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Holstenkamp, Lars; Hein, Wolfgang

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Lars Holstenkamp, Wolfgang Hein

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Financing Solutions for Innovation and Sustainable Development in the Energy Sector
Conceptual Framework[‡]

Lars Holstenkamp[§], Wolfgang Hein[**]
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Zusammenfassung:
Im vorliegenden Beitrag wird ein Überblick gegeben über das Forschungsprojekt „Finanzierungslösungen für Innovation und Nachhaltige Entwicklung im Energiebereich“ (FINE) mit seinen Arbeitspaketen und dem theoretischen Rahmen.

Schlüsselwörter: Solarenergie, Finanzierung, Governance, Innovations- und Technikanalyse

Abstract:
In this paper the authors present an overview of the research project “Finance Solutions for Innovation and Sustainable Development in the energy sector” with its working packages and theoretical framework.

Keywords: Solar Energy, Financing, Governance, Innovation and Technology Analysis

JEL-classification: G32, G38, Q42

Correspondence:
Lars Holstenkamp, Leuphana University of Lüneburg, Institute of Business Law, Wilschenbrucher Weg 69, D-21335 Lüneburg, Fon +49 4131 677 7924, Fax +49 4131 677 7911, holstenkamp@uni.leuphana.de

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§ Lars Holstenkamp is research associate at the Chair of Finance and Financial Institutions of the Leuphana University of Lüneburg, Faculty of Economics.

** Wolfgang Hein is senior researcher at the GIGA – German Institute of Global and Area Studies, Hamburg, Institute of Latin American Studies, and professor of international relations at the University of Hamburg.

Inhalt

I. Research Goals and Methodology

A. Background of the Research Project

There are three major issues which have drawn public attention in the North to the energy sector recently:[1] "**climate change**", "**peak oil**", i.e. the exhaustibility of fossil fuels, and "**energy security**". In the South, the demand for energy is growing. Still, there are many households which do not have access to modern forms of energy. To combat "**energy poverty**" has been set high(er) on the development agenda (again). These issues highlight several challenges countries all over the globe are faced with and which have to be tackled if a sustainable energy system shall be implemented. Several visions for a sustainable future of the energy sector co-exist, making the energy topic a highly contested area. Nevertheless, most observers internationally acknowledge that renewable energy technologies have to be further developed and their share of total energy production has to be increased. Thus, there is the need for sustainable innovations in the energy sector, and the implementation of renewable energies is part of that. Therefore, sufficient capital for the development of the relevant technologies and their implementation will have to be raised. Conversely, those technologies that contribute to a sustainable development in the energy sector are not necessarily those that are being financed. A lack of funds at appropriate terms often turns out to hinder the development and use of technologies, i.e. market introduction and penetration. But the availability of financial resources can also be propulsive. In addition, boom-and-bust cycles driven by investor behavior are possible.

A problem in the development of energy technologies is the long investment cycle of 30 to 50 years.[2] Here, particularly, the problem of path dependence exists.[3] High uncertainties, not least due to changes in laws and regulations as well as unequal competition with mature technologies lead to the fact that only small amounts of private capital are available for the development of innovative technologies.

German experiences have shown that feed-in tariffs – through the introduction of the Renewable Energy Sources Act[4] – can create a framework which, combined with further governmental support[5], creates a supportive environment for private investments in renewable energies, also for larger scale power plants via project financing. Several financial instruments have been developed for or adapted to the renewable energy

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1 For a more detailed discussion of these issues see Deliverable 1.2 of the FINE research project [forthcoming].

2 See e. g. Krewitt (2007), p. 56.

3 See Meyer/Schubert (2007) for a discussion of this and some related concepts. For the term "path creation" and a study of the wind industry see Garud/ Karnøe (2003).

4 Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz, EEG) as of 25 October 2008, BGBl. I S. 2074, last amended through Law of 11 August 2010, BGBl. I S. 1170.

5 See Kruck/Eltrop (2007).

sector, e.g. closed-ended funds[6] or Tradable Renewable Certificates (TRC)[7]. The implementation of the Kyoto Protocol and flexible mechanisms[8] led to a new branch within the financial sector (carbon finance)[9]. Such developments are facilitated by the increasing share of ethical and ecological investments. Partly, private and public actors collaborate in networks[10] and jointly invest in funds[11].

However, certain difficulties are linked to the finance instruments mentioned: Generally, due to high transaction costs, which are independent of project size, only certain projects of a minimum size are financed. The technologies applied must be tested and allow for a reliable calculation of costs. Larger scale projects dominate. The additionality and sustainability of many CDM projects are doubted.[12] Eventually, in rural regions of developing countries, especially in Africa, well-funded demand and financing services for the poorer segments of the population (e.g. microfinance) are missing. Therefore, only few private investors can be found in the rural regions. In addition, the capacities for an adequate local adaptation of the respective technologies are missing in many cases.[13]

The requirements of financing approaches that have been designed for the German or European context as well as the developments of the energy industry and the financial sector therefore differ from the non-European context. Bearing this in mind, the existing financing tools for solar energy – taken as one sub-sector of renewable energies – in different countries are evaluated and a potential transfer of models or single elements or experiences made in European countries to developing countries is discussed.

B. Research Questions and Methodology

The research project FINE is conducted within the thematic focus of "Fields of action for innovation policy for sustainable development" which is part of the Innovation and Technology Analysis (ITA) research program of the German Ministry of Education and Research (BMBF). ITA is described in detail as follows:

> *"What is ITA?*
>
> *Innovation and technology analysis (ITA) is the examination of scientific, technical, and organizational innovations and developments, including their socioeconomic prerequisites and impacts, the conditions under which they are achieved, and their interactions with other scientific, technical, and social developments. The objective is to identify fields of socially desired technological progress, to ascertain*

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6 For more details on closed-ended funds see the case studies of German solar funds in a separate deliverable.

7 See e. g. Nielsen/Jeppesen (2003).

8 Sometimes also called Flexibility Mechanisms or Kyoto Mechanisms; most relevant here are the Clean Development Mechanism (CDM) and Joint Implementation (JI) which have been implemented through the Marrakesh Accords. See also the separate deliverable of the FINE research project on innovative financing schemes [forthcoming].

9 For an overview see e. g. Carbon Finance Unit (2007).

10 See Manning/Wienges (2006).

11 One example is the Global Energy Efficiency and Renewable Energy Fund (GEEREF). On this see e. g. Holstenkamp (2010); Bird (2009); Behrens (2009).

12 These issues will be discussed in the deliverable of the FINE research project on innovative financing schemes [forthcoming].

13 See Davidson/Turkson (2001).

potential for shaping that progress, and to point out political room for manoeuvre. Innovation and technology analysis is intended to offer orientation in a high-tech society and to help promote humane, socially equitable, and environmentally compatible technological engineering. Building on the proven methods and results of technology assessment (TA), innovation and technology analysis is a concept for analyzing and evaluating technologies. Its broad approach links research and practice.

ITA studies disclose unused potential in new technologies and inquire into innovative ways to deal with possible risks. Innovation and technology analysis is interdisciplinary and brings scientific, technical, ecological, ethical, social, legal, economic, and political aspects to bear. In order to optimize problem-solving dynamics, innovation and technology analysis begins with the social conditions governing innovation, identifies institutional obstacles to innovation, and advances proposals for overcoming such barriers. The inclusion of business and its instruments for product assessment is intended to lead to synergies with integrated, modern ITA."[14]

The first target of the research project is to describe the current state of financing renewable energies, especially solar energy, in Europe, Latin America (Costa Rica), and Africa (Tanzania) as one type of such a "socially desired technological progress". Financing and governance structures belong to or constitute a part of what is called "socioeconomic prerequisites" in the above ITA definition. Questions raised include:

- Which financing instruments are used?
- How do different actors work together?
- What are the main risks and obstacles faced by actors in the solar energy business in the different contexts?
- What impact did the financial crisis have (or has the financial crisis)?

Second, the solar energy case studies function as example to explore the link between financing and innovation processes, especially the market introduction and penetration. Third, potential financing solutions for solar energy in rural areas of developing countries are analyzed.

The project is divided into two main working packages (WPs):

- WP 1: Literature review, expert interviews, and development of the conceptual framework;
- WP2: Empirical analyses (case studies), comparison, and recommendations.

The expert interviews in WP 1 are used as an additional information source besides the literature. Working package 2 is divided into four parts, with analyses in the European context as part 2.1, in the non-European context (Costa Rica, Tanzania) as part 2.2, the evaluation and derivation of recommendations as part 2.3 and the analysis of the impacts of the financial crisis as part 2.4. The selection of case studies will be explained below (see Chapter III). Information sources for the case studies include publicly available descriptions via libraries and internet, project deliverables/ documents, and (semi-)structured interviews.

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[14] VDI/VDE Innovation + Technik GmbH n. d.

C. Structure of the Paper

In this paper the overall conceptual framework for the research project is presented. In the next chapter the three different levels of analysis will be described: the norm-building level (II.A), the case study level (II.B), and the ITA concept level (II.C). Chapter III contains information about the cases chosen, i.e. regarding the countries about Germany and Europe/ the European Union (EU), about Costa Rica and Tanzania on the one hand (III.A) and on the other hand about the different technologies looked at (III.B). Several parts of what has been said above and will be written below is described and explained in much more detail in separate deliverables of the research project FINE.

II. Levels of Analysis

A. Norm-Building Level

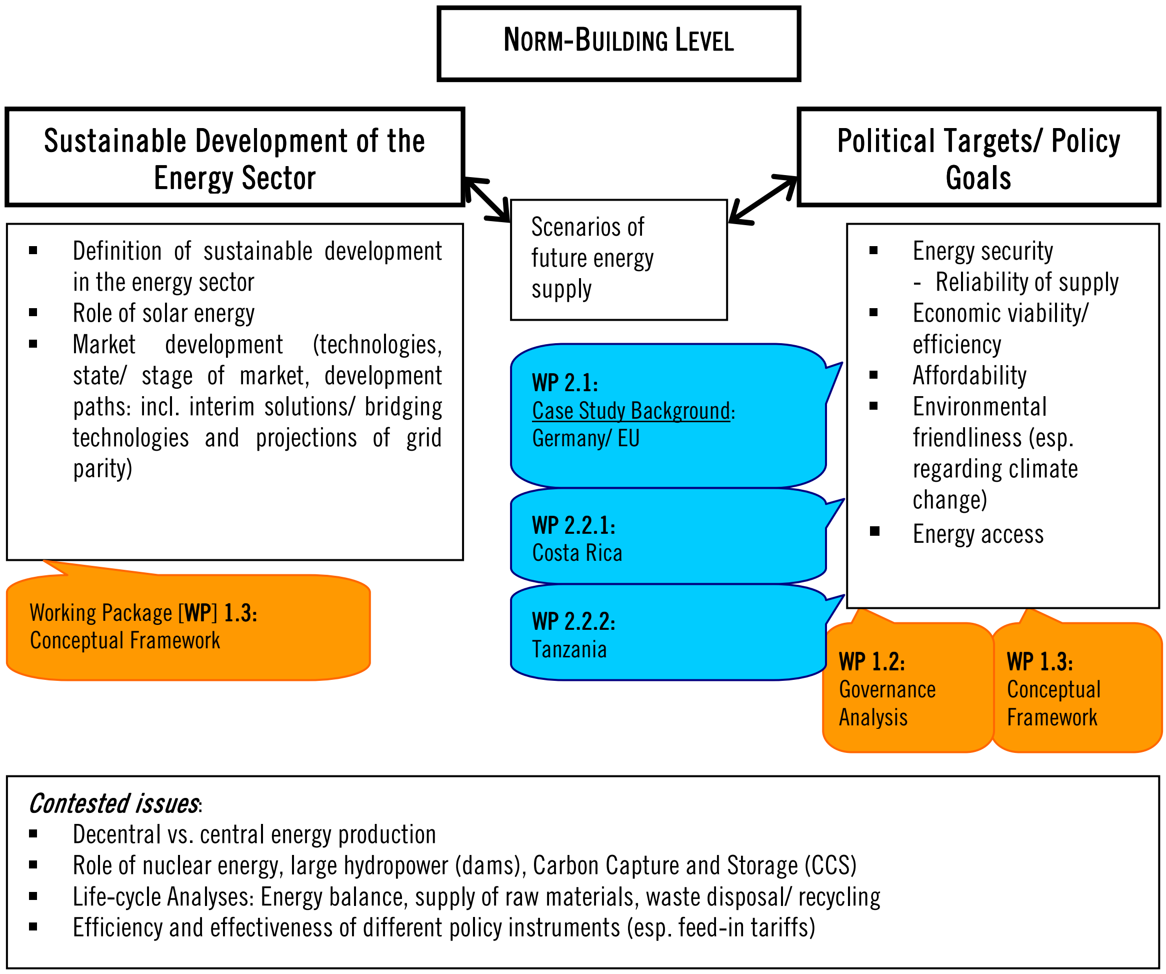

Fig. 1: Norm-Building Level – Analysis of Concepts of Sustainable Development and Political Targets in the Energy Sector

Historically, the electricity sector has always been a highly regulated, in many countries all over the world a publicly dominated segment of the economy. The same can be said about the gas sector and to some extent also about the exploration and supply and demand of oil. Renewable energy markets are publicly created and supported markets.[15] This is why for private investors the stability of public support and regulatory regimes is essential.[16] Or as it has been named elsewhere: "Transparency, Longevity, and Certainty (TLC)"[17]. Norm building and consequent set up and revision of energy policy targets therefore is of high importance for the analysis of financing structures, since the overall policy framework has direct impacts on funds available and financing instruments which can be used and which are evolving in reaction to policy changes.

One such example is the occurrence of climate policy and the issue of "sustainable energy supply" which will be dealt with in more detail in the forthcoming Deliverable 1.2 of the FINE research project. There, it will be analyzed how sustainable development is defined (and by whom) with regard to the energy sector and which role solar energy might play. Moreover, there are a number of contested issues like distributed vs. central energy supply, the role of nuclear energy and large hydropower, as well as Carbon Capture and Storage (CCS), the discussion of life-cycle costs and benefits of different technologies, and the efficiency and effectiveness of different policy instruments, especially feed-in tariffs (FiTs). Whatever the answer to these questions in the national or regional context is, it has direct impacts on policy goals and potential scenarios for future energy supply – and through this also on the role solar energy can and shall play.

The national and regional discussions and background on renewable energy policies and overall energy policy targets – generally listed as energy security, economic viability/ efficiency, affordability as well as access to energy, and environmental (especially climate) friendliness – will be reflected on in a first part of the case studies: the German and wider European Union (EU) background, the Costa Rican and the Tanzanian context. Normally, scenarios and calculations of future energy supply, i.e. which portion of the (on a worldwide scale growing) energy demand will be delivered through which form of energy, are used to inform politicians about the feasibility of their targets and/or to influence policies in order to reach different goals. Therefore, these scenarios are part of the discussion on sustainability as well as on the national and regional energy policy frameworks.

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[15] For more on the state of renewable energy markets and implications for governance and finance see Deliverable 1.3 of the FINE research project [forthcoming].

[16] See e. g. Hamilton (2009).

[17] DBCCA (2009).

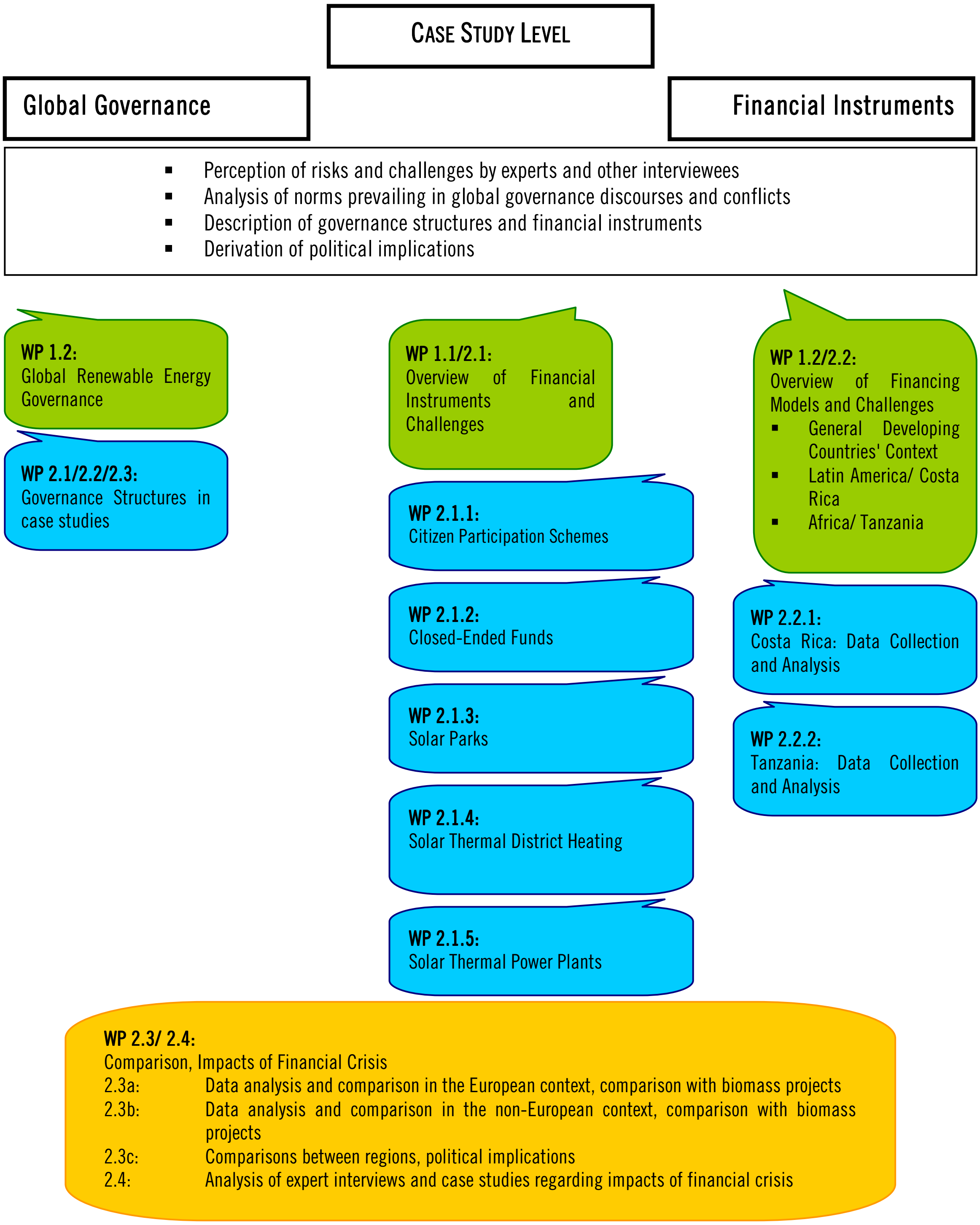

Fig. 2: Case Study Level – Analysis of Governance Structures and Financial Instruments in Selected Cases

B. Case Study Level

The aspects mentioned in the previous paragraph build the foundation for what is analyzed through the case studies: the global governance of renewable energy development, mainly in the South, and financial instruments or schemes applied in the cases. In Fig. 2 you can see the different working packages and steps assigned to these two foci under which solar energy deployment is evaluated.

Several regional cases in Costa Rica and Tanzania have been chosen and analyzed. In the European context, different types of projects and financial instruments are looked at: citizen participation schemes in Germany, nearly all using photovoltaics (PV); closed-ended funds whose shares are sold in Germany (mainly PV); solar parks in different European countries; (larger scale) solar thermal district heating, where most plants are located in Denmark, followed by Germany and Sweden; solar thermal power plants (Concentrating Solar Power, CSP). The idea is to compare financial solutions in different countries with different technologies and corresponding investment volumes.

Results of the case studies will be compared with the growing literature on financing renewable energies in general and in developing countries especially. The same applies for governance structures.[18] Both are linked in at least two ways: First, actors involved in global governance are participating in projects at the local or regional level. Thus, studying economic governance of renewable energy projects builds the micro level in a multi-level framework. Financing and related questions like ownership are an essential part of economic governance structures. Second, risk-return characteristics of projects plus additional criteria used by different types of investors as well as risk-sharing agreements between different parties determine who will finance which part of a project. Looking at the institutional and procedural side of these activities reveals interesting results for a global governance analysis.

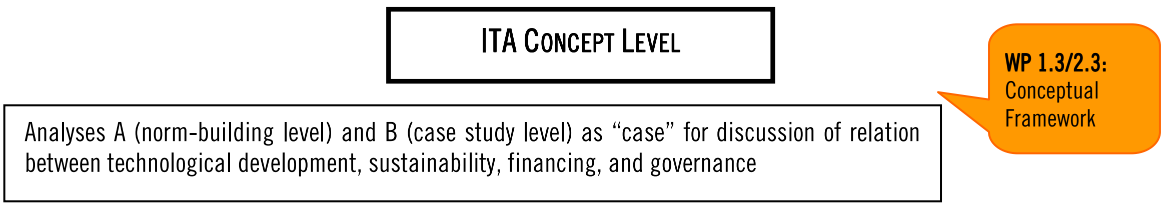

Fig. 3: ITA Concept Level – Discussion of Implications for Innovation and Technology Analysis

C. ITA Concept Level

The third level which will be of relevance in the research project is the overall ITA concept level. As shown in Fig. 3 the energy sector is taken as one example to discuss at the end what might follow for innovation and

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18 For both issues and related literature see Deliverables 2.1 and 3.1 of the FINE research project [forthcoming].

technology analysis out of the results obtained. The basic idea is to fill in a gap identified by Fürstenwerth: Financial market perspectives were mostly absent from technology analysis (TA) works; financial issues were neglected in TA.[19] What this research is trying to do is to establish links between TA and the growing body of literature on global governance and financing of renewable energies, especially in developing countries, thereby going beyond venture capital as discussed in the cited Fürstenwerth article.

There are at least three different perspectives or entry points for financial analysis when evaluating technologies: first, the discussion and development of financing solutions for certain projects, mainly by modifying existing tools so that the needed characteristics result (**financial engineering**); second, the description and analysis of organizational models and types of financing including their legal implications (**'traditional' finance**, similarly: **neo-institutional approaches**); third, the application of **modeling tools** developed by financial economists (e. g. portfolio theory).[20]

III. Selection of Cases

A. Country Cases – Background

Europe, and within Europe especially Germany, is among the lead markets for renewable energies (beyond hydropower). Comparatively long experiences exist in financing institutions. Several financing instruments have been applied to different types of renewable energy projects. Within the European Union (EU) the selection of cases will be according to (a) the status of lead market for the respective technology and (b) the challenges faced by private entities trying to establish projects in these countries where potential parallels – at least with regard to certain single issues – to the situation in developing countries exist.

Costa Rica and Tanzania have been chosen since in both cases solar energy is seen as a technical solution for rural electrification. Nevertheless, they represent two diverse groups of developing countries (see Tab. 1). While Costa Rica is a Middle Income Country (MIC), Tanzania belongs to the poorest countries worldwide. In general, electrification rates in Costa Rica are high. On the contrary, a majority of Tanzanians does not have access to modern forms of energy. Despite some similarities – the electrification challenge for remote areas or the high importance of hydropower for instance – there are therefore major differences between both country cases that will most probably have an impact on governance and financing structures in the solar energy sector.

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19 See Fürstenwerth (2001).

20 For more details on this in the context of the solar energy sector see Deliverable 7.1 of the FINE research project [forthcoming].

Tab. 1: Development and Energy Indicators by Country

	Germany	Costa Rica	Tanzania
General Country Data[b]			
Population (million), 2009	81.9	4.6	43.7
GNI per capita (current US$), 2009	42,560	6,230	500
Income level (class)	HIC	upper MIC	LIC
Electricity Sector Data[b]			
Electricity production (billion kWh), 2007	629.546	9.05	4.175
Electric power consumption (kWh per capita), 2007	7184.31	1862.62	81.67
CO_2 emissions (metric tons per capita), 2007	9.6	1.8	0.1
Electricity production from			
- coal sources (%)	49.3	0	2.7
- hydroelectric sources (%)	3.3	74.8	60.1
- natural gas sources (%)	11.6	0	36.2
- nuclear sources (%)	22.3	0	0
- oil sources (%)	1.8	8.0	0.9
- other sources (%)	11.7	17.2	0.0
Human Development Indicators[a]			
Life expectancy at birth (years)	80.213	79.096	56.947
Mean years of schooling of adults (years)	12.210	8.350	5.110
GNI per capita (constant 2008 US$ PPP)	35,308	10,870	1,344
Inequality-adjusted Human Development Index	0.814	0.576	0.285
Income Gini coefficient	28.3	48.9	34.6
Population living below $1.25 PPP per day (%), 2000[b]	n.d.	4.41	88.52
Gender Inequality Index	0.240	0.501	n.d.
Adjusted Net Savings (% of GNI)	15.7	9.1	5.1
Human Development Index	0.885	0.725	0.398
Human Development Index, rank	10	62	148

GNI = Gross National Income; HIC = High Income Country; LIC = Low Income Country; MIC = Middle Income Country; PPP = Power Purchase Parity; n.d. = no data available

Source: [a] *United Nations Development Programme (UNDP): International Human Development Indicators* [b] *The World Bank: World Development Indicators*

B. Technology Focus

Beside the country cases a type of renewable energy had to be chosen. The focus will be on solar energy in the research project since

(a) a variety of different technologies and project types exists which has an impact on the financial characteristics and therefore also the financial instrument that can be/ are applied;

(b) besides wind energy solar has got the biggest potential according to most of the energy supply projections;

(c) experiences with different types of financing schemes exist in all countries studied.

Within the different national and regional contexts different solar technologies are looked at, but mostly thin film and crystalline PV, not organic PV cells or concentrator PV. The reason is that the research is mainly dealing with market penetration and according financing structures and strategies. CSP is included in order to have an example of a renewable energy technology for centralized production with high investment volumes, which pose significant financing challenges. Different solar technologies and the state of the different markets will be subject of Deliverable 1.3 of the FINE research project [forthcoming].

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Institut für Wirtschaftsrecht (IfWR) der Leuphana Universität Lüneburg
Wilschenbrucher Weg 69
21335 Lüneburg
http://www.leuphana.de/ifwr