Physikalisch-Technische Bundesanstalt
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National Metrology Institute

INTERNATIONAL COOPERATION

Quality and Safety Criteria Applied in Financing Photovoltaic Projects

A practical appraisal of information on the examples of India and Indonesia

german cooperation
DEUTSCHE ZUSAMMENARBEIT

On behalf of

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Table of Contents

Executive summary

Background

Increasing the share of renewable energy in the national energy mix ranks high on the political agenda of many governments around the globe. Multi- and bilateral development banks support national governments in pursuing this objective and provide funding for renewable energy projects. The ultimate success and sustainability of the investment as well as the achievement of national renewable energy targets depend to a large extent on the quality, performance and safety of the financed energy system. Therefore, adequate quality and safety criteria should be taken into account in the respective financing scheme.

In this context, this study analyses current approaches, possible bottlenecks and lessons learned in photovoltaic (PV) projects in India and Indonesia. An emphasis is put on criteria which entail the use of services of the quality infrastructure, including metrology, testing, standardization, certification, inspection and accreditation.

The study, commissioned by the Physikalisch-Technische Bundesanstalt (PTB), was conducted between December 2015 and March 2016. The data collection comprised desk research as well as interviews with relevant international and local stakeholders in India and Indonesia. Preliminary results were discussed in a stakeholder roundtable in India in March 2016 and used as input for the Host-Country Seminar "Promoting Renewable Energies in Asia – the Quality Challenge" held during the Annual Meeting of the Asian Development Bank (ADB) from 2nd to 5th May, 2016 in Frankfurt, Germany.

Main findings

Insufficient consideration of quality and safety criteria in financing schemes may lead to risks for the performance of PV systems.

Quality and safety issues arise in PV projects across the globe, with approximately 30% of PV installations having serious defects, mainly caused by installation errors.[1] Also in India and Indonesia, where the development of PV is relatively recent, problems related to quality and safety have occurred in PV projects.

Therefore, quality and safety aspects need to be taken into consideration in financing schemes to avoid issues such as power losses, safety problems, fire risks and low reliability of PV systems that can negatively affect the performance of individual projects, the reputation of the PV sector and the achievement of national and international objectives for the development of renewable energy. This includes targets concerning electrification rates and the composition of the national energy mix, goals for reducing CO_2 emissions and air pollution on a national level, but also related international agreements, such as the Sustainable Development Goals of the Agenda 2030.

Development banks exert different levels of influence on quality and safety in function of the applied financing scheme and bank-internal approaches to quality assurance.

Development banks apply different financing schemes, including direct financing and refinancing of projects as well as the possibility of supporting Public-Private-Partnerships (PPP). Direct financing of a project gives the bank most influence on quality and safety during the implementation as the project can be followed more closely, while the refinancing approach focuses the collaboration on the local partner bank rather than the specific projects and the actors involved in the implementation. In a Public-Private

1 TÜV Rheinland 2015

Partnership (PPP) structure the development bank is often financing the infrastructure for the PV system, leaving the power generation to the private party engaged in the project.

While development banks have general procurement guidelines as well as tools to ensure the environmental and social sustainability of their projects, there are no specific publicly available guidelines for the assurance of quality and safety in financed PV projects. It is common practice that technical aspects are reviewed by experts who evaluate quality and safety in a given project based on internal criteria and individual knowledge.

National project partners assume the responsibility and risks related to quality and safety aspects although necessary processes might not be in place.

The responsibility for the preparation and implementation of criteria that allow to assure high quality and safety in a PV project usually lies with the local project executing agency, while the financial risk rests with the system operator, as plant performance below estimations results in a reduced return on investment.

The responsibility of development banks regarding quality and safety of the financed projects is often perceived as limited within the organisation. In line with this perception, the extent of support offered to the project partners varies considerably between banks.

As the relevant national policies, regulations, standards and procedures are still not fully developed in many cases, the implementation of the relevant quality and safety criteria is not always assured.

International standards and a functioning quality infrastructure (QI) foster quality and safety in the PV sector.

When quality criteria are included in financing schemes, it is mainly by referring to the relevant international standards. In order to assure quality through standards, the availability of all associated and internationally recognised services, such as testing, inspection and calibration, is crucial so compliance with these standards can be verified.

The study highlights the importance of a functioning quality infrastructure (QI) which is essential to assure the quality and safety of PV installations. Through the presence of all necessary services, a well-developed QI can improve the performance of the installed PV systems, the return on investment and the safety of workers and people in the surroundings of the installations, such as users of buildings with rooftop installations. It has thus a positive influence on the long-term value of PV projects.

Many developing and emerging economies including India and Indonesia are still in the process of building up the required services of the national quality infrastructure and gaps persist. Consequently, the local PV sector can either make use of QI services that are not internationally recognized, which results in a lack of confidence in the quality and security of local products, especially in international markets; or the needed services have to be purchased abroad, which leads to higher costs and longer times needed to procure these services.

In the last years, India and Indonesia have taken important steps towards developing the services of the national QI needed to assure quality and safety in the PV sector. Opportunities for further improvement include, for example, the adoption of all relevant international standards by the national standardization body, the provision of reliable metrological services for cell calibration, the development of effective inspection and certification schemes, and the availability of all relevant accredited and internationally recognised testing services. Additionally, the local PV industry needs to be supported to be able to fulfil international standards in all areas and improve its competitiveness compared to foreign companies.

Awareness of the need for quality and safety in PV is lacking.

A fundamental obstacle is the low awareness amongst many actors, including the financial sector, policy makers, public administration, private companies and end users, that quality and safety needs to be given more consideration in PV projects. The technology is often perceived as comparatively easy and safe. Therefore, the demand for quality assurance and safety measures remains low.

Recommendations

Based on the findings of the study, the following recommendations can be made:

General recommendations

- Systematic collection of performance data of PV installations on a regional or national level
- Study on risks for investments in PV due to quality and safety issues and concrete measures to reduce these risks
- Establishment of national working groups on quality and safety in PV, bringing together relevant stakeholders
- Elaboration of national guidelines for quality assurance in PV financing
- Development and review of training activities to conform with international best practices.

Recommendations for development banks

Development banks should gradually increase their quality and safety criteria and implementation support. The following requirements should be included in particular project agreements:

- Use of high quality solar irradiation data
- Reference to international standards
- Requirement of certification of workforce and components (with periodical audits of the production process) and pre-defined testing procedures
- External expert to follow the project implementation and ensure quality (especially for big projects)
- Use of best practice guides and instruction manuals for different phases and tasks
- Performance monitoring and disclosure measures for a systematic collection of performance data
- Reduced time constraints for project implementation
- Long-term performance warranty with penalty in case of non-achievement
- Developer/EPC revenue should depend on long-term plant performance.

Additionally, development banks should:

- Assess the state of the operating framework of the local project executing agency and adjust support measures and requirements accordingly
- Create additional opportunities to discuss requirements and ensure a common understanding of quality aspects among all actors involved in the project implementation
- Support the development of the national QI, providing funding e.g. for laboratory infrastructure
- Implement capacity building initiatives and consultancy for regulatory bodies
- Take an active role in national initiatives for the improvement of quality in the PV sector.

Recommendations for PTB

- Support of the national QI development relevant for the PV sector also in other countries
- Increased collaboration with development banks
- Continuous support for coordination and cooperation among key stakeholders for PV development
- Contribution to the implementation of the above recommended actions, e.g. relevant studies, working groups and related activities, through facilitation and knowledge sharing.

1. Introduction

1.1 Background

Increasing the share of renewable energy in the national energy mix ranks high on the political agenda of many governments around the globe. To achieve this objective, funding schemes for renewable energy projects have been put in place to attract investment in the energy sector, often with involvement of national or multilateral development banks.

The ultimate success and sustainability of the investment as well as the achievement of national renewable energy targets depend to a large extent on the quality, performance and safety of the financed energy system, for instance, a solar energy park. Therefore, adequate quality and safety criteria should already be taken into account in the preparation of the project, the tendering and selection process and assured during the project implementation by the responsible financial institutions. However, experience shows that in practice, quality and safety related problems still occur in the installation and operation of renewable energy systems which may affect the financial viability of the investments and may result in safety risks.

In this context, the Physikalisch-Technische Bundesanstalt (PTB) – the National Metrology Institute of Germany – commissioned an independent study on the inclusion of quality and safety criteria in the financing schemes for renewable energy projects of development banks. As implementing organisation of the German Ministry for Economic Cooperation and Development (BMZ), PTB supports developing and emerging economies in the comprehensive field of quality infrastructure. The increasing demand for cooperation in the energy sector among PTB's partner countries has been a driving force to closer explore the relation between funding schemes and quality issues.

1.2 Objective and scope

The study investigates current approaches, possible bottlenecks and lessons learned with respect to quality and safety criteria applied in financing renewable energy projects. The technical focus lies on off-grid and grid-connected photovoltaic (PV) projects in India and Indonesia, including ground mounted as well as rooftop PV plants. An emphasis is put on those criteria which entail the use of quality infrastructure services, i.e. metrology, testing, standardization, certification, accreditation and inspection.

In light of how quality and safety aspects are included nowadays by international financial institutions in the funding process of PV projects, this study aims to provide recommendations on how to improve the incorporation of quality and safety related requirements in the funding schemes for PV projects.

The study addresses primarily international financial institutions, both multi- and bilateral, with a distinct mandate to promote sustainable energy in developing countries, and the international technical cooperation department of PTB. However, the results of the study can also be of interest for national development banks, development agencies, ministries and commercial banks involved in PV-related financing.

The results of this study were discussed in a roundtable event with stakeholders in India and used as input for the Host Country Seminar "Promoting Renewable Energies in Asia – the Quality Challenge" held during the Annual Meeting of the Asian Development Bank (ADB) from 2nd to 5th May, 2016 in Frankfurt, Germany.

1.3 Methodology

This study is of qualitative nature, using a combination of primary and secondary data. First, a comprehensive desk research of the Indian and Indonesian PV markets was carried out. Here, several public reports of international organisations were analysed (e.g. EKONID[2], GIZ[3], IRENA[4], Prayas Energy Group[5], TERI[6] and TÜV Rheinland[7]). Based on these studies a stakeholder map with relevant stakeholders for the study was prepared and adjusted throughout the stakeholder consultation. Stakeholders were classified into three groups according to their importance and into different categories according to their field of action (e.g. financial, government or QI institutions).

Next, the relevant stakeholders identified during the mapping process were contacted and asked to participate in the study as interview partners. 18 semi-structured telephone interviews with international and Indian stakeholders were conducted. Additionally, six interviews with relevant stakeholders in India and 14 interviews with Indonesian stakeholders were carried out in the respective country. The interview questions were mainly open questions grouped into main topics covering financing schemes, quality and safety, and country specific issues. The questions were adapted to the interviewee's background and expertise. After the telephone interviews a summary was prepared and sent to the corresponding interview partner for review. A sample questionnaire can be found in annex 1 and the list of interviewees in annex 2. The information from the interviews was included anonymously in the study. The order of the interviewees in the annex does not correspond to the numbers in the references.

A round table discussion with relevant stakeholders in India was organised, during which the preliminary results of the study were presented and discussed, allowing for confirmation and completion of the India-related results on-site.

Additionally, the final draft of the study was sent to several interviewees for consultation and their comments were integrated in the final version of this study.

We would like to thank all interviewees and participants of the round table discussion for their collaboration and valuable insights.

1.4 Study structure

In the following, chapter 2 provides an overview of the context of this study. The case study countries, funding schemes and relevant actors as well as the quality infrastructure and its connections to the energy value chain are introduced.

In chapter 3 and 4 the findings are presented. Chapter 3 focuses on recurring quality and safety issues in photovoltaic projects and financing risks related to these issues. Chapter 4 looks at development bank approaches to ensure quality and safety in financed PV projects that are currently applied.

Finally, in chapter 5 recommendations are given to increase quality and safety in PV projects. These include general recommendations that are of interest for all actors in the PV sector, as well as specific recommendations for development banks and PTB.

[2] EKONID 2015
[3] GIZ 2014
[4] IRENA 2015
[5] Prayas Energy Group 2014
[6] TERI 2015
[7] TÜV Rheinland 2014 & 2015

2. Context

2.1 Case study countries India and Indonesia

General remark on the case study countries:

India and Indonesia were selected for this study because of ongoing and planned cooperation projects by PTB in the field of PV. The two countries also represent different maturity stages of the PV industry: Indonesia is beginning to further develop the technology and India has already several years of experience and is rapidly expanding its PV capacity. Both, in India and Indonesia important steps for the development of the PV sector and related quality infrastructure services have been made in the last years. Further concrete steps with this regard are planned.

The quality and safety challenges revealed in the study are relevant in countries around the globe and are **not specific to the selected case studies.**

2.1.1 India

General information and policies relevant for PV

With a population of approximately 1.3 billion and a GDP of 2,066 billion US dollars in 2014, India ranks second and fourth worldwide, respectively.[8] In the last six years the country experienced an average GDP growth of 7.2%.[9]

According to the World Energy Outlook 2015, about one fifth of the Indian population had no access to electricity in 2013.[10] Demand for energy continues to increase due to economic and population growth. The energy demand has traditionally been met mainly with fossil fuels which is reflected in the fact that India was the third largest consumer of coal worldwide in 2010.[11]

In order to increase India's renewable energy production, the Jawaharlal Nehru National Solar Mission was launched in 2010. The aim of the mission is to install 100 GW of solar power by 2022, of which 40 GW are planned to be built as grid connected rooftop plants and 60 GW shall be ground mounted. The government has released several policies to support the development of PV, opening the sector for foreign investment and granting income tax benefits and capital subsidies for solar projects.[12] Also the Renewable Purchase Obligation (RPO) that indicates the minimum percentage of renewable energies to be bought by state utilities and other selected institutions, has been revised recently, prescribing a minimum of 10.5% of renewable energy in the institutions' energy mix by 2022.[13]

The regulating organisation of the energy sector is the Central Electricity Authority (CEA) of the Ministry of Power. It issues technical regulations for all energy sources in aspects such as grid connectivity and adherence to the requirements is mandatory. Specific regulations for the PV sector, e.g. on the commissioning of the installations, are yet to be published.[14]

The Ministry for New and Renewable Energy (MNRE) has three specific programmes for supporting PV development: grid connected rooftop and small solar power plants, off-grid and decentralised solar

[8] Tradingeconomics 2016
[9] Statista 2016
[10] IEA 2016
[11] WWF & TERI 2013
[12] TERI 2015, p. 4
[13] TERI 2015, p. 18
[14] Prayas (Energy Group) 2014

application, and a scheme for development of solar parks and ultra mega solar power projects. For those public PV programmes, MNRE provides technical specifications, indicating a number of international standards that have to be adhered to in order to access the programmes and related subsidies.

Two additional government institutions support the development of PV in India. The Indian Renewable Energy Development Agency (IREDA) is a non-banking financial institution that provides loans for PV power plants as well as component production.[15] The Solar Energy Corporation of India Ltd. (SECI) has been established in 2011 to support the implementation of the National Solar Mission.[16]

In tenders for PV projects, a reverse bidding process is applied. This means that the project is assigned to the bidder offering the lowest price for the generated energy, or to the lowest bid for subsidy. For each phase and batch of the National Solar Mission, the specific approach is defined by MNRE.

For projects of the first phase of the National Solar Mission, NVVN (NTPC Vidyut Vyapar Nigam Ltd., the government company responsible for power trading under the National Thermal Power Corporation Ltd.), carried out reverse bidding processes based on the price of electricity for grid connected solar power. For the second phase of the mission, SECI became the nodal agency for solar power projects and for the first batch the Viability Gap Funding (VGF) scheme was introduced. Here, the tariff for power purchase was fixed and projects were supported with a capital grant for the construction phase. Projects to be funded were determined through a reverse bidding process with the lowest bid for capital subsidy being granted the government support.[17] Also Public-Private Partnerships (PPP) in the renewable energy sector was encouraged with this scheme.[18] For the second batch of the second phase, bidders were again selected through a reverse bidding process on price, starting from a lower benchmark than during the previous phase. The third batch of the second phase, initiated in 2015, uses a state specific VGF scheme.[19]

Country specific challenges in the PV sector

Despite the policy support given to PV in India, some challenges remain, slowing down the development of the technology in the country. On the policy level, the fact that each Indian state can implement different policies regulating the PV sector and that procedures differ between different states increases the difficulties for investors and other actors in gaining a full understanding of the country situation.[20] Furthermore, it was mentioned in the interviews that technical specifications set on the central level are not always implemented on the state level, which reduces the usefulness and efficiency of existing tools for quality assurance.[21]

Generally, the achievement of the target set for 2020 puts considerable time pressure as PV capacity needs to be developed fast. This is felt on the ministerial level, in public institutions involved and is transmitted to developers and EPCs that are expected to deliver within short deadlines. The rapid development pace results in shortages of skilled labour at all levels and due to time pressure and lacking expertise quality and safety might suffer.[22]

Additionally, prices are held very low in the sector, a tendency that is reinforced with the reverse bidding process. Raising enough equity is challenging and the structure of available loans needs to be adapted to

[15] Interview 29
[16] Interview 30
[17] Interview 33
[18] Department of Economic Affairs 2008
[19] MNRE 2015a
[20] TERI 2015, p.24
[21] Interview 16
[22] Interviews 31, 32

the low cost requirements in the sector.[23] Local players cannot always keep up with international competitors in bidding processes, especially for big projects.[24]

Moreover, gaps in the permit procedure for PV projects can be observed. The period to get the permit for a project is uncertain due to the involvement of several ministries with varying delays in processing.[25]

A further challenge for PV in India lies in the grid integration of PV generated power. Currently, the grid is unreliable and often gets cut off in low voltage level. This mainly affects the output of rooftop PV plants connected to low-voltage feeders, as it impedes feeding electricity to the grid during outage periods.[26] Flexibility of the grid is necessary to include renewable energy in the best way when it is available.[27]

In some cases, in addition to the PV plant also grid infrastructure is still missing and needs to be developed.[28] Some states are providing land for large-scale PV projects and take care of the connection to the grid to ease these problems.[29]

2.1.2 Indonesia

General information and policies relevant for PV

Indonesia has over 14,000 islands and is the largest island country in the world. Its population of over 255 million makes it the world's fourth most populous country. The economic situation can be described as strong, with an average GDP growth rate of over 5% from 2000 to 2015.[30] The economic growth is to a great extent carbon intense, which is reflected in the fact that Indonesia is the world's tenth largest greenhouse gas emitter.[31] The country has an upcoming middle class of about 74 million people who will generate an estimated increase of demand for electricity of over 7% per year.[32]

Already now Indonesia is struggling to provide electricity for its needs and the percentage of Indonesian households connected to the nation's electricity grid was about 88% in 2015.[33] Great discrepancies can be seen between different locations with Jakarta being nearly entirely electrified and parts of Papua lacking electricity for more than half of the population.[34]

In order to reduce the fossil fuel consumption and CO_2 emissions, advance electrification and re-establish Indonesia's energy independence, the Government of Indonesia is planning to increase the share of renewable energies in the energy mix to 23% by 2025 through the National Energy Policy (Government Regulation No. 79/2014).[35]

Efforts were made by the Indonesian government to improve the policy framework for investments in the area of renewable energies. Ministerial Regulation No. 4/2012, for example, obliges PLN, the state-owned electricity company with a monopoly on electricity sales, to purchase renewable energy generated by facilities between one and 10 MW capacity. Furthermore, for most renewable energy sources feed-in-tariffs were introduced that establish a fixed rate at which produced electricity will be bought. Also for solar PV an

[23] Interview 13
[24] Interview 12
[25] Interview 26
[26] Interview 11
[27] Interview 12
[28] Interview 13
[29] Interview 26
[30] Tradingeconomics 2015
[31] Wolff et al. 2015
[32] PWC 2013, p.5
[33] Interview 18
[34] Interview 25
[35] IEA 2015

attempt was made with MEMR Regulation 17/2013 that established a standard procedure for tendering processes for PV projects and set a ceiling feed-in-tariff for PV energy.[36] However, this regulation has been under revision and is being replaced by MEMR Regulation 19/2016 in August 2016. Also a feed-in-tariff for rooftop PV is still under preparation.[37] This has led to the sector being without supporting policies for an extended period of time and has slowed down the development of the PV sector in the country.

Although PPPs are generally encouraged for infrastructure development projects, this structure is not yet relevant for PV as the general policy framework still needs to be improved and experience in the sector needs to be gained beforehand.[38]

Country specific challenges in the PV sector

In Indonesia, the missing policy framework and political coherence are the strongest obstacles for the development of PV.[39] Currently, PLN is the only institution able to assign new PV projects by direct assignment without the need to prepare a tendering process.[40] However, the price of energy production from other sources, mainly coal, is much lower than the production price of PV, which makes it less interesting for PLN to assign such projects. Additionally, the subsidy framework of Indonesia and the involvement of several ministries and offices make it particularly difficult to establish a coherent framework in the country that effectively supports renewable energies in general and PV in particular.[41]

Furthermore, a tendency to assign projects to state-owned enterprises in the sector is present, discouraging private actors and reducing the possibility to compete on higher quality.[42]

Another issue is that local commercial banks are reluctant to finance PV projects in Indonesia. This is due to high risk, poor quality of submitted feasibility studies and negative experiences in previous investments in renewable energy projects, such as frequent cost-overruns and business interruptions.[43]

[36] Devine et al. 2015
[37] Interview 18
[38] Interview 24
[39] Interviews 10, 19, 24
[40] Interviews 17, 18
[41] Interview 21
[42] Interview 17
[43] Wolff et al. 2015, pp. 24-28 & Interview 10

2.2 Financing of PV systems: Stakeholders and funding schemes

2.2.1 Key stakeholders in PV financing

Figure 1 shows the most important groups of actors that are usually involved in development bank financed PV projects.

Table 1 Key actors in development bank financed PV projects

Actor group	**International financial institution**	**Project executing agency**	**System operator**	**Consultant**
Description	Multi- and bi-lateral development banks with a distinct mandate to promote sustainable energy in developing countries.	Ministries, state banks, state-owned electricity companies or private actors.	Project developers and EPC contractors.	Specialised external consultants and engineers.
Role	Provide funding for the PV project.	Are the local partners of development banks, responsible for the implementation of the PV project	Construct and operate the PV plant.	Are contracted by one of the previously described actors to monitor and/or support the project implementation.

Table 1 © Physikalisch-Technische Bundesanstalt

The stakeholders consulted for this study are listed in the following table.

Table 2 Key stakeholders of the study

Type	**Organisation**	**Description**
International		
Multilateral Financial Institution	ADB	The Asian Development Bank (ADB) promotes social and economic development in Asia by providing loans, technical assistance, subsidies, and equity investments.
Bilateral Financial Institution	KfW	The KfW (Kreditanstalt für Wiederaufbau) is a development bank owned by the German state. It supports the German government in reaching its development goals.
Multilateral Financial Institution	World Bank Group	The World Bank is the largest multinational development bank worldwide and its main goal is to reduce poverty worldwide.
International Organisation	IRENA	The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future.
QI Institution	TÜV Rheinland	TÜV Rheinland is a leading international technical service provider.
India		
Multilateral Financial Institution	ADB India	The Asian Development Bank (ADB) promotes social and economic development in Asia by providing loans, technical assistance, subsidies, and equity investments.
Bilateral Financial Institution	KfW India	The KfW (Kreditanstalt für Wiederaufbau) is a development bank owned by the German state. It supports the German government in reaching its development goals.
Multilateral Financial	World Bank India	The World Bank is the largest multinational development bank worldwide and its

Institution		main goal is to reduce poverty worldwide.
Government Institution	MNRE	The Ministry of New and Renewable Energy (MNRE) is primarily responsible for development, protection, international cooperation, and coordination of renewable energy sources.
Government Institution	IREDA	India Renewable Energy Development Agency (IREDA) is a non-banking-financial institution engaged in renewable energy projects.
Government Institution	SECI	The Solar Energy Corporation of India Ltd. (SECI) is responsible for the implementation of several MNRE schemes that support the development of solar power in India.
Research Institute	TERI	The Energy and Research Institute (TERI) conducts research in the field of energy with the goal of fostering sustainable development.
International Development Organisation	GIZ India	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is an experienced service provider for sustainable development and supports the German Government in achieving its goals in the field of international cooperation.
QI Institution	NISE	The National Institute for Solar Energy (NISE) conducts research and development activities in the field of solar energy under MNRE.
QI Institution	BIS	The Bureau of Indian Standards (BIS) is the national standards body of India.
QI Institution	NPL	The National Physical Laboratory (NPL) is the national metrology institute of India.
EPC	L&T	Larsen & Toubro (L&T) is a major technology, engineering, construction, manufacturing and financial services conglomerate, with global operations, involved in EPC for PV installations in India.
Developer	First Solar	First Solar India Ltd. provides comprehensive solutions in the PV sector.
Developer / EPC	ACME Solar	ACME Solar offers development, construction and operation services for solar PV and solar thermal projects.
Indonesia		
Bilateral Financial Institution	KfW and DEG Indonesia	The KfW (Kreditanstalt für Wiederaufbau), with its subsidiary DEG, is a development bank owned by the German state. It supports the German government in reaching its development goals.
Multilateral Financial Institution	IFC Indonesia	The International Finance Corporation (IFC) is part of the World Bank Group, and the world's largest global development institution focused on the private sector.
Government Institution	EBTKE	The Directorate General for New and Renewable Energies and Energy Conservation (EBTKE) was set up as a focal point for renewable energy in Indonesia.
Government Institution	BKPM	BKPM is the Investment Coordinating Board of the Republic of Indonesia.
State-owned enterprise	PLN	PLN is Indonesia's largest power utility company.
Financial Institution	PT Sarana Multi Infrastruktur	PT Sarana Multi Infrastruktur (PT SMI) is a state-owned enterprise established for financing infrastructure.
Financial Institution	IIGF	Indonesia Infrastructure Guarantee Fund (IIGF) provides a framework to attract private investment and participation of a measurable scale in infrastructure projects.
International Development Organisation	ASEAN RESP	The Renewable Energy Support Programme for the Association of Southeast Asian Nations (ASEAN RESP) is carried out by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the ASEAN Centre for Energy.
International Development Organisation	EnDev (GIZ)	Energising Development (EnDev) is an energy access partnership currently financed by six donor countries that promotes sustainable access to modern energy services that meet the needs of the poor.
NGO	YBUL	Yayasan Bina Usaha Lingkunga (YBUL) promotes community-based renewable energy development through collaborations and innovative solutions.
NGO	METI	The Indonesian Renewable Energy Society (METI) is a communication, consultancy and cooperation forum among renewable energy practitioners.
QI Institution	SUCOFINDO	SUCOFINDO is a state-owned enterprise that offers a variety of quality assurance services.

Table 2: © Physikalisch-Technische Bundesanstalt

2.2.2 Funding schemes applied in PV projects by development banks

Based on interviews with several representatives of ADB, KfW and the World Bank, it can be said that multi- and bilateral development banks have similar approaches in financing PV projects. Funding can be carried out directly, in a refinancing approach or through a Private-Public-Partnership (PPP). For direct financing, a distinction between private and public funding can be made. In the following the different approaches are explained in general terms. A detailed description of public and private direct financing models applied by

KfW, as an example for development bank funding, as well as the case of IREDA as a national development agency can be found in the annex.

In the direct public funding approach, which is represented in figure 1, the development bank collaborates with a public institution that acts as project executing agency in the target country. This can be state-owned power utilities like NTPC or MAHAGENCO in India, for example, or the state-owned electricity company PLN in Indonesia. The loan agreement is signed between the development bank and the national government. The tender process is carried out by the project executing agency or by the local state government (in India). The development bank can influence which criteria are listed in the tender documents. Inclusion and scope of the integrated criteria in the tenders as well as in contracts vary between the banks and between projects. For quality assurance throughout the implementation of a project, an implementation consultant or lender's engineer is engaged to follow the project. An external consultant is sometimes also contracted for conducting the feasibility study that is used as a basis for the project. The EPC contractor is generally selected by the project executing agency. Usually the funds are transferred directly from the development bank to the EPC carrying out the project.

Figure 1 Direct financing - public funding approach

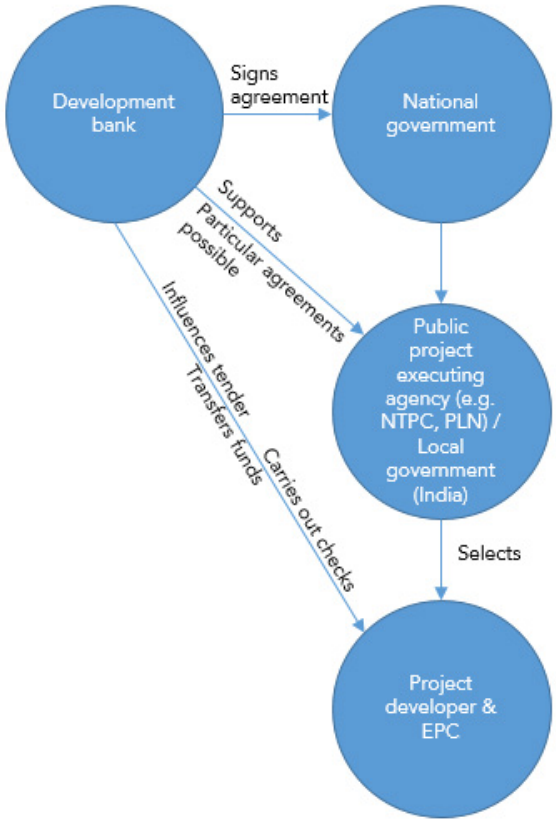

Figure 1: © Physikalisch-Technische Bundesanstalt

For private funding each international financial institution has a separate subsidiary or department. For KfW these are the Deutsche Investitions- und Entwicklungsgesellschaft (DEG) as well as the IPEX-Bank that is in charge of international project and export finance. The International Finance Corporation (IFC) carries out investments in the private sector for the World Bank group. ADB, on the other hand, has an internal department for private financing. These entities can grant loans to private institutions, including banks as well as other private actors in a business-to-business approach; no public partner is required (figure 2). For projects financed by these entities, a due diligence is performed to assess the risk and determine the financial viability of the borrower and/or project. For the technical aspects it is common to involve international consultants and/or expert engineers who support the project developer in the compilation of necessary documents as well as in the construction phase. Also environmental and social risks are taken into consideration systematically. The private institution receiving the loan selects the project developer and EPC.

Figure 2 Direct financing - private funding approach

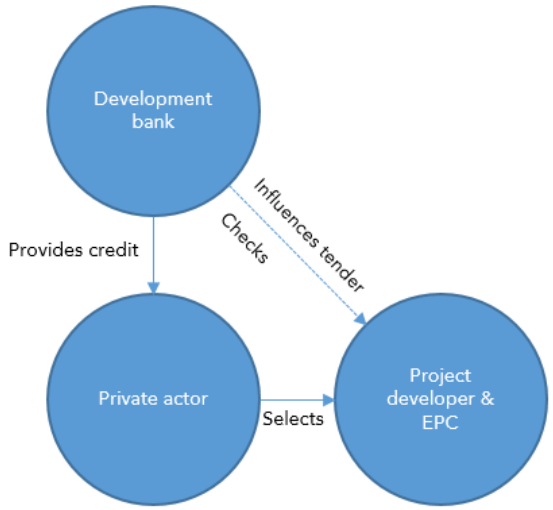

Figure 2: © Physikalisch-Technische Bundesanstalt

Figure 3 Refinancing of PV projects

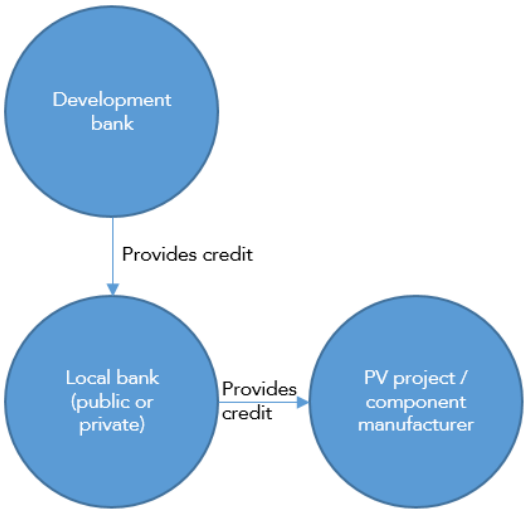

Figure 3: © Physikalisch-Technische Bundesanstalt

An additional approach is the refinancing of projects that are supported by a local bank. This approach can include national or commercial banks, whereby the loan is given to the local financial institution that lends it on to private actors for the implementation of PV projects or for the production of PV components, as depicted in figure 3. General criteria for project selection are agreed upon between the development bank and the local financial institution.

In some cases, projects are carried out in the form of Public-Private-Partnerships (PPP), where a separate entity, a so-called special purpose vehicle (SPV), is created to implement and own the project. This approach is used by ADB in India, for example, where the development bank finances the infrastructure for solar parks and focuses mainly on transmission and grid evacuation, while a private entity is in charge of the PV installation and energy production.[44] Figure 4 shows the relationship between the different actors: the development bank signs an agreement with the national government. The local government institution (that acts as project executing agency) and a private actor create a SPV for the implementation of the project. The public institution concedes the right to provide a public service to the private actor, who in turn brings the financial input and holds most or all of the equity of the created entity.[45]

[44] Interview 12
[45] Department of Economic Affairs 2015, p.8

Figure 4 Funding in PPP structure

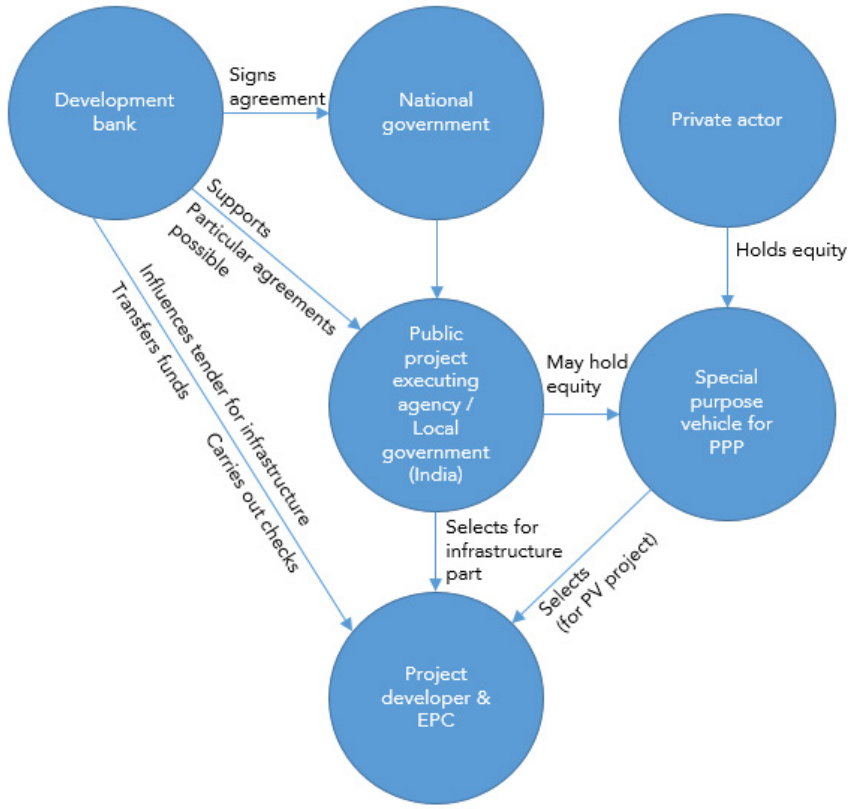

Figure 4: © Physikalisch-Technische Bundesanstalt

2.3 Quality infrastructure and the photovoltaic value chain

The national QI, as illustrated in figure 5, comprises metrology, standardization, conformity assessment - including testing, inspection and certification - and accreditation. It is an interrelated system, in which no component can be developed without developing the others as they complement each other. Key entities of the system are the National Metrology Institute, the National Standards Body, the National Accreditation Body as well as conformity assessment bodies.

QI services are important throughout the value chain, from the manufacturing of components to electricity consumption. Only with the necessary QI services in place, it can be assured that the technology and installation have the necessary quality level, so that the expected amount of energy can be safely produced and consumed. This is particularly relevant in cases where a country plans to set-up own manufacturing capacities for renewable energy systems, but also to monitor the quality of imported products or services.

The national QI should not be developed in an isolated way, but linked to the international system by establishing the respective relations, e.g. to ISO and IEC for standardization or the International Office for Weights and Measures (BIPM) for metrology. Only in this way it is possible to ensure international traceability, comparability and recognition of the local services and to benefit fully from the national QI. Also the national policy framework and relevant public institutions are to be seen as a part of the QI as they establish the framework for the different servic

Figure 5 Funding in PPP structure

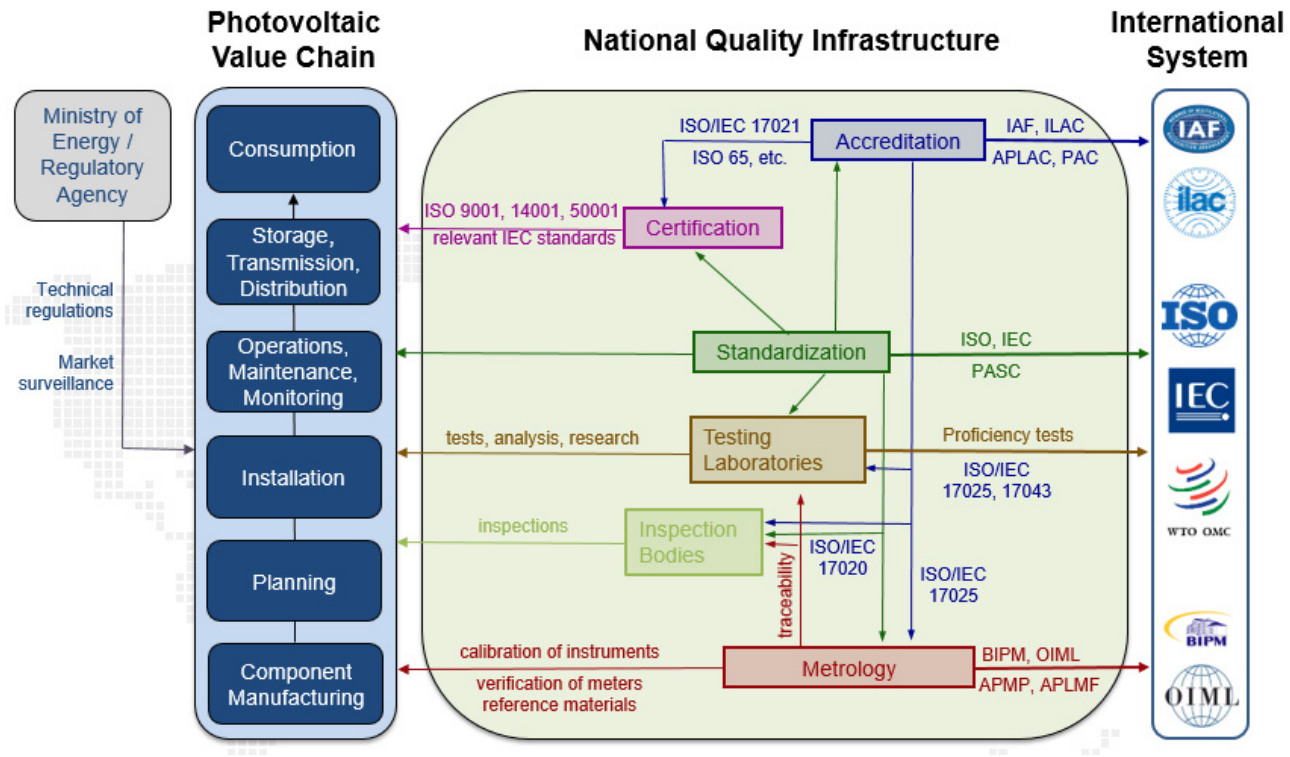

Figure 5: © Physikalisch-Technische Bundesanstalt

3. Quality issues, safety issues and related risks for financing

3.1 Overview of quality and safety issues and related financing risks

A limited amount of data on the performance and related problems occurring in PV systems is available, partly because system operators and component manufacturers often prefer not to disclose such information.[46] Nevertheless, industry experts recognise that quality and safety issues that lead to performance losses and safety risks in the PV sector persist. This was confirmed in a recent study by TÜV Rheinland that found nearly one third of over 100 PV plants worldwide had serious defects.[47] In an earlier study by Photon, experts estimated that over 70% of PV systems in Germany had flaws.[48] Table 3 summarises the main issues found in PV plants, according to stakeholders interviewed for this study and recent studies, including TÜV Rheinland's yearly quality monitor,[49] EKONID's target market analysis,[50] and publications by IRENA[51] and TERI[52].

[46] Solar Bankability 2016
[47] TÜV Rheinland 2015, p.6
[48] Photon 2013
[49] TÜV Rheinland 2014 & 2015
[50] EKONID 2015
[51] IRENA 2015

Overview of quality and safety problems and resulting risks in PV financing

Table 3 Quality infrastructure and the photovoltaic value chain

Value Chain	Quality issues	Related risks	Examples of QI services that can reduce existing risks
Operations, maintenance and monitoring	Insufficient cleaning or cleaning instructions.	Reduced performance of the plant.	Creation of procedures and implementation of management systems according to international best practices.
	Lacking monitoring impeding the detection of underperformance and the collection of comprehensive performance data.	Persistent uncertainty about performance of PV systems.	Reliable testing of plant performance. Calibration of performance measurement devices, e.g. electricity meters.
Installation and commissioning	Lack of experience of installers resulting in installation errors.	Can result in reduced performance, slower payback, reduced return on investment, risk of fire, increased maintenance costs.	Training and certification of installers. Adoption and application of relevant international standards, e.g. for technical installation. Application of inspection and commissioning schemes according to international best practices.
	Poor system documentation.	Higher costs due to inefficiency and possible quality gaps.	Adoption and application of relevant international standards.
Planning	Lack of reliable irradiation data.	Uncertainty due to poor data as basis and resulting incorrect yield estimations.	Calibration of environmental testing equipment, e.g. pyranometres for solar irradiation measurements.
	Lack of experience and knowledge of the relevant service providers (may lead to e.g. uncertainty about reliability of feasibility studies, lacking consideration of relevant information or omission of necessary planning procedures like structural integrity calculations).	Possible mistakes in the project planning leading to reduced performance and wrong estimations.	Training and awareness raising on the consideration of quality criteria in the planning phase.
Manufacturing and transport of components	Lower quality of domestic products compared to imported products and difficulty of quality assurance locally.	When local content requirements are in place, it may be challenging to ensure a good level of quality with locally produced components.	Testing of components, e.g. module performance. Accreditation of conformity assessment services, e.g. module and inverter testing. Calibration of reference cells.
	Limited industry and technology experience.	Varying quality and reliability of the components. High uncertainty due to reduced reliability of testing mechanisms and missing procedures. Possible underestimation of durability risk.	Application of international standards for PV components. Application of accredited and internationally recognized certification schemes.
	Not all international standards are up to date and sufficiently adapted to the specific local requirements (e.g. climatic conditions).	Insufficient information about the longevity and performance of PV modules under local conditions.	Availability of additional testing services. Adaptation of international standards to local conditions, e.g. climate conditions.
	Transportation damage: micro cracks and resulting performance loss.	Possible performance loss and difficulty of assigning responsibility.	Reliable and locally available testing services.

Table 3: © Physikalisch-Technische Bundesanstalt

[52] TERI 2015 & 2016

A recent study carried out as part of the Solar Bankability project of the European Union calculated which component issues have the biggest financial impact. The following table shows the Cost Priority Numbers (CPN) that indicate the highest risks for PV modules and inverters. Listed aspects refer to component quality directly, as well as to the quality of installation and operations and maintenance, as will be discussed more in detail in the following parts of this chapter. As the table shows, installation errors have the highest impact in terms of costs. To avoid failures like glass breakage, PID (Potential Induced Degradation), snail tracks or damaged backsheets, module quality and careful handling need to be assured

Table 4 Cost Priority Numbers (CPN) for PV modules and inverters[53]

Failures PV modules	CPN per year (€/kWp)
Improperly installed	15.45
Glass breakage	10.10
PID (Potential Induced Degradation)	7.75
Snail track	6.48
Defective backsheet	4.43
Delamination	3.59
Hotspot	2.98
Soiling	2.87
Shading	2.02
Broken module	1.65
Failure bypass diode and junction box	1.62
Overheating junction box	1.50
Corrosion of cell connectors	1.10

Failures inverters	CPN per year (€/kWp)
Wrong installation	2.43
Fan failure and overheating	1.78
Inverter not operating	0.88
Burned supply cable and / or socket	0.78
Error message	0.23
Switch failure / damage	0.20
DC entry fuse failure	0.20
Fault due to grounding issues	0.19
Polluted air filter	0.15
Wrong connection	0.15
Inverter theft or vandalism	0.12
Inverter pollution	0.03
Inverter wrongly sized	0.01

Table 4: © Physikalisch-Technische Bundesanstalt

3.2 Manufacturing and transport of components

PV components manufactured in developing economies are not always able to meet international quality standards, making it challenging to support the local market while at the same time ensuring the use of high quality products in PV projects by setting requirements accordingly.[54]

Some stakeholders mentioned that in India overall quality of PV components remains lower than for internationally available products.[55] One interviewee highlighted that the quality of PV modules of bigger Indian producers, who can control the entire value chain from raw material to end product is similar to imports while especially smaller producers of PV modules are still struggling to achieve high quality end products. Also the production of combiner boxes that gather the output of several strings of PV modules for connection to the inverter still shows some shortcomings in India.[56] The domestic content requirement of India's National Solar Mission prescribes the use of locally manufactured modules and cells for 375 MW, or half of the capacity installed in the first batch of Phase II.[57] This might increase the challenge for quality

[53] Solar Bankability 2016 p.61, 63
[54] Interview 5
[55] Interviews 5, 6
[56] Interview 8
[57] mondaq Ltd. 2014

assurance in these PV projects and, according to the World Trade Organisation (WTO), is against international trade agreements.[58] An additional challenge in the Indian context is the rapid expansion of the solar sector that is taking place, making it difficult for the supply side to keep up with the increasing demand for PV components.[59]

Similarly, local PV components from Indonesia also struggle to meet the quality level of imported products.[60] This is particularly critical as several laws mandate the maximization of Indonesian products in the sector (Law No. 30 of 2007 on Energy, Law No. 30 of 2009 on Electricity and Law No. 3 of 2014 on Industry)[61] and a recent court ruling classifies domestic products as equivalent in quality to foreign competitor products.[62] For financing PV plants in Indonesia, the quality risk is thus important.

Another issue is component damage during transport. This is especially relevant for PV modules where rough transport conditions can cause micro-cracks that can considerably lower the performance of the modules. Here, an additional risk arises through the difficulty of assigning responsibility for the damage if tests are not conducted at arrival of the modules.[63]

The existing international standards for the PV sector are not always sufficiently adapted to specific local conditions (e.g. impacts of dust and salt) and the development of new standards is relatively slow. Some stakeholders mentioned for example, the IEC Standard 61215, a minimum standard which specifies certain characteristics of crystalline modules, such as the design. Tests can be conducted to check the compliance with this standard, but they give insufficient information about the longevity of the module. The module can thus meet the standard, but this does not guarantee good long-term performance. A similar problem applies to thin-film modules for the IEC standard 61646. This exposes investors to greater risk, as the uncertainty related to component durability may be underestimated.[64]

A further challenge in countries with a relatively new PV sector is the limited practical industry experience that can only be developed over time. Processes for quality assurance still need to be established in many cases and testing mechanisms need to be adapted to local conditions. Awareness of all the variables that play a role in different tests, such as the impacts of different temperatures and humidity levels, is necessary yet often still in need of development. This can result in premature judgements about component quality.[65] A lack of reliability of testing mechanisms results in uncertainty about component quality and consequently in risks for financing PV plants.

3.3 Planning

The planning phase of a PV project is crucial for quality assurance as the planning determines the later performance of the plant. A diverse set of issues arise here that can be linked to the lack of knowledge and experience by different actors in PV markets that have recently started to develop.[66] A survey conducted among approximately 250 solar project developers in India found that over 60% of respondents experienced a lack of skilled labour, with a quarter of them facing problems in finding skilled PV system designers.[67] This

[58] PV magazine 2016
[59] Interview 32
[60] Interviews 17, 21, 23, 24
[61] Devine et al. 2015
[62] Interview 21
[63] TÜV Rheinland 2014, p. 16
[64] Interviews 1, 3
[65] Interview 1
[66] Interviews 4, 5
[67] TERI 2016, p. 66

challenge is further increasing, as PV capacity is expanded rapidly and not enough skilled labour is available to meet the increasing demand.[68]

A major issue for successful planning is a lack of reliable solar irradiation data. Experts quoted that this is a current problem in Asia.[69] Often projects are based on estimations and imprecise satellite data which lead to incorrect predictions.[70] While in India the Solar Radiation Resource Assessment (SRRA) has allowed to collect reliable irradiation data for the whole country during four years[71], in Indonesia projects are mainly based on satellite data[72], where the margin of uncertainty remains higher. In both countries awareness about the need for high quality data is still relatively low, which creates the additional problem that demand for such information remains low and PV projects are often designed with erroneous calculations as a basis.

The limited experience of project developers and in some cases of external consultants can give rise to a number of problems. Competent planning has to take into consideration a large number of details concerning the location as well as the technology and follow established procedures to assure that all important aspects are covered. External factors that need to be considered are for example shading, wind, and seismic information about the area as well as building and rooftop conditions.[73] In terms of technology, choosing a module type that is suitable for the local climate is crucial. Also the choice of the correct inverter type is important, as an unsuitable inverter can increase the risk of fire, e.g. due to overheating.[74] Some developers and Engineering, Procurement and Construction (EPC) contractors do not have the needed skills and experience to conduct a comprehensive site assessment and to consider all the details in site design. While large companies do have in-house experts, smaller firms might struggle.[75] Also knowledge about local and national permit requirements and procedures to obtain them is crucial.[76]

Poor planning can result in complications in the installation as well as during operations and maintenance. It can impede correct functioning and reduce plant performance. In many cases, specific local conditions or long-term environmental influences are not taken into consideration.[77] The poor quality of documents, such as feasibility studies for PV projects, is often the reason for project failure in Indonesia.[78]

An additional issue is the still developing knowledge of investors and banks about the PV sector, which makes it difficult for them to assess the risk of PV projects and to influence their quality by integrating specific requirements into financing agreements. These results in a reluctance to invest in the sector and when investments are made quality decisions for the project are often left to the developer and/or EPC contractor. Depending on the EPC's experience and on the contract conditions the tendency might be to choose immediate financial savings over quality.[79] The challenge lies thus in selecting the right EPC with a clear understanding of quality needs and the willingness to implement a high quality project despite possible time and cost constraints.[80] Tight timelines set in contracts and cost constraints due to the reverse bidding process, with which projects are assigned to the bidder with the lowest price, put pressure on project quality.[81]

[68] Interviews 31, 32
[69] Interview 3, EBTKE 2015, p. 5 & EKONID 2015, p. 51
[70] Interview 11 & TERI 2015, p. 23
[71] Interview 11
[72] Interview 18
[73] Interview 8
[74] Interview 31
[75] Interviews 8, 31
[76] PI Berlin AG 2016
[77] Interview 1
[78] Interview 10 & Wolff et al. 2015, p. 33
[79] Interview 1
[80] Interview 28
[81] Interview 31

3.4 Installation and commissioning

During installation, the most issues occurring in PV plants are due to a lack of experience and training of installers[82] as well as a lack of clear instructions and monitoring of the installation. A study by TÜV Rheinland from 2015 demonstrated that 30% of over 100 considered PV plants worldwide had serious defects, more than half of which were caused by installation faults.[83] The exact issues arising in the installation phase vary. Common mistakes are loose screws or contacts and wrongly or poorly plugged connectors, which can result in a higher risk of fire especially in the case of rooftop PV.[84]

The quality of electrical installations shows gaps and is not always up to international standards. Defects related to the cabling system are common.[85] A study about off-grid installations in Indonesia showed that workmanship issues occurred most often in electrical connections and wiring.[86] Inverter issues might arise where the PV plant is coupled with a diesel generator that is not well maintained.[87] Furthermore, system documentation and labelling is often insufficient during installation, making maintenance and repairs more difficult.

Installation problems should be noticed during inspections and commissioning of the plant. However, set procedures for inspections and commissioning as well as strict qualification requirements for the person in charge of the process are often missing. Therefore, commissioning is carried out based on varying criteria and problems arise when the people in charge lack expertise and experience, possibly neglecting important aspects during the process.[88]

The quality of installation is directly related to the performance and safety of the PV system. A lack thereof can thus lead to safety risks, reduced performance and reduced return on investment.

3.5 Operations, maintenance and monitoring

Several interview partners stated that correct maintenance is currently an issue in PV plants installed in India and Indonesia.[89] The most frequent issue encountered during operations and maintenance (O&M) in India is related to the cleaning of PV panels. As clear instructions are often missing or fail to consider specific local conditions, the accumulation of pollution and dust on solar panels, referred to as soiling, may reduce the performance of PV plants.[90] In arid regions, up to a quarter of the energy yield can be lost.[91] A GIZ study revealed that unequal performance of PV plants in India is common. Amongst other, this can be explained by a lack of focus on monitoring and corresponding maintenance.[92] Moreover, inverter failure was identified as a recurring issue that causes system break-down.[93]

In Indonesia the main problems occur in the O&M phase. O&M is both technically and financially challenging for the local actors, especially in remote areas. Often the system is not maintained correctly or problems arise and cannot be fixed. For off-grid installations a common problem is that batteries are misused, which drastically reduces their lifespan. Replacing a battery is too expensive for the local community and the plant is left to decay.[94] In some cases monitoring systems do not work or it is not clear

[82] IRENA 2015, p. 25
[83] TÜV Rheinland 2015, p. 6
[84] Interviews 3, 31
[85] TÜV Rheinland 2015, Photon 2013
[86] GIZ EnDev Indonesia 2014
[87] Interview 8
[88] Interview 3
[89] Interviews 8, 14
[90] Interviews 8, 11
[91] Solar Bankability 2016
[92] Interview 11
[93] TERI 2016, pp. 64-65
[94] Interview 19

who is responsible for maintenance. GIZ has been active in capacity building for local communities for its Energising Development (EnDev) project.[95]

The gaps in monitoring in both countries can cause a delayed detection of performance losses as well as a lack of comprehensive data on the power generation of PV power plants, thus resulting in persistent uncertainty about the performance of PV systems.

Quality lacks in operations and maintenance bear financial risks because they reduce the safety of the PV plant as well as its performance. Therefore, also in this phase energy production and return on investment can be negatively affected.

3.6 Quality infrastructure and awareness

Several interview partners mentioned a lack of awareness about the need for higher quality and safety in the PV sector on the part of the financial sector, policy makers, public administration and end users.[96] Solar PV is often perceived as a comparatively easy technology and therefore quality and safety assurance might be given too little consideration.[97] Also within solar operations, a lack of quality awareness amongst involved parties can often be noted: developers and EPC contractors with a short-term involvement in PV projects or with an intention to exit the project early, show less inclination towards proactively prosecuting higher quality and safety standards. This is however slowly changing, as quality awareness is increasing. [98]

International standards and certifications are often listed as quality and safety criteria for photovoltaic projects. However, the national QI might not yet offer all internationally recognized services needed to assure compliance with these standards and the local industry might not be able to fulfil international standards in some areas. The QI in a country has to be developed hand in hand with the market and considering the specific national conditions, rather than copy-pasting schemes from one country to another.[99]

As long as the national QI does not offer all internationally recognised services needed, the local industry has two options: either, local services are used despite their limited recognition or services have to be purchased abroad. The first option might result in a lack of confidence in the quality and safety of local products. This is particularly problematic in a market like the one for PV where components are produced and traded internationally, as it represents a disadvantage for the local industry compared with international competitors and might impede the international success of local producers. The second option, on the other hand, results in higher costs and longer waiting times, as products have to be shipped to neighbouring countries for testing, for example.

Opportunities for further development of the local QI in Indonesia and India exist. Improvements are possible in the establishment of reliable metrological services for PV cell calibration for example, the adoption or adaptation of all relevant international standards by the national standardization body, the development of effective inspection and certification schemes, and availability of all relevant accredited testing services.

In the area of testing services, for example, in India the laboratory capacity is not sufficient to comply with the market demand. For instance, testing services for bigger inverters are lacking. In Indonesia, testing services are not further developed, as demand is lacking.

[95] Interview 17
[96] Interviews 1, 8, 10
[97] Interview 28
[98] Interviews 1, 31
[99] Interview 4, IRENA 2015 p. 23

4. Quality and safety assurance in development bank funding

4.1 Quality and safety assurance in different funding schemes

In the direct financing approach of both public and private projects, the development banks have a stronger influence on quality and safety criteria of a project. Checks are carried out from the beginning of the project and project specific agreements allow discussing and including technical requirements that can go beyond international standards. In the refinancing approach, on the other hand, control of specific projects is limited as they can be at different stages of development when the loan is granted and the often reduced size of individual projects creates challenges for individual project follow-up.

Some interviewees suggested that quality and safety awareness increase with a PPP structure, due to equity ownership by the engaged private party.[100] Additionally, the involvement of the government might lead to a stricter implementation of quality and safety requirements.[101] For the development bank the influence on quality and safety remains the same, whereby it only covers the public project part for which development bank financing is provided.

Development banks can define quality criteria in guidelines; they can include quality and safety aspects in financing agreements and require the inclusion of related requirements in calls for tenders for projects that receive funding. These documents are directed at and agreed upon with distinct actors in the financing process, as shown at the example of direct public financing in the figure below. The following sections (4.2, 4.3 and 4.4) describe how quality and safety criteria are currently included in the different documents.

Figure 6 Relevant documents for quality and safety assurance in the direct public financing approach

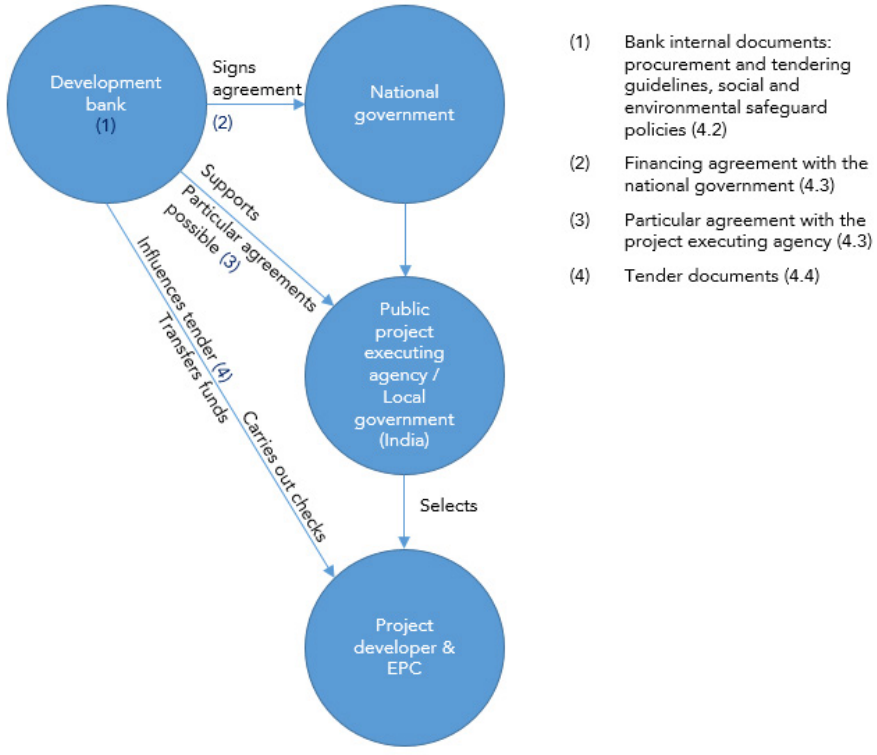

Figure 6: © Physikalisch-Technische Bundesanstalt

[100] Interviews 10, 28
[101] Interview 28

4.2 Quality and safety criteria considered in the procurement and tendering guidelines of development banks

The development banks involved in this study have general procurement guidelines and additional tools such as guidelines for sustainable procurement and tendering that are already available at KfW (Toolbox Sustainable Procurement)[102] and are being finalised by the World Bank. Also safeguard policies for environmental and social aspects have been developed. Those existing guidelines are referred to in the financing agreements on government level and have to be considered in the project implementation by all parties involved, i.e. the project executing agency as well as the developer and EPC. The guidelines mention quality and safety aspects very generally. An example is the following passage of ADB's procurement guidelines[103] about standards:

"*Standards and technical specifications quoted in bidding documents shall promote the broadest possible competition, while assuring the critical performance or other requirements for the goods and/or works under procurement. As far as possible, the borrower shall specify internationally accepted standards such as those issued by the International Standards Organization with which the equipment or materials or workmanship shall comply. Where such international standards are unavailable or are inappropriate, national standards may be specified. In all cases, the bidding documents shall state that equipment, material, or workmanship meeting other standards, which must specify substantial equivalence, will also be accepted.*"

However, so far, none of the institutions has a specific guideline to ensure quality and safety in PV that is publicly accessible. Internal documents that support project staff in this sector exist for KfW and are under development for the World Bank.[104]

This means that currently, only general quality and safety aspects that are part of the procurement and social guidelines mentioned above are covered comprehensively while for PV specific quality and safety aspects, the inclusion and evaluation is based on internal guidelines and the individual knowledge of internal or external experts engaged in each project. Therefore, evaluation criteria may vary from project to project.

4.3 Quality and safety criteria considered in the financing agreements between international financial institutions and partners

Financing agreements are signed between the development bank and the national government of the country where projects are carried out. The local project executing agencies of development bank projects are in most cases government institutions in the respective country, which are responsible for the implementation of PV projects or for on-lending. Usually, the financing agreements do not include specifications regarding quality and safety. They do, however, make reference to the development banks' procurement guidelines and additional policies that were already mentioned.

Regarding agreements with the project executing agency, KfW for example, signs additional particular agreements for each project. Here quality criteria are included mainly in the form of standards, testing and certification requirements. Requirements can also exceed international standards when deemed necessary. In selected cases, KfW also stipulates the engagement of an external expert in engineering who follows the project throughout the process or for punctual checks.[105]

[102] KfW 2014
[103] ADB 2015, p.17
[104] Interviews 1, 6
[105] Interview 1

4.4 Quality and safety criteria included in calls for tenders for PV projects in India and Indonesia

While a call for tender represents one of the first opportunities for including quality and safety criteria into a PV project, tendering documents are not nationally standardized and no systematic inclusion of such criteria exists in India or Indonesia.

4.4.1 Tendering process in India

Awareness about the need for including requirements for quality assurance is rising among investors in India. More and more institutions include quality criteria in their calls for tenders and require the developers to have previous experience or install technology that has been successfully applied in other PV projects. However, a general approach has still not been developed and the currently applied criteria are not always sufficient to ensure the right choice of developer and EPC contractor is made.[106]

SECI has recently standardized the inclusion of a performance warranty in its tenders for PV projects,[107] in some cases requiring previous experience on the part of the developer. An example of a call for tender issued by SECI in 2015 states the following in the section "Technical Eligibility Criteria": [108]

"The Bidder should have designed, supplied, installed & commissioned at least one Grid connected Solar PV Power Project having a capacity of not less than 50 kW which should have been commissioned at least six months prior to Techno-Commercial Bid Opening date." [109]

As another example, a call for tenders by the National Institute of Solar Energy (NISE) from 2014 required the bidders to use Indian solar cells and modules tested according to specific international standards (IEC 61215 and IEC 61730) and to have proven experience with a minimum of five plants designed, manufactured, supplied, installed and commissioned in the last five years with a cumulative capacity of two MWp including different technology types.[110]

On state level, some calls for tender (e.g. Punjab Energy Development Agency from 2015) do not require experience from the bidder, but the technology used needs to be successfully operational for at least one year in one other project, independent of the location of the installation.[111]

4.4.2 Tendering process in Indonesia

Given the early stage of development of the PV sector in Indonesia, only a reduced number of public tenders for PV projects have taken place so far. The Directorate General of New and Renewable Energy and Energy Conservation (EBTKE) has carried out tenders for 11 locations and a total capacity of 19.5 MW between 2013 and 2014. Tender documents are available in Bahasa Indonesia only. Several of these tenders failed as none of the bidders were able to meet the required conditions. A particular difficulty arises as locations are specified very concretely without ensuring land availability for the project developer.[112] Next to the specific location, it was mentioned that sometimes technical requirements are set in a way to exclude most competition and give only few options for procurement, particularly where local content is required.

[106] Interviews 1, 28
[107] Interviews 8, 11
[108] SECI 2015: RFS No: SECI/Cont./77/2015 p.15
[109] Some stakeholders perceive these requirements as too little demanding, as the operation of a 50 kW PV installation during 6 months does not assure qualification for the installation and operation of multi-MW systems with a lifetime of 25 years or more. The requirements are thus not sufficient to reduce the risk of low-quality installations.
[110] NISE 2014
[111] PEDA 2015: PEDA/2015-16/4, p.20
[112] Sentosa 2014

For the PV project that is currently being financed by KfW in Indonesia, a tender process for an implementation consultant to follow the project is underway.[113] The call for tender for the project implementation will take place later on.

4.5 Division of responsibilities and risks

The responsibility for assuring quality and safety aspects in PV projects usually rests with the local project executing agency. Depending on the structures and processes in place on national level, the project executing agency might be able to bear this responsibility only to a certain extent.

The financial risk related to those aspects is assumed by the system operator, as plant performance below estimations results in a reduced return on investment. Developers use insurances to cover parts of the risks from pre-arrival of components to the commissioning of the plant. After the commissioning, available insurance options are limited. Insurance cover for long-term power generation has only recently been introduced in India and is not common due to its elevated cost.[114] Indonesian insurance providers do currently not offer insurance for PV projects. However, larger foreign EPCs implementing projects in Indonesia provide a performance guarantee to the system owner for the runtime of the O&M contract that is usually backed by insurance to cover the system owner in case of bankruptcy of the EPC.[115] Insurance providers offering insurance for PV projects in other countries have detailed checklists and specialised engineers to assess the risk of each project.

Within development banks, responsibility for quality and safety of financed projects is often perceived as reduced.[116] Some banks see their mandate to support sustainable development as achieved when investments in renewable energies are made.[117] Others take into consideration also their responsibility in reducing CO_2 emissions and supporting the development of the national project partners. Those latter ones are more involved in quality assurance and partner support for the financed PV installations, as only long-term performance according to estimations and improved local competencies can achieve these goals.[118]

[113] Interview 10
[114] Interviews 31, 32
[115] Interview 21
[116] Interviews 12, 34
[117] Interview 34
[118] Interview 1

5. Recommendations

5.1 General recommendations

The following recommendations are valid for all stakeholders of the PV sector (i.e. financial, government and QI institutions, as well as NGOs and research institutes).

In general, data on the actual performance of installed PV systems is lacking. Reasons for this can be seen in the recent development of the sector as well as in the reluctance of plant owners, EPCs and component manufacturers to disclose individual plant information or the fear of criticism in light of possible negative effects on national development goals. Nevertheless, the **systematic comparison of performance estimations and reliable data on a regional or national level** would be an important step to better understand recurring issues and take measures to assure performance of future PV installations.

In addition to the systematic collection of performance data, a **study on concrete risks** for investments in PV due to quality and safety issues is recommendable. The results could support investors and banks in making more informed decisions and should include suggestions on **measures** to be taken to reduce such risks. A similar study to quantify risks in PV projects is being carried out for the European context in the framework of the Solar Bankability project, where a first report was published in March 2016.[119]

On the national level, **working groups** on quality and safety issues in PV with the participation of the relevant stakeholders are recommended. In the working groups issues should be discussed with the objective of increasing quality and safety in the sector by coordinating related initiatives, policies and programmes. These groups may be led by institutions of the QI or by PV sector organisations. A systematic coordination and cooperation between different stakeholders and coordination of activities and supporting policies is essential to make quality and safety assurance in the PV sector efficient and holistic.

The elaboration of **national guidelines for the inclusion of quality and safety criteria in PV financing** could be a possible outcome of the above mentioned working groups. Such guidelines would be an important tool to improve the general understanding of quality and safety criteria relevant for PV, harmonise the requirements for PV projects and foster quality and safety in the sector. This could result in increased information sharing and simplified procedures as stipulated by the Paris Declaration on Aid Effectiveness[120] under the subject of donor harmonisation, and generate the necessary demand for the development of relevant services of the national quality infrastructure.

Furthermore, there is an important need to increase the overall know-how of stakeholders in the PV sector to reduce quality-related gaps and risks. **Training activities** for different actors in the field should be developed considering international best practices for quality and safety. In countries with already existing training offers, such as India for example, the activities should be reviewed to assure also here that quality and safety criteria according to international best practices are considered systematically.

5.2 Recommendations for development banks

It is recommended that development banks **increasingly demand and support** the implementation of quality and safety in PV projects, taking into consideration the stage of development of both, the regulatory and organisational framework the local project executing agency relies on, as well as the national QI infrastructure.

[119] Solar Bankability 2016
[120] OECD 2005/2008

In particular project agreements development banks should:

- Request high quality solar irradiation data.
  → In India, for example, the Solar Mapping and Monitoring (SolMap) project of GIZ has combined precise ground measurements with satellite derived irradiance values of the past 16 years to provide more reliable irradiation data.[121]

- Include international standards and demand certification of components and workforce (i.e. installers and operators) by accredited certification bodies. In addition to that, a certification with periodical audits of the production process should be requested for components to ensure that the quality of the products remains high over time.[122]

- Define precise quality requirements as well as testing procedures and factory inspections, mentioning explicitly that a random testing of modules by a third party has to be carried out, or specifying concrete tests for components that need to be conducted.[123] Also consequences of non-compliance should be defined in advance as it will facilitate claims for compensation.
  → TÜV Rheinland has found that when these aspects are included in contracts, the quality of delivered products is consistently higher than when this information is not included.[124]

- Demand a performance warranty for a longer period with an agreed penalty in case of non-achievement.
  → SECI (India) recently made the inclusion of a performance warranty in its tenders for PV plants a standard procedure (see Chapter 4.4).[125]

- Tie the revenue of the developer and/or EPC to long-term performance of the PV plant and in this way increase the quality and safety awareness on the part of the developer and/or EPC contractor.
  → KfW and Mahagenco applied this approach in a project in India, in which the contract with the EPC contractor has a runtime of 10 years and links the payment of a yearly lump sum to the achievement of a previously defined performance.[126]

- Require the inclusion of an external expert for bigger projects, to follow the project implementation and ensure its quality. Additionally, regular plant inspections and component checks by experts can be included in the agreement to assure quality and safety during the operation phase of the plant.[127]
  → Most banks and investors hire so-called lender's engineers that ensure the project is implemented according to the lender's expectations by carrying out punctual checks. KfW additionally requires an implementation engineer in some cases, who supports the project executing agency throughout the process[128].

- Stipulate the use of best practice guides and instruction manuals for different phases and tasks, such as detailed maintenance and cleaning instructions that can increase the quality of the PV system and reduce the risk of performance loss.

[121] Interview 11
[122] Solar Bankability 2016
[123] GIZ 2014, pp. 2-3
[124] Interview 3
[125] Interviews 8, 11
[126] Interview 2
[127] TÜV Rheinland 2014, p. 12
[128] Interviews 1, 10

→ Examples are the Technical Manual for Banks and FIs on Grid Connected Rooftop Solar PV[129] developed by TERI in India, the Utility Scale Solar Power Plants Guide for Developers and Investors based on experiences in India by IFC[130], and the ASEAN RE Guidelines for PV Project Development in the Philippines by the Renewable Energy Support Programme for ASEAN[131].

- Agree on performance monitoring and disclosure measures to enable the systematic collection of performance data of PV systems in the region, as suggested in the general recommendations above.
- Reduce time constraints for the implementation of PV projects to give EPCs the possibility to dedicate the necessary time and attention to quality and safety aspects during project implementation.[132]

In addition, the following activities should be carried out:

- Assess the state of the operating framework of the local project executing agency as mentioned above, and adopt measures accordingly.
  → In India, for example, technical specifications for rooftop PV have been released recently by MNRE. In this case, development banks could refer to the locally available specifications and focus on assuring their implementation in the project.
- Create additional opportunities for the discussion of specific requirements to ensure that quality and safety aspects as well as their importance are understood by all parties involved in the project.[133]
- Support the development of necessary services of the national QI, by financing the infrastructure for testing or calibration laboratories, for example.
- Implement more capacity building initiatives and consultancy for regulatory bodies to foster the development of the PV sector.[134]
  → ADB supports the Indonesian government in establishing a policy framework for PV[135], KfW provided expertise for the development of technical requirements for a loan scheme of IREDA in India, and the World Bank supports regulatory bodies in establishing requirements for PV that assure a safe grid connection of new plants[136].

Development banks should also take an **active role in national initiatives** to foster the improvement of quality and safety in the PV sector, by taking part in national working groups as suggested above and contribute to relevant studies and guidelines providing their perspective and expertise.

5.3 Recommendations for PTB

Considering the need for the development of QI services identified in this study, PTB should use its experience made in the projects in India and Indonesia to foster the development of national QI services relevant for the PV sector also in other developing economies. This should take into account the concrete

[129] TERI 2015
[130] IFC 2012
[131] ASEAN 2014
[132] Interview 28
[133] Interview 28
[134] Interview 4
[135] Interview 18
[136] Interview 4

demand of the local market, including all necessary services to assure quality along the value chain of PV projects identified in collaboration with all relevant stakeholders.

One of the stakeholders being the financial sector, PTB should actively **involve financial institutions** in current and future projects. Development banks have a considerable leverage potential to foster the inclusion of quality and safety criteria in the PV sector and support the necessary demand for developing a functioning QI. A stronger collaboration between PTB and development banks could lead to a better use of this leverage and increase the efficiency and reach of initiatives.

Activities to **foster coordination and cooperation between key stakeholders** in the sector should be maintained. These activities can take a crucial role in supporting the implementation of the recommendations on national level, i.e. the creation of national working groups.

For the implementation of the general recommendations, PTB does not only play an important role as **facilitator**. It can also **provide QI-related know-how**, which can be of value for the suggested study, the working groups, the development of national guidelines and the review or development of training activities for different actors in the PV sector.

Annex

Annex 1: Questionnaire for telephone interviews

Financing schemes

- Could you explain which funding schemes for solar/renewable energy projects are applied by your organisation / development banks?
- How are partners selected? How does the collaboration work? Who has which role?
- How does your organisation / do development banks consider quality and safety aspects in financing PV installations at the moment? Where do you see areas for improvement?
- Does your organisation / do development banks have a specific tool for quality and safety assurance in renewable energy projects?
- How does your organisation / do development banks integrate quality and safety criteria in calls for tenders / influence calls for tenders by partners?
- Are specific quality and safety requirements set in the contract with the partners? Can also subcontractors be influenced?
- What are the greatest risks in financing PV projects? How can they be reduced?

Quality and safety (additional)

- What are the biggest issues related to quality and safety along the PV value chain?
- Which approaches do already exist to solve these problems?

Country-specific information

- How many PV projects are currently financed by your organisation / development banks in India / Indonesia?
- Which policies and programmes exist that influence the development of the PV sector and the financing of PV projects in India / Indonesia?
- What are the biggest challenges for the PV sector in India or Indonesia?
- Which quality infrastructure services exist for the PV sector?
- Which types of insurance exist for PV projects in India / Indonesia?

Annex 2: List of interviewees

Organisation	Name	Position
ACME Solar Energy Pvt. Ltd.	Sudhir Verma	Chief Operating Officer
ADB	Prijantha Wijayatunga	Principal Energy Specialist
ADB	Len George	Energy Specialist
AES Consulting - Clean Energy Consultancy	Andre Eka Susanto	Senior Vice President
BKPM	Delfinur Rizky Novihamzah	Section Head of Water Resources and Renewable Energy Infrastructure
DEG	Matthias Goulnik	Director
DEG	Bobby Mangaratua	Investment Manager
EBTKE	Ida Nuryatin Finahari	Deputy Director of Program for Various New Energy and Renewable Energy
EBTKE	Widya Adi Nugroho	Assistant Deputy Director of Various New and Renewable Energy
First Solar Power India Pvt. Ltd.	Amit Kumar Mittal	Technical Director
GIZ	Indradip Mitra	Renewable Energy Specialist India
GIZ	Amalia Suryani	Advisor Energising Development (EnDev) Indonesia
GIZ	Rudolf Rauch	Programme Director Energy Programme Indonesia / ASEAN
GIZ	Anant Shukla	Senior Advisor Renewable Energy Support Programme for ASEAN (ASEAN RESP)
IFC	Susan Nurhasanah	Investment Officer
IIGF	Arianto Wibowo	Executive Vice President
IREDA	BV Rao	Technical Director
IREDA	Abhilakh Singh	General Manager Solar Power and IT Departments
IRENA	Francisco Boshell	Renewable Energy Markets and Standards Analyst
KfW	Daniel Etschmann	Solar Energy Specialist
KfW	Franz Haller	Project Manager South Asia
KfW	Christoph Twerenbold	Senior Sector Coordinator
L&T	Milan Kumar	Head Engineering & Services, Solar Business
METI	E. Bawa Santosa	Executive Director
METI	Bambang Sumaryo	Vice Chairman of Business Development, Investment and Promotion
NISE / MNRE	OS Sastry	Director General
Photovoltaik-Institut Berlin	Asier Ukar	Senior Technical Manager
PLN	Rizki Wahyuni Asikin	Engineer Alternative Energy at New and Renewable Energy Division
PTB	Saurabh Kumar	National Project Consultant India
PT SMI	Gan Gan Dirgantara	Head of Project Development & Advisory
PT SMI	Rizki Chandra Amorin	Project Development & Advisory
PT SMI	Mohammad Fadli Zapran	Project Development & Advisory
SECI	Bharath Reddy	Senior Manager
SUCOFINDO	Agus Husni Zaenudin	Senior Manager Renewable Energy
SUCOFINDO	Suharyono	Vice President
TERI	Ujjwal Bhattacharjee	Senior Fellow
TÜV Rheinland	Jörg Althaus	Head of Business Field Solar Energy

World Bank	Mohua Mukherjee	Senior Energy Specialist
World Bank	Parthapriya Ghosh	Senior Social Development Specialist
World Bank	Pyush Dogra	Senior Environmental Specialist
World Bank	Amit Jain	Renewable Energy Specialist
YBUL	Agus Widianto	Executive Director
YBUL	Ida Murni Sulaiman	Program Assistant

Annex 3: Concrete examples of financing schemes of a development bank and a national development agency

Kreditanstalt für Wiederaufbau (KfW)

KfW is supporting the development of solar power in India as part of the renewable energy strategy of the Indian Government and is involved in the recently inaugurated Indo-German Solar Partnership.[137] PV projects are supported through subsidized lending and are either directly financed or refinanced.[138]

The objectives of KfW in the energy sector in Indonesia are within the scope of the German-Indonesian cooperation in which the focus is on climate change and energy since 2013.[139] For Indonesia, KfW also applies the financing model of subsidized lending for directly financed projects and is granting policy loans, which are dedicated to specific reforms in the energy sector. There is currently one ongoing project through which PV diesel hybrid systems for island grids are financed.

For funding PV projects KfW uses two distinct models: public funding and private funding. KfW development bank is responsible for projects in cooperation with public partners, DEG and IPEX on the other hand fund private projects in the PV sector.

- Public funding: In this approach KfW cooperates with a local public partner, the project executing agency that engages in the implementation of the PV project. When financing a project, KfW concludes a loan agreement and particular agreements with the public entity. The particular agreements include financing measures, target indicators, reporting requirements as well as the tendering and financing modalities.[140] Concrete quality and safety aspects as well as social and environmental requirements can be integrated in the particular agreements. Furthermore, it can be determined that an experienced implementation consultant is hired to provide support to the project executing agency throughout the implementation of the project.
  The loan is secured through the finance ministry of the cooperation country.[141] Experts of the bank can check the environmental and safety aspects of the project in advance. Tenders are usually conducted by the project executing agency and the bank can influence which requirements are listed in these documents. Detailed technical specifications, such as specific standards and tests or the requirement of previous experience of developers can be defined in the tender documents. KfW checks the fulfilment of the demanded criteria so that the project corresponds to the state-of-the-art regarding quality and safety criteria and ensures a fair competition. Also a "short list (or equal)" that names trusted manufacturers, installers or consultants may be used to ensure quality. In this case EPC contractors are limited in their choice of suppliers and service providers to the ones listed or have to provide evidence that their choice has equally developed competencies.[142]
  The project executing agency is also responsible for conducting the feasibility study, for which additional funding can be provided by KfW. In rare cases, when KfW works with less experienced project executing agencies, the bank contracts a consultant to carry out the feasibility study. Particular specifications can be determined for the feasibility study, for example the bank can insist on an international tender for the selection of a consultant to carry out the study.

[137] MNRE 2015b
[138] Interviews 1, 2
[139] KfW 2015
[140] Interview 2
[141] Interview 1
[142] Interview 2

Projects are generally evaluated twice by KfW. The first evaluation takes place after the installation of the plant (technical evaluation). The second evaluation is done after three to four years when the unintended effects of the project are evaluated (developmental evaluation).[143]

- Private funding: Private funding is done by KfW's subsidiaries, IPEX (International Project and Export Finance) and DEG (Deutsche Investitions- und Entwicklungsgesellschaft). DEG's approach for funding is different from the previously described public funding, as there is no public entity involved and the bank deals directly with the project company. Small projects are bundled to form a bigger project for which a holding becomes the borrower. A feasibility study is conducted by the project sponsor to identify which kind of technology is useful. To assure the quality of the project especially in terms of technical aspects an external lender's engineer is hired, who checks whether the project is in compliance with the lender's requirements. Long-term warranties are used to assure performance of the PV plant. For all projects a due diligence is carried out to evaluate the risk and determine the financial viability of financed projects. Furthermore, the bank requires a completion guarantee from project sponsors. Hereby specified technical parameters have to be met and in case of non-achievement the project sponsor has to ensure that the problems are solved. For the financial completion once the plant is in operation, it is verified whether the outputs are in line with the business plan and if the cash flow is strong enough during the first three or six months of operation. In case of underperformance the project sponsor is requested to enhance the corresponding issues.[144]

Indian Renewable Energy Development Agency (IREDA)

The Indian Renewable Energy Development Agency (IREDA) was established in 1987 as a non-banking financial institution to support the development of renewable energies.[145] IREDA finances renewable energy projects and supports the PV sector through loans for PV power plants and component production.[146] The agency receives funds from different sources and can also co-finance large-scale projects with development banks or other financial institutions, or act as an intermediary between development banks and local actors.[147] IREDA is currently the main partner of KfW for the refinancing of PV projects in India.[148]

A low-cost loan scheme for grid-connected rooftop PV that provides debt finance at a favourable interest rate was introduced in July 2015. It is targeted at commercial, industrial and institutional actors and loans can cover up to 75% of the total project cost.[149] For this scheme, extensive information about technical aspects is required. This includes solar irradiation data, a roof shadow analysis, details about used modules including warranty and certification, as well as detailed information about the inverter, mounting structure, monitoring system and power evacuation arrangement that will be used.[150] The requirements were developed in collaboration with an expert for solar PV of KfW.

The vast majority of projects funded by IREDA are private sector projects. Projects are checked for their financial and technical viability, whereby the technical aspects include certificates and information about

[143] Interview 10
[144] Interview 15
[145] IREDA 2011
[146] Interview 29
[147] Interview 13
[148] Interview 1
[149] TERI 2016, p.8
[150] IREDA 2015

previous projects of the involved developers, EPC and O&M contractors as well as performance warranties for components, PV modules in particular. Reference is made to international standards and local conditions are taken into consideration.[151] Projects are monitored at intervals of approximately six months by IREDA's engineers. However, performance data is not collected systematically. A study examining the performance of financed PV plants is being carried out at the time of publication of the present study[152]

[151] Interview 13
[152] Interview 29

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Acronyms

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
ASEAN RESP	Renewable Energy Support Programme for ASEAN
BIS	Bureau of Indian Standards
BIPM	International Office for Weights and Measures
BSD	Business Sustainability Development
BKPM	Indonesia Investment Coordinating Board
CEA	Central Electricity Authority
CO_2	Carbon Dioxide
CPN	Cost Priority Number
DEG	Deutsche Investitions- und Entwicklungsgesellschaft
EBTKE	Directorate General of New and Renewable Energy and Energy Conservation
EKONID	German-Indonesian Chamber of Industry and Commerce
EnDev	Energising Development
EPC	Engineering, Procurement and Construction
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IIGF	Indonesian Infrastructure Guarantee Fund
IREDA	Indian Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
IPEX	International Project and Export Finance
ISO	International Organization for Standardization
KfW	Kreditanstalt für Wiederaufbau
KW	Kilowatt
L&T	Larsen and Toubro
MAHAGENCO	Maharastra State Power Generation Company
METI	Indonesian Renewable Energy Society
MNRE	Ministry for New and Renewable Energy
MEMR	Ministry of Energy and Mineral Resources
MW	Megawatt
MWp	Megawatt peak
NGO	Non-Governmental Organisation
NISE	National Institute for Solar Energy
NPL	National Physical Laboratory
NTPC	National Thermal Power Corporation Ltd.
NVVN	NTPC Vidyut Vyapar Nigam Ltd.
O&M	Operations and Maintenance
PLN	Perusahaan Listrik Negara
PPP	Public-Private Partnership
PTB	Physikalisch-Technische Bundesanstalt
PT SMI	PT Sarana Multi Infrastruktur
PV	Photovoltaic
QI	Quality Infrastructure
RPO	Renewable Purchase Obligation
SECI	Solar Energy Corporation of India Ltd.
SolMap	Solar Mapping and Monitoring
SRRA	Solar Radiation Resource Assessment
SPV	Special Purpose Vehicle
SUCOFINDO	Superintending Company of Indonesia
TERI	The Energy and Resources Institute
TÜV	Technischer Überwachungsverein
US	United States
VGF	Viability Gap Funding
WTO	World Trade Organisation
YBUL	Yayasan Bina Usaha Lingkunga

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