Quality Assurance of SWH in Emerging Markets: An overview of influential factors in Egypt and Tunisia

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Abstract

Solar thermal technologies have a diverse range and scale of application, creating market potential worldwide. Due to favorable natural conditions, fuel price volatility and rising heat demand, southern Mediterranean countries present a promising market for solar thermal. Yet many barriers hinder this regional market, such as establishing a strong base for quality assurance and monitoring. The research in this paper has focused on the necessary factors for a strong and functional quality infrastructure to implement a quality certification scheme for solar water heaters (SWH). The geographical focus has been the Middle East and North Africa (MENA) region, highlighting its regional scheme, Solar Heating Arab Mark and Certification Initiative (SHAMCI).

The research included case studies from Egypt and Tunisia due to the varying market maturity levels in both countries while sharing comparable quality infrastructure conditions. By reviewing previous studies and utilizing business modeling, a set of assessment factors for the market quality component have been formulated and introduced through a survey to experts from Egypt and Tunisia. Analysis of the survey results has produced comparative statements from the case studies and investigated the suitability of the assessment factors. The results are seen as helpful for the implementation of certification schemes in many regions around the world.

Keywords: solar water heaters, SWH, quality assurance, certification, MENA

1. Introduction

1.1. International Momentum of the Solar Thermal Technology

Solar heating and cooling was estimated to produce over 16% of the total energy for low-temperature applications by 2050 (Ölz, 2011). Despite the growth in solar thermal markets until 2016 reaching a global cumulated capacity of 456 GWth, many European markets witnessed considerable declines. On the other hand, new potential markets have emerged outside Europe with significant market growths (REN21, 2017). Some of these new markets face numerous obstacles, such as economic incompetency due to fuel subsidies, unfavorable national support frameworks, and lack of quality measures or industry standardization. In order to address the latter, international efforts have been exerted to support global solar thermal markets.

The International Energy Agency Solar Heating and Cooling (IEA SHC) programme – Task 43 Solar Rating and Certification provided collaborative research to improve testing and characterization methods for different solar thermal products. The IEA SHC Task 57 – Solar Standards and Certification built on Task 43, focusing on quality certification of solar thermal products, and paving for a global certification scheme. However, harmonization among already existing schemes is the first step to global certification (Nielsen et al., 2012; Fischer and Drück, 2014). Outcomes of the IEA SHC Tasks helped founding the Global Solar Certification Network (GSCN). Another remarkable international project is the Global Solar Water Heating Market Transformation and Strengthening Initiative (GSWH). The GSWH project built a knowledge exchange platform for the solar thermal field, and supported SWH market development in five countries (GSWH, 2014b).

1.2. Quality Certification in Regional Solar Thermal Markets

On the European level, the solar thermal quality label Solar Keymark has expanded as a quality label for SWH, while fostering solar thermal innovation (Mehnert et al., 2012). For most certification schemes, the process requires three independent quality bodies: a certification body, a solar thermal testing facility, and a quality

Selection and/or peer review under responsibility of Scientific Committee
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inspection body (Kramer et al., 2009). Among these three, testing facilities demand the highest investment in order to comply with international solar thermal testing standards and achieve their desirable functionality. According to a study conducted by the International Renewable Energy Agency (IRENA), the development costs of an SWH testing laboratory were estimated in the range of 0.5 to 2.0 million US dollars (IRENA, 2015). Quality labels, such as Solar Keymark, can cut down on certification expenses through mutual recognition of a network of national testing institutions and inspection bodies.

According to a market assessment conducted as part of the GSWH project, most MENA countries contributing to the study have adopted national solar thermal standards to ensure a market quality benchmark. However, in most of these cases quality assurance of solar thermal products is unreliable due to the absence of a coherent and neutral quality control system. Consequently, the solar thermal industry in MENA has lacked harmonization in manufacture quality and testing procedure, which also cast obstacles upon international trade. In order to improve the solar thermal product's quality and facilitate cross-country trade, the Solar Heating Arab Mark Certification Initiative (SHAMCI) was kick-started in 2011 – 2012 (GSWH, 2014a).

SHAMCI is the first regional third-party quality certification scheme for solar thermal products and services. Although based on the European Solar Keymark, it has been adapted to meet the requirements of developing countries, mainly the emerging solar thermal Arab markets. The project was initiated by the Regional Center for Renewable Energy and Energy Efficiency (RCREEE), the League of Arab States (LAS), the Arab Industrial Development and Mining Organization (AIDMO), and with the technical support of the University of Stuttgart. SHAMCI network, the managerial structure of the scheme, included representatives from different national as well as regional and international experts (SHAMCI Network, 2016; Kraidy, 2017).

1.3. Objectives and Challenges of Regional Certification in MENA

SHAMCI's objectives are, first and foremost, standardizing the processes of inspection, testing and certification of solar thermal products in order to facilitate their technical benchmarking (GSWH, 2014a). Second, SHAMCI aims at fostering the solar thermal industry across MENA, providing the flexibility to implement the certification scheme nationally at the initial stages (until 2021) according to predefined requirements (SHAMCI Network, 2016). This flexibility reduces the burden of international accreditation on national bodies and expensive testing abroad on local manufacturers. In the long-term, SHAMCI aspires to collaborate with other international schemes for a wider recognition of regionally manufactured products (Kraidy, 2017).

Regarding challenges, SHAMCI does not require a practitioner certification until 2021 (SHAMCI Network, 2016; Kraidy, 2017). Poor installation by under-qualified practitioners or due to lack of installation standards may have a higher negative impact on emerging SWH markets than the lack of product certification (IRENA, 2015). Another technical challenge is the technology's poor documentation (IRENA, 2015). Yet, SHAMCI's planned database of certified products is expected to act as a knowledge dissemination tool. Heavy subsidies on fossil fuels in many MENA countries are a significant market barrier for SWHs (GSWH, 2014a). Recent subsidy reform policies in some countries may contribute to SWH's better economic competitiveness (GSWH, 2015). The market maturity level can also influence the applicable quality assurance measures, as large companies are more capable of meeting higher measures (Han et al., 2010). This can be different in the Arab markets due to the relatively small number of local manufacturers (GSWH, 2015).

1.4. Quality Assurance and Market Growth

Quality assurance is the system of standards and measures applied to achieve the expected performance of products and services, maintaining this performance level over time, thus achieving consumer satisfaction and market growth (IRENA, 2015). However, keeping a balance between ensuring quality and promoting growth in a new market can be complicated due to the strong interlink between technical, economic and social factors. Studies from the IRENA guideline on Quality Infrastructure for Solar Water Heaters has shown that, with few exceptions, market size is usually proportional to the rate of quality infrastructure development (IRENA, 2015). This is due to the additional financial and technical burdens that can accompany a higher level of quality.

To ease the costs of quality assurance in emerging markets, the guideline has introduced five potential market stages, and recommended coupling steps of quality infrastructure development with a corresponding market stage. International agencies with strong partnerships in the region have fostered this development, such as the National Metrology Institute of Germany (PTB)'s project: Strengthening quality infrastructure for solar thermal

energy in Maghreb, and the German Corporation for International Cooperation (GIZ)'s collaboration in Tunisia.

1.5. Solar Thermal Market Assessment Tool: TechScope

The Solar Water Heating TechScope Market Readiness Assessment tool, or TechScope for short, is a composite index that provides an open-source reproducible assessment of a national SWH market progress. The analysis tool is one of the outcomes of the GSWH project. A detailed guiding report accompanies the tool, and includes assessment results from the five countries participating in the GSWH initiative; Lebanon being the only MENA country. Additional independent reports from Latin American, Caribbean, and Arab countries have added up to a total of 27 countries applying this methodology. According to the guiding report, TechScope evaluations are basic and exclude in-depth policy design, timeframe, or interaction (GSWH, 2014b). Nevertheless, it provides a standardized benchmark among different countries, and assesses one country's long-term progress.

The TechScope integrates four assessment parameters (Table 1), and a set of indicators feeding each parameter's data input. The indicators have certain weights that add up to a final market score described as a rational number from zero to five; zero being an 'emerging' market and five being a 'very strong' market. *Product standards and certification* stands as one of the indicators for the parameter *business climate*, with a weight of 5%. This indicator assesses the market's quality component through a tier of factors seen as necessary for a functional quality system. These factors are introduced in subsection 2.2.

Tab. 1: Parameters and indicators of the TechScope SWH Market Readiness Assessment tool, adapted from GSWH guiding report (GSWH, 2014b)

	Description	**Weight**	**Indicators**	**Weight**
Parameter I	SWH support framework	29%	SWH targets	5%
			Financial incentives for system installation	8%
			SWH loan programs	7%
			Building mandates	5%
			Outreach campaigns	4%
Parameter II	National conditions	30%	Insolation	5%
			SWH market penetration	4%
			Residential energy consumption growth	5%
			SWH market growth	4%
			Competitiveness: Payback period	7%
			Competitiveness: Heating fuel subsidy	5%
Parameter III	Financing	20%	Country credit rating	5%
			Access to finance	15%
Parameter IV	Business climate	21%	Doing business	5%
			Manufacturing capacity	3%
			Product standards and certification	5%
			Installer certification	4%
			Industry association	4%
TOTAL		*100%*		*100%*

The study assessing eight Arab SWH markets have shown how the parameter weightings can be detrimental to a country's final score (Figure 1). According to the OECD Handbook, the effect of weighting is specifically important when the composite index is used for comparing national performance (Hoffmann and et al, 2008). For instance, examining the country scores and the scores of the product quality indicator suggested Lebanon, Tunisia, and Morocco as front leaders in terms of both country and quality scores. In contrast, Palestine's strong country ranking cannot be attributed to its quality market component, the latter putting it in the same place as the least ranking country, Sudan. Due to data gaps and inconsistencies, the TechScope scores for these countries are intended as a future guideline only, and not a direct comparative tool (GSWH, 2015). Yet, this may degrade the tool's objective of providing reliable insights to decision-makers and lead to misguiding assessments.

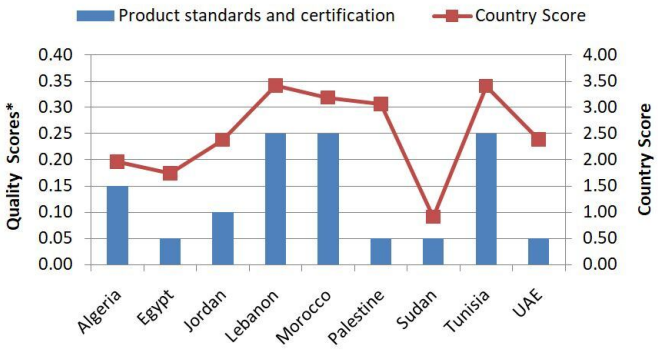

Fig. 1: TechScope SWH market readiness assessment tool: score summary for Arab countries, data sources: GSWH, 2014b, 2015 (* Scores of the indicator 'Product Standards and Certification')

2. Research Components

This research addressed the following two questions:

- What are the main actors, driving forces, and objectives of SHAMCI?
- What are the necessary factors defining a strong and functional national quality infrastructure, in order to implement a quality certification scheme for solar thermal products and services?

Business modeling of the SHAMCI project aimed at addressing the first question. A research survey conducted with experts from Egypt and Tunisia has been dedicated to the second question.

2.1. Business Model

Since SHAMCI involves the main constituents of a business case – providing a certain service, demand for this service and revenue streams among stakeholders, constructing a business model helped to identify SHAMCI's strengths and challenges in a market context. The adopted CANVAS business model is composed of nine main blocks representing the internal components of the business case, and four external environment forces influencing it (Table 2) (Osterwalder et al., 2010). Due to the complex, multilayered nature of SHAMCI (e.g., the diversity of stakeholders, different national and regional levels of administration … etc.), different actors may represent the model's *customer segment* according to the examined perspective. This model examined the end-users as SHAMCI's customer segment. The choice of this layer assumed that end-users are either directly or indirectly the core determinant of most market models. Further assumptions made were:

- Value proposition of SHAMCI is constant to end-users among the countries of interest in terms of its existence as a regional quality mark, and regardless of market specific influences
- Channels discussed are expected abstract functions of different national or private entities
- Environment influences are analyzed at the regional level according to the available literature and data

Due to the stated assumptions, it is important to consider the following possible model inaccuracies:

- End-user's general perception of solar thermal technologies can differ among countries, which may affect the customer relationship with SHAMCI

- Revenue systems can differ according to the national economy and market parameters
- The role and weight of each key partner may vary in different countries
- Detailed country-specific influences in the environment were not modeled

Modeling has facilitated identifying the key players of SHAMCI, which in turn informed the theoretical framework of the survey research. However, examining national economies per country is yet recommended.

Tab. 2: SHAMCI business model CANVAS, adapted from Strategyzer (strategyzer.com) [1]

<table>
<tr><td></td><td colspan="5">Key Trends
Fuel price volatility
National RE and EE action plans
SWH support framework
Electricity grid stabilization
Fuel subsidy reform</td><td></td></tr>
<tr><td>Industry Forces</td><td>Key Partners</td><td>Key Activities</td><td>Value Proposition</td><td>Customer Relationships</td><td>Customer Segment</td><td>Market Forces</td></tr>
<tr><td>Cheaper alternatives

Existing competitors

Regulations and legislation</td><td>National / regional agencies

Promotion partners</td><td>Efficient communication channels

National level adoption

Key Resources

Quality mark

Knowledge exchange</td><td>Higher product quality

Impartial assessment</td><td>Uncomplicated

Transparent

Channels

Market (labelled products)

Online database</td><td>End-users</td><td>Market size

Energy demand

Subsidies</td></tr>
<tr><td></td><td colspan="3">Cost Structure
Promotion
Market incentives
Other</td><td colspan="2">Revenue Streams
(Part of) Product price</td><td></td></tr>
<tr><td></td><td colspan="5">Macroeconomic Forces
Increasing living standards
Regional market status
National economy status</td><td></td></tr>
</table>

2.2. Expert Questionnaires

To identify and assess the influential factors affecting the implementation of a national certification scheme, a comparative study of two countries has been conducted. Egypt and Tunisia were chosen based on their respective scores in the SWH market readiness assessment tool – TechScope. The countries lied in different categories regarding their quality infrastructure, with Tunisia having more favorable conditions as an SWH market; i.e., a higher TechScope score (see Figure 1). A survey research using a self-administered questionnaire as its data collection tool gathered specific information from expert groups.

Given the complexity of the cognitive process of answering survey questions, different errors may occur

[1] Layout from Business Model Foundry AG (Strategyzer; strategyzer.com); the model is registered under a Creative Commons Attribution-Share Alike 3.0 Unported License.

accordingly (Schaeffer and Presser, 2003). Thus, following survey best-practices is of great importance to obtain accurate data. The survey at hand considered measures such as data confidentiality, optimized design and layout of the questionnaire, and choosing the right type of questions according to the research objective and the characteristics of the target groups. Figure 2 represents the steps followed to conduct the survey research.

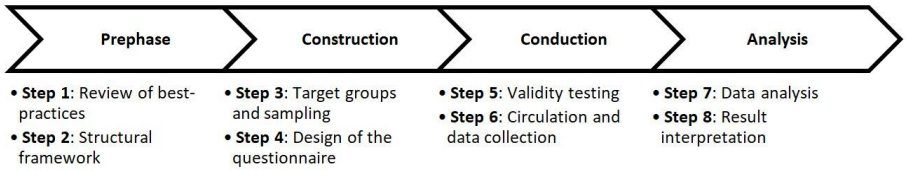

Fig. 2: Schematic of the applied steps to conduct the research survey in this study

The survey's data tool, the questionnaire, assessed predefined factors influencing SWH quality infrastructure as described by the quality component indicator, 'Product standards and certification', under parameter IV of the SWH market assessment tool, TechScope (see subsection 1.5). The factors (also referred to as *the assessed factors* in the scope of this paper) are:

I. Existence of a national standards entity
II. Existence of solar thermal equipment standards
III. Availability of domestic solar thermal testing facilities
IV. Introduction of national solar thermal products certification
V. Introduction of regional or international solar thermal products certification

Additionally, the questionnaire has allowed exploring emergent factors perceived as important by the sampled experts. This exploratory nature was important to maintain the study's objectivity and provide respondents with the flexibility to convey their full experience about the survey subject.

The target groups were in accordance with the key-actors identified in the business model (see Table 2), and the aforementioned assessed factors. Due to the highly specialized nature of the study, the population for sampling has been limited. Other limitations included time, resources, and respondents' availability. In this case, the selection of an organization most representing the research purpose, such as the Regional Center for Renewable Energy and Energy Efficiency (RCREEE), allows collecting individual responses that may reflect an approximate effect of a random sample (Glasow, 2005). Recommendations from RCREEE helped identify professionals with the needed experience. The selected respondents reflected the following target groups:

- Governmental institutions with a technical function
- Governmental institutions with an executive function
- Nongovernmental not for profit organizations
- Industry associations
- Private sector

2.3. Data Analysis

Due to its mixed nature, analysis approaches followed the type of data analyzed. That is, qualitative for open-end questions whereas quantitative for closed-end questions. Both analysis processes were parallel, independent, and started after the end of data collection phase. Triangulation of results; the process of result comparison from different approaches in order to form reasonable and constructive interpretations, has been adopted to form end results (SSC, 2001). The questionnaire response rate reached 52.6%, where out of the nineteen contacted candidates the collected responses were ten in total. Contacts from two target groups 'governmental institutions of an executive function' and 'private sector' have not responded altogether and, thus, their respective groups were missing in the sample representation. Further discussion on this issue is in subsection 3.3.

The adopted approach for the qualitative data (or content) analysis was 'Inductive Category Formation' after Mayring (2014), chosen by exclusion of other methods of interpretation which by definition did not match this research's conditions (Mayring, 2014). The analysis consisted of two phases: first, processing raw data and

second, analysis according to the adopted approach. As for quantitative evaluation, the variables of each question were first identified and tabulated. Then, the data was categorized into two question types: closed-end, single response questions based on an evaluative rating scale (ten questions), and a ranking question to assess factors according to predefined criteria (one question).

As described in Döring and Bortz, 2016, quantitative data analysis comprise data cleansing, sample description, descriptive analysis, inferential statistical analysis, and interpretation of statistical results. It is important to stress that the small size of the received datasets in this study has limited the statistical significance and generalization of result interpretations. The use of commonly applied statistical approaches has been substituted by a selection of measures describing the data sets and exploring possible correlations (Glasow, 2005). The context of the questions has been considered at all time in order to avoid misleading interpretation.

3. Results and Discussion

The interpretations included in this section are strictly case-based and any general statements made are considered as assumptions. Limitations on the study are discussed in subsection 3.3.

3.1. Qualitative Results Interpretation

The findings can be summarized in Table 3 according to the analysis method and the dominant category:

Tab. 3: Comparative summary of the qualitative data analysis results

Analysis	Parameter	Dominant Main Categories	Dominant Categories	Absolute* Frequency	Relative** Frequency
Per Question	Q3: Lack of quality assurance	1. Perception of technology	B2: Reputation of technology	4 (2 Egypt) (2 Tunisia)	15%
			B1: Trust in the product	3 (1 Egypt) (2 Tunisia)	12 %
	Q6: Other factors	3. Policy	B6: Incentive policies for industry	4 (2 Egypt) (2 Tunisia)	29%
Per Target Group	Governmental technical	2. Market	B8: Exposure to regional and international markets	4 (1 Egypt) (3 Tunisia)	13%
			B10: Market quality monitoring	4 (4 Tunisia)	13%
	NGO	3. Policy	B6: Incentive policies for industry	4 (4 Egypt)	20%
			B9: Control on imported low-quality products	4 (2 Egypt) (2 Tunisia)	20%
Per Country	Egypt	3. Policy	B6: Incentive policies for industry	4	19%
	Tunisia	2. Market	B10: Market quality monitoring	4	13%

* Total number of occurrences per parameter

** Percentage of occurrence compared to the total number of coded statements per parameter

The findings have been compared with the recommendations of IRENA's guideline (IRENA, 2015), which proposes five stages of quality measures according to the specific SWH market needs per stage. Comparing these market stages to the results suggested that the SWH Tunisian market can be transforming from stage two 'Market Introduction' to stage three 'Market Growth', given the interest in market expansion and import control. Whereas since Egyptian responses advocated policy measures to boost the quality infrastructure and motivate the industry to adopt higher quality measures, the Egyptian market may be at stage one 'Market Assessment'.

The category system has also been compared to the evaluative indicators of the SWH market readiness assessment tool, the TechScope (see subsection 1.5). Most prominently, the inferred categories from the qualitative survey responses concurred with the indicators for data input about SWH policy frameworks in the TechScope score (Table 4). However, the categories were concerning quality assurance and monitoring specifically, while the TechScope addressed the context of general SWH support policies. Clear national targets and strategies, financial incentive programs, and compulsive mandates for SWH integration were among the common interest points for the TechScope and the category system.

Tab. 4: Similarities between indicators of the market assessment tool, TechScope, and the qualitative data analysis results, the category system

Parameter	TechScope indicators	Survey Category system	Main Category
I. SWH support framework	1: SWH targets	B17: Clear national strategy for solar energy	Policy
	2: Financial incentives for system installation 3: SWH loan programs	B6: Incentive policies for industry B14: Incentive policies for quality infrastructure	
	4: Building mandates	B15: Correlating product quality and incentive policies	
	5: Outreach campaigns	B18: Awareness campaigns for the certification scheme	

3.2. Quantitative Results Interpretation

Quantitative data analysis has shown trends of convergence and divergence between both country responses according to the measured aspect as follows:

- Results from Egypt and Tunisia have been harmonious regarding the influence of quality assurance on SWH emerging markets, while greatly differing for other aspects, such as awareness and familiarity of the concerned stakeholders with the national SWH standards
- Comparing results of single-answer questions per country yielded differences. For instance, although responses reflected the national standardization entity in Egypt as 'very highly active', its influence on the field of SWH products and services has been majorly described as 'rare'. In Tunisia, both the performance level and influence of the standardization entity were rated average. This variance raised the question of how each of the entities performed. Hence, inferences cannot be definitive without extra case-based investigation
- Analysis of the ranking question has shown only a slight difference in priority between Egypt and Tunisia (Figure 3). According to the responses, the existence of national testing facilities was relatively more important for the SWH quality infrastructure in Tunisia than the existence of national solar thermal equipment standards. This may be attributed to the higher readiness of Tunisian SWH market compared to Egypt, as indicated by its TechScope country scores (see Figure 1)
- Concerning statistical inferences, results indicated that the importance of quality assurance for promoting SWH in emerging markets received the highest mean score on the rating system. This complemented the finding from qualitative data analysis regarding how lack of quality control negatively affected the reputation of the solar thermal industry.

- Responses from Egypt and Tunisia both indicated high mean scores for question 10, evaluating national SWH testing facilities. This can be attributed to the recent national efforts exerted in both countries to strengthen the quality infrastructure for solar thermal, such as PTB projects in Tunisia and the expansion of Egypt's Solar Thermal Testing laboratories at the New and Renewable Energy Agency (NREA).

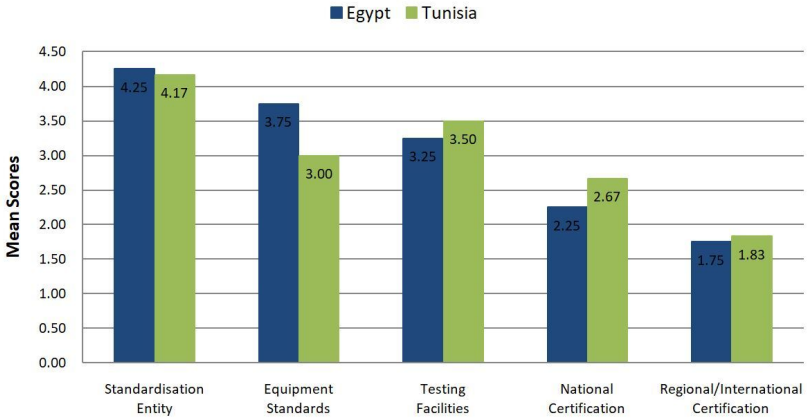

Fig. 3: Statistical analysis of mean scores per country for the ranking question (no. 4), evaluating the relevant importance of influential factors of the SWH quality infrastructure introduced in the TechScope assessment tool

3.3. Discussion

Constraints on the conducted survey research included limited validity testing for the data collection tool, the questionnaire, prior to its circulation among respondents. This can impose measurement error on the results. The questionnaire has followed best practices and common wisdom in terms of design and structure. However, since the tool was specifically designed for the study at hand, it had no preceding theoretical framework for benchmarking. For these two reasons, the absence of previous framework and limitations on pretesting, validity has been restricted to content validity as to how well the questionnaire addressed the research questions.

Other measurement error may include *satisficing* and *acquiescence*[2] from the respondents' side, and inhomogeneous sample representation due to nonresponse of some target groups which are 'governmental institutions with an executive function' and 'private sector'. Comprehensive measures of validity and reliability have been applied to the qualitative and quantitative data analyses as instructed by the relevant approach. Nevertheless, further measures to improve the results can be considered for both processes, as shown in Table 5.

Tab. 5: Recommendations for the survey research improvement referred to the currently applied measures

Parameter	Applied:	Recommended:
Validity of the data collection tool	• Limited pretesting • Content validity	• Formal extensive pretesting • Research repetition to enhance validity
Sampling	• Purposive sampling • Small sample size • Limited target groups due to the specific experience required	• Mixed sampling • Larger sample size to reduce measurement error • Broader target groups

[2] Satisficing is the opposite of optimizing in responding to a survey question. When satisficing, a respondent skips over one or more of the cognitive steps of answering a question, hence, provides erroneous information. This can be due to insufficient prior knowledge of the subject. It can also occur at a weak or strong level, ranging from selecting the first "good enough" response in sight, up to responding completely at random. Acquiescence is the tendency to confirm a statement regardless of the question asked, especially for 'agree/disagree' or 'yes/no' question types. Some reasons for acquiescence include the social pressure, lack of experience on the subject, and the tendency to satisfice [18,19].

Nonresponse	• Misrepresentation of some target groups due to nonresponse	• Larger sample size to reduce the effect of nonresponse • Offering financial or moral gain • Weighting data collected from different target groups • Adopting additional data collection tools, e.g., interviews
Qualitative data analysis	• Reliability by single intra-coder agreement and third-level inter-coder agreement tests	• Reliability by multiple intra-coder agreements and stricter inter-coder agreement tests • Reiteration to enhance validity
Quantitative data analysis	• Small sample size, thus weak statistical significance and limited results generalization • Result interpretation mainly based on descriptive statistics	• Larger sample size for better statistical significance • Statistical analysis models • Result interpretation based on inferential statistics • Research repetition to enhance validity and results generalization

4. Conclusion

This study has addressed two research objectives: first to analyze the main determinants of the regional SWH certification scheme, SHAMCI, and second to identify and evaluate factors influencing the quality infrastructure in emerging SWH markets. A business model of SHAMCI identified its main actors, internal and external influences. The actors included end-users, national authorities, SHAMCI network, regional and international agencies, and industry actors such as manufacturers. Influences, such as value channels, revenue streams, and market environment, have been linked to the project's proposed benefit of providing impartial and transparent SWH product assessment. The survey research conducted in the scope of this study built upon outcomes of the business model to examine influential factors of the SWH quality infrastructure according to the market assessment tool TechScope, and explore possible other factors in the countries of focus.

Using a self-administered questionnaire as a data-collecting tool, the survey research has targeted experts from Egypt and Tunisia with open-end and closed-end questions. Triangulation, which is comparing results from qualitative and quantitative analyses, has been applied to construct end interpretations. However, due to limitations discussed thoroughly in subsection 3.3, interpretations are case-based within the scope of this study and generalization is strictly limited to assumptions.

4.1. Case-study: Egypt

Overall, responses from Egypt stressed on policy-based measures to promote their national market. This may indicate a need for a stronger support framework, specifically to foster SWH quality assurance. Furthermore, comparing the obtained results to the five market stages mentioned in IRENA's guideline on Quality Infrastructure for Solar Water Heaters, the Egyptian SWH market may be at stage one 'Market Assessment'.

4.2. Case-study: Tunisia

Qualitative responses from Tunisia were interested in factors related to the market category, such as potential market expansion regionally and internationally, and the importance of quality monitoring on imported SWH products. According to IRENA's guideline, the previous two statements coincided with recommended policies to transit a market from stage two 'Market Introduction' to stage three 'Market Growth'. The inferences may also suggest possible inadequate quality monitoring on SWH imports to the Tunisian market.

4.3. Response Convergence and Divergence

Qualitative and quantitative responses from Egypt and Tunisia have agreed on the importance of quality

assurance in their respective national SWH markets, stressing the influence of the product's quality level on the reputation of the technology and the effect a lack of quality monitoring had on the product's perception in the market. While in contrast to Egypt, responses from Tunisia regarding the predefined factors proposed that the existence of solar thermal testing facilities was relatively more important than the existence of national solar thermal equipment standards.

4.4. Assessment Tool for Market Quality Component

The developed categories from the accumulated qualitative content analysis were similar to the data indicators assessing the policy component of an SWH market of the market assessment tool, TechScope. Yet, the contexts differed, as the categories were specifically quality oriented. For example, the TechScope indicator 'building mandates' that reflected regulatory frameworks for compulsory SWH installation in new buildings, concurred with category B15 which addressed 'correlating product quality and incentive policies', e.g., adopting a recognized benchmark of product quality as prerequisite for government SWH tenders. This finding reinforced the assumption that a more accurate assessment tool is needed to reflect the SWH market quality component, especially in emerging markets. Also, associating the quality component to the market maturity level can help decision-makers to avoid introducing either infeasible or insufficient quality assurance measures.

4.5. Recommendations

The outcomes of this research were not sufficient to construct an assessment tool dedicated to measuring an SWH market quality component. Nonetheless, the findings suggested introducing additional assessment parameters to the factors evaluating the TechScope quality component, e.g., indicators specifically dedicated to quality-related incentive policies and measures. Lastly, considering the limited generalization of this study, recommendations have been formulated to increase the reliability of the research structure, the validity of results and hence, the generalization of inferences. The repetition of the survey study on a larger sample size and comparing results with the research at hand can improve the inferences made for the case-studies of Egypt and Tunisia. Further repetition of the study in countries with emerging SWH markets at different growth stages may also strengthen the studied correlation between quality assurance and market maturity level, as well as assist in building a specialized market assessment toolkit to evaluate the SWH market quality component.

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