personal interviews
*) Projects implemented as a business partnership, from which 500 $m^2$ in Aruba and 4,450 $m^2$ in Nicaragua were solar cooling projects directly realised in the context of a business partnership in Jamaica. **) Total amounts without business partnership projects

7 out of the 8 project interventions supported had a focus on *solar heating technologies* (hot water preparation and/or space heating), 2 projects involved *solar drying* (e.g. solar air collectors) and 1 project had an explicit focus on *solar cooling technologies*. 2 projects had a multi-focus on either heating & cooling or heating & drying technologies.

The total capacity of 470 solar thermal installations was about 6,700 kW, corresponding to about 9,500 $m^2$ of solar collectors being put in place. The specific investment costs were 1,135 EUR/kW installed over all projects and 982 EUR/kW considering all projects without business partnerships.

The by far biggest share of the 4.5 million EUR ADC funding (approx. 3.1 million EUR) was used for the main project components that typically included building awareness on all levels (social institutions, policy makers, public administration, industries & service sector, financing sector, households), building competence and capacity of teachers/trainers (e.g. vocational schools, universities), technicians and multiplicators, developing a supply chain of qualitative STE products with assistance for producers and installers, and to some extent for supporting the creation of suitable framework conditions in the countries (e.g. grant financing scheme, Labelling criteria, development of solar testing facilities).

**EQ 17: How high is the resource input compared to similar interventions and achieved impacts?**

*Main findings:*

As mentioned above, the average system cost of solar thermal installations (incl. solar water heaters, heating systems, larger applications providing process heat and solar dryers) were about 980 EUR/kW (with a cost range between 560 EUR/kW for hot water systems built in Albania and 1,200 EUR/kW for hot water systems in Mozambique), whereas for solar cooling systems about 1,700 EUR/kW. The specific investment costs are within the usual range of solar-thermal projects, the large spread around the mean cost cannot be evaluated for each demonstration project, since project specifications were not available for all types of pilot projects implemented. Usually, costs vary due to the kind of application, type of solar panels, storage capacity or complexity of system integration. But depend also on the location, since the proportion of costs for import and local supply may vary significantly.

The achieved leverage of 1:7 – about 1.4 million EUR of subsidy inducing an investment of approx. 9.8 million EUR (together with other co-financing sources of about 8.4 million EUR, compare with Table 4) can be considered as very efficient spending of public funds; with benefits generated towards different user groups, including low-income population, social institutions or local businesses.

The overall subsidy rate on the total investment costs leveraged was about 14 % including projects implemented as a business partnership and about 32 % without. Private businesses, NGOs and other business partners implementing STS, in the case of projects evaluated here all with Austrian participation, are therefore important partners of development cooperation, because they provide services and investments for problem-solving solutions. They invest to a certain extent own funds in new markets, create jobs, build capacity at different levels of expertise, build and operate STE facilities and thus contribute to poverty reduction.

Considering the share of subsidy provided by ADC per kW of installation (for all types of projects), the funding rate amounted to an average of 213 EUR/kW, with large variations among different projects, however, the average being in the comparable range of small scale solar thermal installations funded in Austria through the environmental funding scheme *("Umweltförderung im Inland")* managed by Kommunalkredit Public Consulting (funding range 150-220 EUR/kW or 25 % of eligible costs of projects larger than 100 m²). Acknowledging the underdevelopment of some markets and therefore higher acquisition costs for STE systems, the contribution level by ADC is comparable with the funding scheme provided in Austria. According to the latest IEA-SHC Assessment Report from 2017, a comparison for South Africa indicates specific investment costs for a single-family domestic hot water system (4 m² solar panel/300 ltr. storage) in the range of 340-640 EUR/kW and 385-600 EUR/kW for a large DHW (75 m²/6,000 ltr.). The average system costs within the pilot projects financed under *Soltrain* were in the similar range of 440 EUR/kW (compare with Table 4). Unfortunately, no other comparable benchmarks are available from other projects implemented in the countries covered within this study, at least from the standpoint of similar quality and diligence, which indicates that ADC support was in most countries the unique or at least the most important funding source for high-quality ST installations.

## 5.5 Impact

**EQ 18: To what extent have the interventions contributed to improved access to affordable energy services for businesses and end consumers?**

This outcome has been re-constructed by the evaluation team based on the project proposal. If at all reference was made to increased share of renewables, and improved access to affordable energy services, it has not always been very specific, and only in few cases have quantitative figures been provided – mainly related to the production of renewable energy and associated carbon emission reductions.

Based on the information available it can be stated, that the interventions of STE projects have only improved the access to affordable energy services for SMEs and social institutions where demonstration systems were installed.

*Background information:*

Referring to the SDG 7 “Ensure access to affordable, reliable, sustainable and modern energy for all”, per definition all projects supporting the increase of renewable energy in the total final energy consumption can be considered to be “improving the access“ to sustainable energy for all. It is also the only context within which this evaluation can be considering any impacts achievable by the ADC supported projects. Namely, the amount of solar-thermal based installations triggered directly by number of demonstration projects realised with ADC support or indirectly, by the improved framework conditions that were created in the countries with the support of the ADC intervention.

Improving the access to energy in general, i.e. giving access and therefore considering the production of hot water or heating/cooling from a renewable energy source, where no such access has been available before, has not been in the consideration by any of the STE interventions with exception of the Central American solar drying project (new solar dryers were installed to support local productive uses at farms). Households, businesses and social institutions generally did have a kind of hot water installation (mainly based on electricity or oil/gas) but lacked a sustainable or reliable system. Reference to the quantitative aspect of the renewable energy share is made in EQ 20.

However, considering the “quality aspect” within the access to energy, this dimension does not only consider the amount of energy produced of renewable sources, but also the efficient production with a high-quality and durable supply system; this aspect can be considered fulfilled by all project interventions financed by ADC, since the focus of project activities was exactly on these quality aspects, and moreover one main reason to finance such projects.

There is another dimension of quality towards the improved access, namely if a back-up energy supply system is provided. Especially in applications such as health centres, hospitals, nurseries, IT-service centres (e.g. DigiCel Jamaica) it is important to have a back-up to the solar-based energy supply system available, and the availability to work independently from e.g. a power failure for a certain period. Most of the STS in social institutions and a few businesses had been installed as add-on to an existing energy conversion system, and where they replaced the existing energy conversion system (e.g. oil combustion), were equipped with an electric resistant heating rod as back up. STE installations from their technical configuration usually include such back-ups, and therefore increase the acceptance at beneficiaries while improving the availability of the energy service requested.

**EQ 19: In how far have the interventions contributed to growth of the market for solar thermal systems?**

*Main findings:*

Although market growth, defined as increased number of ST projects installed in a country and target sectors, is not explicitly within the focus of majority of development projects supported by ADC, implicit reference to increasing the market penetration with STE can be made within nearly all projects. Looking at the project documents or log frames (in case available), interventions focussed mainly on developing the supply side of STE, by addressing the issues of technology availability and improvement of STS components, quality of installation & maintenance, price of STS and costs for installation & maintenance. Demand-side issues, as creating awareness and checking the need among user groups and the conditions under which STE can be made available to customers (at which feasible technical and financial conditions as well as affordability) are somehow underrepresented. To enhance the growth of the market that will lead to increased demand it is important to create the needs at the level of user groups, in addition to an enabling policy environment.

In front of these limitations, projects like *Soltrain* have positively contributed to the development of the institutional market segment, by supporting demonstration systems in vocational schools, hospitals, retirement homes, breweries, hotels and other larger infrastructures that have not been tackled by any subsidy programmes so far, and in addition helped the suppliers & installers involved to grow or maintain their business within the STE field, where local markets were deteriorating due to adverse subsidy schemes or missing policies.

In another region supported by ADC, Central America, the introduction of solar drying systems for carpentries and for small rural farming centres for drying of fruits, coffee, herbs etc., was promoted in Guatemala, Nicaragua and El Salvador. There, a new patented solar air collector from Austria had provided an effective solution to local farmers and processing companies for preserving food. The impact in terms of number of installations was small (see Figure 2 in the Annex G) but led to the creation of local supply chains with farmers, processing and distribution companies being involved and benefitting from additional capacity building activities through the programme. Early market development support was an important driver to disseminate a new technology for the benefit of local population and businesses, in addition it helped the supplier from Austria to grow its business in other countries (promoting solar air collectors meanwhile in 30 countries of the world).

ADC support has therefore been successful in project interventions where capacity development for more complex technical and engineered solutions and early market development stage has been required, and where under sometimes adverse market conditions information and user barriers among target groups and energy users had been successfully tackled.

**EQ 20: In how far have the interventions contributed to an increased share of renewable energies?**

*Main findings:*

The projects did result in numerous pilot installations and demonstration projects being developed, however, due to their limited size and number compared to overall installations on a national scale the overall impact on contribution to increased share of renewables and $CO_2$ emission reductions (compare also EQ 21) is not traceable.

Nevertheless, in the long-term STE projects provide a potential to increase the share of renewable energy in the countries' total final energy consumption (TFEC). As the figure below shows, some countries are already close to 100 % in their TFEC, however others do have a significant potential to increase their renewables share in the country's energy production.

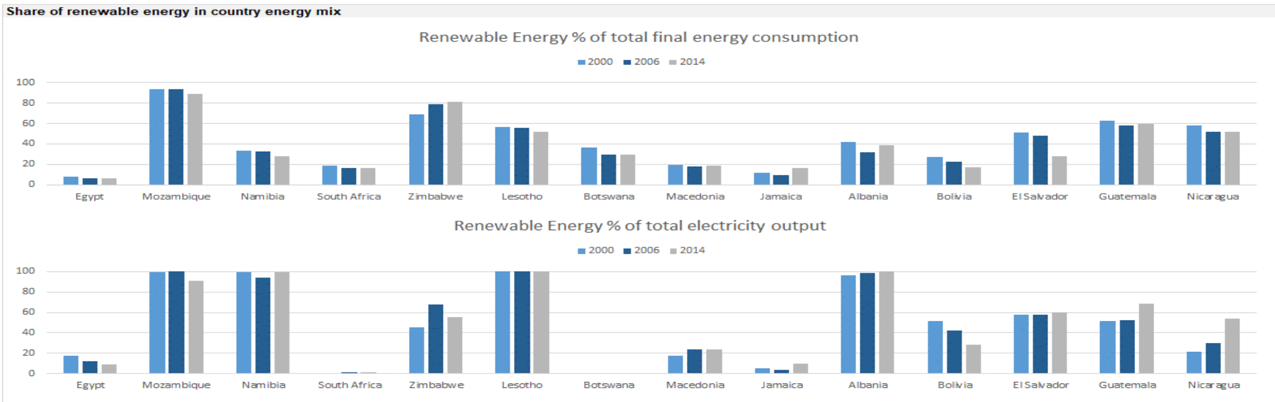



*Figure 3: Share of renewable energy in country energy mix (Sources: WDI Database: World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program)*

Although, not totally influenced by project interventions and ADC support, certain impacts on the level of solar energy use and qualitative as well as quantitative aspects are getting into focus. Moreover, the kind of competition between solar thermal and solar PV for useful installation space (e.g. on roofs) can result in a positive stimulation for increasing the share of renewables, but in early adopting markets can also lead to its deterioration, especially, if the policy framework and governmental priorities (on national and regional level) are not strengthened.

The role of donors such as ADA therefore lies in supporting the grounding for a clear government strategy and strong enabling policy framework on a longer-term basis, but this would require project interventions to be considered in a longer-term engagement, since these developments naturally need time.

Further reference is made to a contextual assessment of the global STE market developments, which is provided in Annex G.

**EQ 21: In how far have the interventions contributed to climate change mitigation (GHG emission reduction)?**

*Main findings:*

ADC financial support led directly to 470 STE installations, thereof 425 hot water systems, 42 hot air systems and 2 solar cooling systems. The installations took place in all sectors from social institutions (schools, hospitals,…) to industry, service sector (e.g. hotels) and private houses. The total installed thermal capacity was 6,600 kW and the total energy generated by the systems about 6,850 MWh per year, with a typical lifetime of 20 years this would amount to about 138,000 MWh of energy produced. Since most of the systems replace grid electricity, **the direct GHG emission reductions were calculated to be approximately 5,300 tons $CO_2$ per year, or 106,000 tons $CO_2$ over 20 years.**

The following table lists the number of solar thermal energy systems realised in the countries, their installed capacity and resulting energy savings and $CO_2$emission reduction.

*Table 5: Aggregated data of direct impact of demonstration projects realised per country (Source: Project reports).*

| Country | Installed thermal capacity, $kW_{th}$ | Number of STE systems | Energy savings, in kWh/a | Main type of fuel replaced | $CO_2$emission reduction, in t $CO_2$/a |
|---|---|---|---|---|---|
| **Albania** | 25 | 10 | 16 867 | Oil | 10 |
| **Aruba* °** | 350 | 1 | 360 000 | Electricity | 252 |
| **Bolivia °** | 70 | 50 | 70 000 | Electricity | 28 |
| **Egypt °** | 20 | 1 | 16 229 | Electricity | 7 |
| **El Salvador** | 144 | 18 | 144 000 | Electricity | 43 |
| **Guatemala** | 168 | 6 | 175 920 | Electricity | 74 |
| **Jamaica °** | 690 | 1 | 705 260 | Electricity | 494 |
| **Lesotho** | 24 | 10 | 24 820 | Electricity | 25 |
| **Macedonia** | 107 | 11 | 61 143 | Oil | 37 |
| **Mozambique** | 29 | 2 | 34 850 | Electricity | 35 |
| **Namibia** | 160 | 71 | 185 820 | Electricity | 185 |
| **Nicaragua* °** | 3 227 | 19 | 3 230 360 | Electricity | 2 255 |
| **South Africa** | 928 | 85 | 973 284 | Electricity | 969 |
| **Zimbabwe** | 719 | 185 | 852 410 | Electricity | 849 |
| **Total** | **6 660** | **470** | **6 850 962** | | **5 263** |

* 500 m² in Aruba and 4,450 m² in Nicaragua were solar cooling projects directly realised in the context of a business partnership in Jamaica.

° Projects were implemented in the framework of business partnerships (ADA's business support programme), with additional own financing means from business partners

There are no indirect GHG emission reductions attributed to the project interventions. The reason is that the projects in general were not intended to be or to include a roll-out programme for STE, and therefore emission reductions from replication activities have not been targeted and provided in the intervention logic.

**EQ 22: In how far have the interventions contributed to improved environmental conditions (e.g. pollution reduction, reduction of use of fossil fuels?**

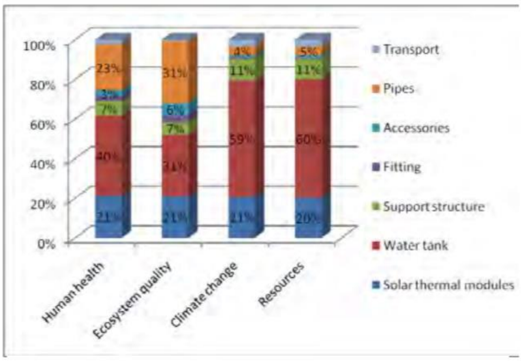
*Main findings:*

Impact assessment studies show that solar thermal systems are a suitable solution to reduce the environmental burden of domestic hot water production, by highlighting the backup energy as the major factor on environmental impacts. However, these studies do not end with a clear-cut environmental hierarchy among different STE systems and their regional background: i.e. if energy users depend on electricity or oil/gas as a backup energy. For all STS, regardless of backup energy, the solar panels, water tank and pipes emerge as the relevant components influencing the environmental conditions of STS.

The environmental impacts are mostly explained by the use of a large amount of steel which stands for the most important part of the impacts of the hot water tank. As for solar thermal panels, it is aluminium (mainly for the frame) that causes most of the impacts.

The source referred to in here[13] argues that the energy pay-back time of solar systems is in average lower than 2 years, comparing the amount of energy required for the fabrication of STS with the energy produced during their operation.

*Figure 4: Distribution of environmental impacts of STE systems used in tropical climates for each category of impact*




The overall environmental benefits of STS promoted and installed with the support of the project interventions have to be viewed under the considerations of the primary energy source they are *replacing* – or, since most of STE installations supported by ADC projects were new greenfield projects, *avoiding* – a certain amount of fossil fuel and electricity. The carbon intensity and share of renewables in energy/electricity production and use is therefore the primary indicator determining the improvement of environmental conditions on a country-by-country basis, namely reduction of fossil fuel input and electricity demand. In countries with a high share of renewables in the TFEC or electricity production, the corresponding savings by replacing e.g. electric heaters will be lower than in others.

The solar thermal systems studied in the mentioned reference as a "scenario within hot regions" show specific differences with the systems used in temperate-climate conditions. Considering the use of oil/gas or electricity consumption makes up the major part of overall impacts. Figure 4 shows the distribution of the impacts for each category. The water tank strikes as the major contributor to the impacts of the STE system, between 31 % and 60 % of each impact. The other significant contributions are made by the solar thermal panels (about 20 % of the impacts), the pipes (mostly because of the copper used), 23 % and 31 % respectively for human health and quality of ecosystems. This are considerations that also influence the project interventions in the way that local production of major STE components does influence the overall environmental impact to a certain extent; however, looking at the transportation impact (e.g. from importing components to target countries), these are of minor relevance.

As mentioned under EQ 21 above, the total installed solar thermal capacity of 6,670 kW has led to a reduction of energy demand of fossil fuels (here: fuel oil) and majority of electricity (in most countries again fossil fuel based) by about 6,868 MWh per year. Considering an average per capita electricity consumption of about 1,500 kWh/year in the countries surveyed (Source: IEA 2014), this represents the annual electricity demand of about 4,300 inhabitants.

[13] Paper on "Environmental Impacts of Solar Thermal Systems with Life Cycle Assessment", presented at World Renewable Energy Congress 2011 by Transénergie (France), http://www.ep.liu.se/ecp/057/vol14/002/ecp57vol14_002.pdf

## 5.6 Sustainability

**EQ 23: How likely is it that the interventions' impacts will be sustained without additional interventions?** Which essential factors can be expected to foster or hinder the further unfolding of impacts?

In this context, sustainability refers to the continuation of changes achieved by an intervention, i.e. outcomes and impacts, also after the end of this intervention. Therefore, it can only be applied to outcomes that were, at least partly, achieved. The outcomes envisaged by SWH and SC projects are shown in the generic intervention logic presented in chapter 4.

The outcome **"Increased local capacities for installation and maintenance of solar thermal systems"** envisaged by SWH and SC projects has largely been achieved. With the exception of Mozambique, respective practical and theoretical training was successfully implemented with participants perceiving an increase in skills and knowledge. Sustainability can be expected to be high at individual level, provided that the newly gained knowledge can be used. Evidence also indicates a high level of institutional sustainability in those countries, were respective training content has been integrated into curricula of vocational training and/ or tertiary education.

For the outcome **"Target populations/ end consumers buy solar thermal systems, use and maintain them**" evidence derived from project reports and stakeholder interviews suggests that this outcome has only been achieved for industry, notably SMEs, and social institutions where demonstration systems have been installed. Except for three systems, all of them are still working, which gives a calculated success rate of >99 %. Respective benefits can be expected to sustain as long as they are functioning, which, amongst others, will be more likely applied due to the other outcomes mentioned here.

**"Fostering or creation of favourable framework conditions by governmental authorities and relevant actors":** Though most target countries have at least some STE related policies in place, a clear attribution of these policies to activities/ outputs of a STE project funded by ADC is only possible in the case of the Solar Thermal Technology Roadmaps developed in the *Soltrain* project for Namibia, Mozambique and South Africa. Sustainability will, however, depend on their implementation. This is rather likely in Namibia, were policy stakeholders were actively involved in the development of the roadmap. It is less likely in the two other countries, were the roadmaps were developed only by project partners.

**"Raised awareness of and confidence in solar thermal systems among target populations and/ or general public" and "Raised awareness among governmental authorities and relevant actors in energy supply":** There is some evidence from stakeholder interviews that awareness raising measures implemented by STE projects have indeed, increased the awareness of STE among governmental authorities. Respective awareness among private households varies between countries and is for example rather high in Namibia and South Africa, but very low in other countries such as Egypt, Mozambique or Macedonia. Whether the high degree of awareness achieved in some countries will sustain, will mostly depend on the popularity of other alternative energy sources such as for example photovoltaic.

**"Increased Research & Development capacities":** Interviews suggest that the increased R&D capacities achieved at universities involved in STE projects will only sustain, if other sources of funding will become available.

**"Creation of new jobs in the field of solar technology":** Based on the interview with the project leader, a longer-term sustainability of the jobs created by the El Salvador-Guatemala-Nicaragua project can already be stated, because the project ended already nine years ago. For the SWH and SC projects the sustainability of the newly created jobs will largely depend on the development of the market for STS.

**"Creation of new income or improvement of self-supply for target groups":** This outcome was only envisaged explicitly by the SD project. Political and economic stability as well as absence of natural disasters provided the increased income generated by the use of solar air dryers can be expected to be sustainable.

# 6 Conclusions and Recommendations

**PROJECT DESIGN**

***Conclusion 1. Project designs often lacked a coherent and systematically defined intervention logic and therefore reporting.***

Since most projects where contracted at a time when the provision of logframes or ToCs were not obligatory, many project proposals did not include a systematic and clearly defined intervention logic, for example in the format of a logframe, logic model or similar or a narrative Theory of Change (ToC) respectively. Therefore, the assumed causal links between outputs, outcomes and impacts as well as the underlying hypotheses and related assumptions for project interventions were often unclear. This has been mentioned as one limitation to assess the medium-term outcomes and longer-term impacts of projects.

The lack of a consistent intervention logic has several repercussions, namely on (1) the assessment of the project proposals, (2) project implementation and, (3) project evaluation. During the project application process, it is almost impossible to assess the consistency of the project concept and to check the plausibility of intended outcome chains. During project implementation, the lack of a ToC makes it extremely difficult to make the right adaptations in case things do not work out as originally planned. For evaluation it implies that a ToC must be re-constructed that might not be entirely correct because contexts change over time.

Also, and perhaps partly as a consequence of the absence of a well-defined intervention logic, the projects' final reports sometimes have been vague on the specific effects achieved or attributable to the interventions that were supported by ADC. If references were made to an increased share of renewables, improved energy efficiency or better access to affordable energy services, they were often quite unspecific and only in few cases quantitative figures have been provided – mainly related to the production of renewable energy and associated carbon emission reductions. The limited reporting on outcomes might have to do with the initially less demanding reporting requirements which, however, have significantly changed over time and are nowadays more demanding and in line with international developments of measuring outcomes and impacts of development initiatives (refer also to conclusion no. 3).

***Recommendation:***

The respective recommendation is mainly relevant for future impact and outcome evaluations and is related to the project application process (ADC internal procedures).

- The "conceptual weaknesses" in the form of inconsistent or incomplete logframes/ToC have already been addressed internally by the requirement to submit a logframe in a standardised format as integral part of the project application. However, as experience shows, the presentation of a planned project in logframe format does not per se guarantee a consistent intervention logic. To ensure the latter, the formulation of assumed outputs, outcomes and impacts as well as of assumptions should be thoroughly reviewed by someone familiar with M&E.
- Also, the support of potential project implementers to familiarize them with the logic underlying outcome-oriented projects would be considered useful. This is especially important for actors from the private sector, because project planning from their perspective usually end with the delivery of products/outputs. To this end, a workshop, for example on participatory impact pathway analysis or similar or accompanying guidance material (manual), could be offered by ADC headquarters or country offices that deal with initial project applications.

***Conclusion 2. Project interventions were supply-focussed and did not put enough emphasis on the demand side necessary to stimulate the growth of the market for STE systems.***

The causal links identified between different factors that have been described by the study authors in a model approach of the "determinants of the market for high-quality solar thermal systems", assume that the demand for STS is driven by (1) affordability/cost of ownership, (2) supply of quality STS products, (3) cost and availability of existing alternatives, (4) positive attitude/image of STS, and (5) political framework conditions. The market for solar thermal systems is demand driven. It is largely determined by the costs of purchasing, installing and maintaining a STS, compared to alternative systems to provide heating and cooling (e.g. by electricity). Awareness of the advantages of STS systems triggers demand. A positive public attitude towards STS is fostered by positive user experiences and demonstration of best practice applications, which depend on well-functioning solar thermal systems. Suppliers (providers and installers of STS) can stimulate demand only by offering affordable systems and ensuring that these systems work, i.e. though product quality and the quality of installation and maintenance. The conclusion from the evaluation is that project interventions focussed by ADC had mainly the supply side within its focus, i.e. projects were focussing typically on aspects that would increase the quality of supply – e.g. improved technology and technology setup, increasing quality of installers and installations, need for engineered solutions, and less on aspects that would stimulate the demand in the medium to long-term (continuous awareness to create a positive attitude towards STS, emphasizing the legal and policy framework on national levels). In fact, the intervention logic of STE projects is considered to be far more complex, because they seek to develop a market for a product that final beneficiaries should eventually buy and use. Analysis shows that here a well formulated theory of change would have been really helpful, because it would have revealed critical assumptions and untenable hypotheses, as for example: that the demand for a specific product can be stimulated through an increased supply; that product quality is decisive for the purchasing decision; that people act rational and that providing them with factual information will change their attitudes and behaviour (in this case purchase behaviour of end-users or decisions of policy makers). Especially the latter, i.e. that behaviour is driven by awareness and or knowledge and can thus be changed through awareness-raising measures only is an out-dated theory (not considering all factors influencing consumer choice) that has been proven wrong in many research studies also in the field of development cooperation.

***Recommendation:***

- Project-type interventions (except *business partnerships*) shall consider the functioning of market mechanisms as a requirement to strengthen the efforts for deploying sustainable energy technologies in underdeveloped or transition economies that will equally increase the *supply and demand* opportunities for such technologies. In the case of STS, this means developing a joint basis with beneficiary governments towards a longer-term engagement in the areas of policy development (governmental priorities and policy frameworks need longer term to develop, therefore they provide good opportunity for development partnerships and joint donor efforts), systematic awareness raising and capacity building among governmental decision-makers, public administration, and beneficiaries from public and private sectors. ADC should engage in such policy projects in the future, eventually in cooperation with other donor organisations or development partners, to leverage available (limited) resources more effectively.

**RELEVANCE**

***Conclusion 3. Projects were fairly aligned with ADC targets but require clear M&E criteria.***

Austria's development cooperation (ADC) is based on the 2002 Development Cooperation Act (DCA[14]) as amended in 2003. The main objectives are poverty reduction, peacebuilding, and environmental protection and conservation of natural resources.

The strategic framework for ADC is outlined in the actual “Three-Year Programme” (3YP), currently for the period 2016-2018[15]. Programme and project aid resources have been concentrated in the last few years on priority countries and regions, such as Western Africa and Sahel, Southern Africa, South-East Europe, Latin America and the Caribbean, Central America[16], only to name those, where project interventions considered here have been implemented. This has contributed to the development of viable long-term partnerships and to savings in transaction costs. This concentration results in greater efficiency and increased visibility of significant ADC contributions in the priority countries. In addition, on a global scale, co-financing is provided to business partnerships and NGOs.

[14]BGBl. I Nr. 65/2003
[15]All recent 3Y-Programmes are available from the ADA website: http://www.entwicklung.at/en/media-centre/publications/programmes/
[16]The engagement in Central America was completed by the end of 2013.

The comprehensive ADC energy approach is defined in a Policy Document „Energy for Sustainable Development"[17] (last update in 2009) and aims at specific and mutually supportive measures at the bilateral programme and project level and at the multilateral level, considering the need for coordination and coherence with other national and international actors and agreements, one of them being the Sustainable Development Goals.

Each project intervention has a specific approach and focuses on different outputs and outcomes, but none of the projects gives indications or is trying to answer to which extent poverty reduction has taken place. However, statements have been made in some reports indicating the beneficial impact of STS on low-income households in regard to solar water heating usage being relevant for reducing household energy consumption and costs. But a larger focus of demonstration projects has been on other sectors, e.g. industry, services, small businesses or social entities, where applications of STS cannot be directly linked to poverty reduction.

The basic conclusion is that STE projects are relevant to reduce poverty but indirectly and towards achieving environmental impacts; moreover, they are considered important elements on the way to achieving the SDGs (mainly SDG 7 and 13). However, the means to monitor & evaluate (M&E) the achievements towards results require clear indications for project implementers and targets to be formulated in project log frames. Ensuring access to affordable, reliable and sustainable energy and improved access to cheaper and cleaner energy technologies reduce operational costs in public entities and businesses and therefore increase the likeliness to poverty reduction at a macroeconomic level. Lowered environmental impacts and increased climate resilience are justified by the vast opportunities that STE applications provide in reducing (fossil) fuel demand and carbon emissions.

***Recommendations:***

- In line with the strategic ADC framework defined in the 3YP, criteria for projects to establish a M&E framework for specific areas of intervention with pre-defined indicators at outcome level (at least immediate outcomes) are to be established against which projects have to report. Respective data can be used for sector evaluations and would significantly increase the robustness of evaluation results.
- In line with international requirements towards the achievement of SDGs, countries are to adhere to a stronger set of indicators to measure impact towards their achievement. For example, the SDGs provide for each goal a set of indicators for monitoring, however, they are usually aggregated on a country level (top down). Using project specific data (bottom-up) would require specific methodologies to interconnect both. Project partners should be made available the set of key indicators that require monitoring and evaluation throughout their projects.

***Conclusion 4. Projects supported by ADC have proven to be relevant, as far as quality aspects and provision of sustainable energy services are concerned.***

The major focus of project interventions was to promote solar thermal systems that were long-lasting and operational beyond other basic hot water systems (with the proof that most of the systems installed with ADC support are still operating). Yet, quality installations require well 'engineered' solutions specially designed to the needs of an enterprise or social institution (e.g. promoted by *Soltrain* and some of the business partnership projects), the availability of financing schemes for small scale STS (such as the income-based scheme for local farmers and producers for purchasing solar dryers in Central America) and large-scale investments (within industrial applications and larger building entities, such as hotels or hospitals). All these aspects justify the financial contribution and engagement of ADA in such types of projects, since they provide opportunities to achieve greater engagement of private sector investment in areas that need development.

The application of innovative business models for the provision of heating/cooling, hot water and dry air services as main applications for solar thermal installations, however, remain among the biggest challenges to further disseminate the technology at an affordable scale and for all kinds of applications in private households and businesses/organizations. Examples are solar-based district heating or cooling systems (e.g. in urban infrastructures

[17]Policy document „Energy for Sustainable Development", ADA, 2010

and for specific applications, such as health-centres/hospitals or public buildings), or the provision of *hot water as a service* (e.g. through specialised Energy Service Companies, so called ESCOs).

***Recommendation:***

- ADA should give room within project interventions to promote innovative business models that support the affordability and sustainable provision of energy services considering the efficient application of renewable energy in partner countries. Cooperation with and involvement of private investors with or without public sector involvement (e.g. through public-private-partnerships) should be enhanced. The instrument of business partnerships as a model to engage strategic partners (e.g. technology and financing partners with local engagement through a *strategic partnership*) could be receiving more attention from those businesses and institutions, if project and funding volumes could be increased and possibly leveraged with other funding and financing sources. With an emphasis to providing the best technological solutions at affordable conditions for the beneficiaries.

***Conclusion 5. Project interventions addressed the needs of target groups at different levels.***

The interventions implemented by STE projects addressing solar water heating (SWH) and solar cooling (SC) targeted mainly three different groups: (1) potential users/end-consumers of STS (private households, industry and social institutions), (2) providers/ installers of STS and (3) policy makers/ governmental authorities. The solar drying project (SD) implemented in Guatemala, Nicaragua and El Salvador addressed farmers and agricultural co-operatives.

With the exception of the SD project implemented in Latin America, STE projects were not able to meet all the needs initially mentioned in project proposals and highlighted in Table 2 (refer to EQ 3), for example the necessary resources to be provided to ensure continuous maintenance of STE systems (especially in public-owned and operated buildings) or to resources and commitment to effectively implement policies in favour of STE. This was probably due to a lack of proper needs analyses that could be used for the identification of appropriate activities/outputs/outcomes. Instead, an analysis of the respective markets was part of several project activities and thus conducted only within the projects' scope (and not beforehand). With Austrian companies and representatives from civil society being the contractors for the majority of projects, needs were derived from a supply-side perspective that does not necessarily reflect the needs of the target groups. When this mis-match became obvious in the course of project implementation, projects tended to rather apply adaptive management by redefining towards the needs of target groups rather than adapting activities/outputs from the ones originally defined. While from a "market development perspective" this approach makes totally sense, it also means that certain target groups, such as the low and lowest income households, are not being addressed by these projects any more. Consequently, no direct outcomes are to be expected for this group which usually constitute the main addressees of development cooperation. The neglecting of other needs, such as for example maintenance of SWH, can be attributed to a lack of awareness and cultural differences towards maintaining a long-lasting infrastructure at the time of project design.

***Recommendation:***

- A fundamental needs assessment towards the elaboration of relevant project activities and outputs is inevitable in favour of appropriate project design, and therefore have to be provided in advance. Wherever the capacity of the implementing partners and resources made available to such analysis in advance of a funding project is lacking, opportunities could be sought to engage local partner organisations or ADA local offices (if available), or sort out conditional funding opportunities for an early-stage needs assessment to become part of funding contract (with the conditionality of other project phases to receive further funding in case the needs assessment has been provided).

**EFFECTIVENESS**

***Conclusion 6. Projects have partially increased local capacities for installation and maintenance, as well the production of STS.***

STE projects supported by ADC have had in nearly all cases a focus on increasing local capacities for the installation and maintenance of STS. Project interventions have initiated to build capacities and know-how of local stakeholders involved in the installation and maintenance of STS through improving Vocational Education and Training (VET) and supporting higher-level education (universities). The trainings have been effective, acknowledging the limited size of projects and thus the limited scope of participants that could be reached through the training programmes; resulting benefits were the mitigation of the lack of local capacity that has been mentioned to be one of the main barriers affecting the STE market development. Training modules and sessions have been developed and promoted together with national stakeholders and project partners, being in some countries universities, in some others national educational institutions (either ministries of education, or national vocational training institutes). Universities and research institutions have introduced academic courses on renewable energies with one focus on STE in countries like Egypt, South Africa, Namibia or Mozambique.

In several countries (like South Africa, Namibia, Egypt, Jamaica, or Albania), during interviews it has been several times mentioned that trainings have stimulated the rise of new entrepreneurs and local companies to install solar thermal systems in their markets. While this can be concluded a successful result of the project interventions, there is no statistical evidence that leads to the assumption that projects have significantly led to the creation of jobs. However, the existence of a 'positive entrepreneurship environment' does not yet result in a higher demand for STS systems in these markets, since the gap between possible users of STS and suppliers is still too significant and would require continued awareness raising measures and a set of favourable policies.

The added value of the training provided in the course of the projects, on medium-scale solar thermal applications has led to the significantly broadened application area from small-scale solar water heating systems in the residential sector to medium-scale systems for hotels, student hostels, hospitals and other social institutions, and finally to large-scale systems for the commercial and industrial sector.

While the provision of training outside of ADC-supported interventions and stimulated by national educational institutions seems to be non-existent (e.g. no private sector organisations offer trainings in the field of STE), efforts were undertaken to institutionalise and standardise them at least to a minimal degree to ensure a country-wide acceptance and quality of the trainings provided across the sector (see the typical contents provided within trainings organised within *Soltrain*).

***Recommendations:***

- Although projects supported by ADC have been instrumental in the development of local technical capacity, evaluation of trainings (e.g. formalised feedback by trainees on the contents of the trainings, incl. the relevance for their application) as well as monitoring and evaluation of their effectiveness (e.g. how many of trainees have been able to get a job in that field in years 2 or 5 after the training) shall be systematically incorporated into project design. The only available indicators so far given in project reports are number of participants in trainings; only in some cases an indicative number of trainees that stepped into or remained in the STE business is provided (either as entrepreneurs or recurrent trainees working for established STE companies in Egypt or Namibia).
- VET systems shall be systematically integrated into the regular national education systems, and systematically the topics of renewable energy and STE be linked within VE programmes of existing related disciplines, such as plumbing or mechanical engineering. Namibia is currently introducing a course for solar technicians (though focus on solar PV with some course elements on solar thermal) with international donor support (GIZ), which could be standardised towards a curriculum for other national VET systems in a similar way. Experiences and partnerships established within existing initiatives, such as *Soltrain*, are considered useful entry points for future project interventions (either within another *Soltrain* project phase or a new project).
- Since the evaluation also revealed that required skills concerning STE vary greatly from sector to sector and country to country, as do the levels of capacity-building and education, practical hands-on trainings at demonstration systems should be designed in the way that they consolidate the theoretically acquired

knowledge and thus improve the effectiveness of training. In addition, the subjects of plant construction, organization, quality management, construction site safety and environmental aspects are to be conveyed, topics that have not been under consideration before in most of the countries.

- Accreditation of trainings and educational programmes that are focused on STE is required for most of the countries to increase the effectiveness and recognition on the market. Development of standardised curricula and accreditation of formal STE trainings shall be therefore considered for support within ADC interventions.

***Conclusion 7. Contribution of projects supported towards raised awareness and confidence of STS among target groups.***

Measuring the effectiveness of awareness raising measures has proved to be nearly impossible, without proper baseline information and level of awareness achieved overall by project interventions. Since there are no quantitative and qualitative data available concerning levels of public awareness in different countries, especially among private households, the conclusion based on interviews indicates a rather limited impact of project activities on the awareness at household and equally but insignificantly higher level of awareness in businesses/institutions, and with slight advantages in those countries where SWH have already been in use for quite some time (e.g. South Africa or Albania, Macedonia).

There are, however, no indications that demonstration systems were being used systematically for awareness raising and promotion purposes among these target groups, which can be argued by the limited availability of funds and resources towards developing and deploying awareness measures.

Overall, the effectiveness of a proper design of awareness raising activities implemented by the projects, e.g. the systematic use of new electronic media (e.g. social media channels) versus traditional, has to be put in question, since this would require availability of a dissemination and marketing strategy and plan, which none of the projects had in mind and thus have not been systematically planned for. Awareness raising measures need to be fledged by continuous programmes for dissemination of STE with defined target groups and under the auspices of the relevant government stakeholders to be effective in the long term. None of the projects implemented with ADA support were in the position to launch these awareness programmes, also due to limited resources to implement country-wide awareness measures. At least stakeholder interviews with policy makers/ governmental stakeholders indicated an increased level of awareness of participants of workshops/ seminars delivered under these projects.

***Recommendations:***

- Project logframes shall define relevant targets and indicators that could be achieved through a set of awareness activities. ADA shall require such target indicators from project partners and should be based on realistic and achievable outputs, segregated by target groups, and indicating number and type of activities, their duration with expected outputs and envisaged outcomes towards achieving campaign aims. Delivering a positive attitude towards the use of STS at household level may be one of the determinants, by explaining about the benefits in terms of cost, but also usability and comfort, another one providing arguments for purchase larger systems in SME/industry or social institutions, with a closer focus on integration aspects and overall cost/benefit.
- Awareness raising measures shall be systematically planned and properly budgeted in advance. Experience from PR and media specialists shall be used together with a request to have marketing and/or dissemination plans be developed by specialist experts or agencies in the framework of such project interventions – addressing the proper target groups, considering the use of online and print media, publication of success stories, promotion of governmental programmes and initiatives, and level of cooperation with national media providers. Notably, the systematic support of awareness measures can be only secured in the case of sufficient budgetary means.
- Innovative approaches to creating awareness and disseminating information about STE shall be considered within ADC project support. As digital innovation evolves across many developing countries, resulting e.g. in

the increased level of availability and application of mobile phone-based solutions[18], such as mobile money (*pay-as-you-go*) or mobile enabled energy solutions, the use of social media shall be considered as one channel for effective communication and dissemination. Perhaps the most obvious advantage of social media is its potential in giving voice to people on their own terms. It can grant visibility to their experiences and needs and provide a venue for discussion and offer a platform for direct participation and communication. And because of its built-in multiplier effect, social media can vastly speed up the diffusion of information, ideas, practices, values and social norms that support positive change towards the use of sustainable energy in general and STE respectively.

***Conclusion 8. Contribution of STE projects towards raised awareness among governmental authorities and stakeholders.***

The outcome of effective awareness creating measures assumes that political framework conditions and support instruments in favour of solar thermal energy would be already in place. However, the reality is that decision makers are constantly influenced from different sides (stakeholder groups, lobbies) and their decisions are often based on compromises, in terms of governmental priorities, legal framework, policy instruments, availability of budget and finance, and finally the mix of (energy) technologies they want to promote within the national and international context. STE projects have been therefore important in supporting basic mindsets and awareness among governmental decision-makers and political stakeholders towards the advantages that solar thermal energy can have for different target groups; however, in the long-term awareness creation at the governmental stakeholder level is not enough to create impact, it needs to be supported by the continuous development of the enabling framework conditions for implementation – see also the following conclusion no. 9.

***Recommendations:***

- In line with recommendation on conclusion no. 7, ADC projects should equally consider the element of increased awareness among governmental stakeholders and the impact this has on providing the grounds for improved political and legal framework conditions in favour of STE.  Current limitations given by project size, focus, outreach and funding possibilities, and too short project durations can be only overcome by a principal commitment by ADA to support systematically the cooperation at governmental level and emphasis to dedicate project funds towards awareness measures that emphasize the benefits of STE on a country level and for different target groups.

***Conclusion 9. Contribution of STE projects to the creation of favourable framework conditions.***

Favourable and stable governmental framework conditions concerning STE, i.e. relevant conditions for the expansion and growth of the market, must be considered as indispensable for a positive development of this technology,. The creation of governmental policy and framework conditions was, however, not the key focus of project interventions. Rather, ADC-funded projects supported national stakeholders, including political decision-makers and governmental agencies, with insight and best-practice experiences from other countries. In this context a comprehensive knowledge-set with focus on technological and operational issues was provided through training and educational programmes, but it seems not with a clear strategy or priority behind. Although some projects initially aimed at enhancing stakeholder dialogue through awareness and capacity-building measures, in fact none of the interventions had been designed towards the development of specific legislation or a national STE strategy or standard. The necessity of the latter was mostly acknowledged only during project implementation, and the inclusion of respective measures was limited by a constraint of resources. This notwithstanding, depending on the specific policy context also such “small-scale” interventions can effectively support the creation of favourable and stable governmental framework conditions concerning STE.

[18] https://www.gsma.com/mobilefordevelopment/programme/mobile-for-development/transforming-lives-through-mobile-innovation/

Based on the analysis of the policy contexts in the project countries the evaluation identified three main constellations which require different approaches as regards project activities to foster the creation of a favourable policy framework.

(1) Countries where political framework conditions in favour of renewable energy policies (or STE) are not in place, i.e. without specific legislation, policies or action plans: Depending on the project duration, projects implemented in such countries can realistically only be expected to trigger the development of such conditions in the future.

(2) Countries, which are about to develop political priorities and framework conditions or where respective policies/ legislation/ action plans are already existent, but not yet implemented: Projects implemented in such countries can actively support the development and/or implementation of the respective policies through targeted measures.

(3) Countries, which develop or have already in place political framework conditions or policy strategies that promote renewable energy, yet not STE but a "competing" technology such as PV: Projects implemented in such countries cannot be expected to change the policy framework in favour of STE. Though the market for STE can still grow, the penetration of the market by STE will be limited due to the political support to the "competing" technology.

***Recommendations:***

- In countries without any political focus on renewable technologies, STE projects have to create an awareness of and an interest in solar thermal systems among relevant stakeholders in the first place. Ideally, this should not only be done through general workshops or other awareness raising events, but rather through the direct approach of and dialogue with respective decision makers. This requires thorough knowledge of the political system and respective decision structures in order to be able to identify the right counterparts.
- In countries that develop and/or start to implement policies, action plans. etc. to foster the use of STE projects, ADC should provide direct support through for example the provision of background information suitable for quotation, review of documents, presentation of good practice examples, etc. Support should always be tailor-made, i.e. responding to stakeholders' needs.
- In countries with emerging or already developed governmental framework conditions favouring "competing" technology the implementation of STE projects should be re-considered.
- Overall, ADC shall envisage to support the development of favourable framework conditions and policies in the long-term, and in line with respective national priorities, as specified under (1)-(3) above. The engagement on a national level with government stakeholders needs long-term involvement and a more strategic approach in terms of national/regional priorities (ADC target countries and regions) aligned with available budget lines. A specific recommendation is to focus projects (except business partnerships) eventually on a few countries only, but with larger, longer-term project interventions and define the priorities for projects in relation to the available framework conditions that need to be aligned on a country level.

***Conclusion 10. Creation of new jobs in the field of STE cannot be attributed to the interventions.***

As mentioned under the findings (EQ 11), creation of new jobs was not an objective of SWH projects and has therefore not been systematically monitored so far. The projects supported by ADC rather aimed at creating an enabling environment for the increased use of SWH thus stimulating the demand and in turn the supply of solar thermal systems. Assuming that the growth of a market would (automatically) lead to job creation is a presumption, the verification of which requires macroeconomic research. For SWH projects considered in this evaluation the number of jobs created as an outcome of the interventions is statistically insignificant and respective information only based on anecdotal evidence. Different from the SWH projects, the SD project implemented in Latin America aimed explicitly at the creation of jobs for the target group. Since the target group uses Solar Drying Systems as a means of production, a simple economic formula allows an estimation of jobs created through the use of solar dryers. For the SD project supported by the ADC this number amounts to approximately 600 jobs.

***Recommendation:***

- With their present design, SWH projects are not able to achieve the creation of a significant number of new jobs as a direct effect of project activities. Indirectly induced job creation is possible but linked to the growth of the market for SWH systems. However, a scientifically based estimation of such job effects in energy-based project interventions requires the use of macro-economic models and respective indicators. Presently, development partners and donors such as the EU, EnDev (Energising Development) or KfW do work on or have drafted methodologies to estimate job creation in energy at preparation stage. Unless agreement is reached on how and based on which indicators job creation can be monitored at the level of project interventions, including them within project, programme or outcome evaluations is not considered useful.
- Related to the above it is recommended that project proposals mention the creation of jobs only as possible project outcome/ impact , if project partners are able to collect respective data.

***Conclusion 11. Project interventions lack a systematic coherence with similar initiatives on a country or regional level.***

The evaluation of *coherence* involves looking at a how well or not different actions work together. It may highlight areas where there are synergies with other interventions which improve overall performance or enable exchange of experience between each other, or which were perhaps not possible or potentially contradictory if introduced at national level.

Projects supported by ADC have in most cases missed the opportunity to systematically cooperate with existing national or regional activities in the field of STE. Checking "internal" coherence means looking at how the various components of the same or similar ADC intervention operate together (or in parallel) to achieve their objectives. At its widest, external coherence can look at compliance with national policies (e.g. achieving ADC targets) or international agreements/declarations (such as contribution of interventions to reaching SDG targets).

This conclusion is made based on the lack of mentioning of project documents and reports highlighting such interlinkages, i.e. assuming that project partners have not planned or looked out for such corresponding links towards other initiatives. The assumption is that such links have not been available (since ADA funded projects were in many countries the earlier drivers for STE development), or, for other untapped reasons (e.g. available networks of project partners on the national/regional levels) such projects have not allowed for establishing these linkages and cooperations or have not been encouraged by ADA during project application/evaluation to do so.

***Recommendation:***

- The focus on coherence may vary depending on the type of evaluation and is particularly important during project assessment, where coherence analysis will look for evidence of synergies or inconsistencies between interventions in a related field which are expected to work together. Project interventions in similar fields (e.g. STE) should be able to learn from each other, from previous experiences and lessons learned in previous ADC- or other donor-funded projects. This would require the project intervention logic to define possible inter-linkages with previous/ongoing activities and how these lessons are incorporated into the new intervention. Similar to a review already requested by other donors, such as EU or World Bank/UN supported and GEF-funded projects.

**EFFICIENCY**

***Conclusion 12. Efficient use of funds in ADC funded interventions can be demonstrated.***

ADC projects have received funding for the implementation in the amount of approx. 4.5 million EUR, covering a period of about 15 years (basically between 2001 until 2016). Thereof, the share of subsidy being used for supporting demonstration projects was in the range of about 1.4 million EUR.

The average system cost of solar thermal installations (incl. solar water heaters, heating systems, larger applications providing process heat and solar dryers) were about 980 EUR/kW (with a cost range between 560 EUR/kW for hot water systems built in Albania and 1,200 EUR/kW for hot water systems in Mozambique), whereas for solar cooling systems about 1,700 EUR/kW. The achieved leverage of 1:7 – about 1.4 million EUR of subsidy inducing an investment of approx.

9.8 million EUR (together with other co-financing sources of about 8.4 million EUR, compare with) and the average 213 EUR/kW can be considered as very efficient spending of public funds, compared to subsidy levels provided by Austrian funding programmes (and due to unavailability of other benchmarks from projects funded in the regions). Funding was provided for specific pilot activities that were well assessed and evaluated against pre-defined criteria. Provision of funds was addressed to most efficient projects, no watering-can principle was used.

***Recommendation:***

- Similar to other funding organisations on a national and international level, it would be useful to continuously monitor the specific funding provided by different interventions towards their efficiency and outcomes achieved. So far it seems that no monitoring is been done on the efficient use of public funds within energy projects. The M&E process should include organisational procedures (% of subsidy provided for which kind of intervention, level of co-funding by project partners or other donors, etc.), technical (amount of installations supported, installed capacities and amount of energy supplied, …) , economical (cost of technology, installation and maintenance against different technologies) and environmental aspects (contribution to GHG emission reductions or reduced amount of fossil fuels) and come up with indicators/benchmarks for ADC funds provided in different projects (STE or other renewables as well), which are considered to be useful for further monitoring requirements (e.g. SDG).

**IMPACT**

***Conclusion 13. Growth of market and increased share of renewables.***

As mentioned before, funded projects have focussed mainly on developing the supply side of STE, by addressing the issues of technology availability and improvement of STS components, quality of installation & maintenance, price of STS and costs for installation & maintenance. Demand-side issues, as creating awareness and checking the need among user groups and the conditions under which STE can be made available to customers (at which feasible technical and financial conditions as well as affordability) have been underrepresented. To enhance the growth of the market that will lead to increased demand it is important to create the needs at the level of user groups, ADC support has been successful in project interventions where capacity development for more complex technical and engineered solutions and early market development stage has been required, and where under adverse market conditions information and user barriers among target groups and energy users had been successfully tackled.

In addition, projects did result in numerous pilot installations and demonstration projects being developed, however, due to their limited size and number compared to overall installations on a national scale the overall impact on contribution to increased share of renewables and $CO_2$ emission reductions (compare also EQ 21) is limited.

***Recommendation:***

- Repeating some of the earlier recommendations by evaluators, the role of ADA can be linked to strategically support the grounding for clear governmental strategies and strong enabling policy frameworks for supporting the growth of the STS market on a longer-term basis; however, this requires project interventions to be supported over a longer-term period, since these developments naturally need time.

***Conclusion 14. Contribution of project interventions to GHG emission reductions is evident.***

Demonstration projects implemented with ADC support have led to direct GHG emission reductions in the amount of approximately 5,300 tons $CO_2$ per year, or 106,000 tons $CO_2$ over 20 years. Although there are no indirect GHG emission reductions attributed to the project interventions due to scale-up or replication activities (projects in general were not intended to be or to include a roll-out programme for STE, and therefore emission reductions from replication activities have not been targeted and provided in the intervention logic), there is a minor global effect on climate change mitigation but directly attributable effect of project interventions visible. The corresponding benchmark used by other donors and funding institutions, the avoidance costs of carbon emissions (expressed in EUR subsidy per t $CO_2$ savings over project lifetime) is about 13 EUR/t $CO_2$ avoided[19], which is favourable range compared to other project interventions and technologies (e.g. UNFCCC benchmark for carbon emission reduction projects used to be below 20 USD/t $CO_2$).

***Recommendation:***

- Several projects supported by ADC did not have *monitoring systems* in place that would allow documenting its achievements on energy savings and carbon emission reduction from its installed demonstration projects. Some others did resolve the issue and had a monitoring system installed throughout different project phases, e.g. in the case of *Soltrain II* the universities involved also have been provided with metering equipment that would provide collective data on project installations, the hot water production, solar yields and their resulting carbon and environmental benefits.

  As a recommendation for future interventions, having a continuous monitoring of direct project effects in place (i.e. on the level of demonstration projects), and considering, if possible, also indirect effects (i.e. effects of policies and market developments through applying assumptions on achievable scale-up and penetration effects – like being done in GEF-funded interventions), will assist in creating better awareness amongst policy makers and investors about successful operations, which shall be fed into success stories by providing real evidence in quantified and projected data.

  However, monitoring systems increase the overall costs of STS, and can be realistically covered only within larger installations. As the case of the business partnership in Jamaica shows, this could also provide real time data for testing business models and bankability of potential projects in order to source financing for new demonstration projects. However, it is recommended that these impacts are reported and published on a sectoral basis, also at available SHIP or SDH databases[20] (e.g. different industrial sectors, such as food processing, agriculture, breweries, hotels or in social institutions public buildings, schools, hospitals) so that their impacts can be properly compared and possibly projected to a national level potential.

**SUSTAINABILITY**

***Conclusion 15. Sustainability of project outcomes is to a large extent likely.***

Sustainability refers to the continuation of changes achieved by an intervention, i.e. outcomes and impacts, also after the end of this intervention. Therefore, it can only be applied to outcomes that were, at least partly, achieved. The outcomes envisaged by SWH and SC projects demonstrate achievement to a large extent (refer to details under EQ23).

The following outcomes are likely to be sustainable:

- Evidence derived from project reports and stakeholder interviews suggests that with only a few exceptions in all SMEs and social institutions, where demonstration systems have been installed, the use of these systems will continue also after the end of the respective projects. However, the sustainable use will largely depend on the regular maintenance of the demonstration systems.
- The increase of local capacities for installation and maintenance of solar thermal systems envisaged by SWH projects has largely been achieved with participants of the respective practical and theoretical training perceiving an increase in skills and knowledge. Provided that the participants will be able to use these newly acquired skills and knowledge the increased capacities can be expected to sustain.
- In countries such as Namibia, where SWH projects were able to actively support the development of framework conditions favourable to the use of SWH, a continuation of the respective political process and the implementation of favourable policies is likely, notably if relevant stakeholders remain in their position.
- Interviews suggest that the increased R&D capacities achieved at universities involved in STE projects will only sustain, if other sources of funding will become available.

[19]1.4 million EUR subsidy divided by 106kt $CO_2$ emission reduction over 20 years.

[20]Reference to these websites: http://ship-plants.info/, http://solar-district-heating.eu/

- There is some evidence from stakeholder interviews that awareness raising measures implemented by STE projects have indeed, increased the awareness of STE among governmental authorities. Whether the high degree of awareness achieved in some countries will sustain, will mostly depend on the popularity of other alternative energy sources such as for example photovoltaic.
- Based on the interview with the lead project partner, a longer-term sustainability of the jobs created by the El Salvador-Guatemala-Nicaragua SD project can already be stated, because the project ended already nine years ago.

***Recommendation:***

- As a general recommendation it can be stated that during project design the likeliness of sustainability of interventions shall be assessed and correlated with interfering risks, e.g. the way how institutional/policy or governance risks, socio-economic, financial or environmental risks will impact the sustainability of project interventions. Assessing the project inherited risks should be generally become part of the application process and linking them to sustainability criteria (in few cases project documents had made sustainability assessments in advance).

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# 8 Annexes

**Annex A: List of Solar thermal Projects considered in the Outcome Evaluation**

**Annex B: Evaluation questions**

**Annex C: List of project reports made available by ADA**

**Annex D: List of interviewees – Austrian stakeholders**

**Annex E: List of interviewees – Stakeholders from project countries**

**Annex F: Online Survey**

**Annex G: Context analysis – global status of solar thermal energy**

**Annex H: Data collection**

**Annex I: Terms of References (in German)**

See separate file