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Regional and structural differences of barriers to implement renewable energies

- Implications for less or least developed countries -

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Abstract

The implementation of renewable energies (RE) is one of the main pillars to fight global greenhouse gas emissions and increase access to clean and affordable electricity. Despite the urgent need of developing RE capacities, they diffuse rather slowly. To accelerate the implementation it is crucial to understand the barriers and challenges for RE. Within this work a broad literature overview is conducted to identify and structure the barriers. In addition, case studies are analyzed to find regional and structural differences. Looking at these differences enables a more specific help for implementing RE in less or least developed countries (LDCs). The analysis reveals that main barriers for LDCs are lack of trained staff and high initial costs.

Keywords: innovation systems; energy policy; technology diffusion

Introduction

One of the major threats for global mankind is the anthropogenic driven greenhouse effect and the resulting climate change (e.g. leading to sea level-rise and weather extremes) (IPCC, 2007). In addition, clean and affordable energy supply is a backbone of sustainable development and wealth for countries and people worldwide (Breyer, Werner, Rolland, & Adelmann, 2011; Programme, 2005).

The latest development of dramatically shrinking costs of renewable energies (REs) (especially photovoltaic) fundamentally changes the market situation (Bhandari & Stadler, 2009; Price, 2011). Currently these GHG emission-free technologies are already cost-competitive compared to oil-fired plants on islands or in rural areas (Breyer, Werner, et al., 2011; Clarke, 2008). Increasingly, they even challenge gas or coal power plants without any subsidies (Breyer, Görig, Gerlach, & Schmid, 2011; IRENA, 2012a, 2012b). Combining these issues, REs have the potential to become the main power generation technologies due to ecological and economic reasons.

Despite these two advantages, yet only few new REs (photovoltaic and wind power) have been installed on a global scale (International Energy Agency, 2012). This leads to the assumption that additional barriers exist beside the economic ones. Painuly for example mentions technological, financial, social, institutional and market distortions or failure as potential barriers (Painuly, 2001). It is crucial to remove these barriers for the implementation of REs to target the GHG emission reduction goals and secure a sustainable and affordable future energy supply.

Trying to help poor people in least developed or developing countries, developed countries often apply their established technologies without taking the different framework conditions in the supported countries into account. This leads to wrongly directed developing aid or support by global organizations. Less or least developed countries (LDCs) have to be analyzed according to their main barriers for implementing RE to successfully support them. They are especially interesting for micro energy systems as the distributed power generation in rural areas is one solution to improve their energy supply system.

Research Objectives

The analysis of identified barriers for implementing REs supports decision makers and investors to create a renewable friendly framework to push the global Energiewende and to ensure access to sustainable energy. Only after understanding the barriers of RE's implementation, it is possible to remove them successfully. Many basic studies on barriers of RE development (cf. Owen, 2006; Painuly, 2001; Unruh, 2000; Verbruggen et al., 2010) have been published over the last decade and underline the scientific and practical relevance of this topic. In addition, consider more country specific or regional case studies are available. Within this paper, these case studies are used to identify the specific barriers of LDCs. As opposed to the reviewed research papers and case studies, this paper focusses on a regional comparison of barriers as new approach.

The analysis follows three main research questions:

- What kind of main and sub barriers exist in general?
- What regional or structural differences can be identified?
- What are the main barriers in LDCs?

Method

To answer these questions, a broad literature analysis is performed. Many country specific case studies have been conducted over the past years. These studies are identified by researching "barrier AND renewable energies" in the title, abstract and keywords of all papers of the science direct journals.

Almost 350 articles are found. They are scanned to get representative studies about developed, newly industrialized, and least developed countries[1].

First, the main barriers are extracted and clustered with their sub barriers along the commonly mentioned categories. To structure the barriers, mainly peer-reviewed papers without specific regional context are investigated (Beck & Martinot, 2004; Boyle, 1994; Negro, Alkemade, & Hekkert, 2012; Owen, 2006; Painuly, 2001; Reddy & Painuly, 2004; Timilsina, Kurdgelashvili, & Narbel, 2012; Union of Concerned Scientists, 2002; Unruh, 2000; Verbruggen et al., 2010; Wee, Yang, Chou, & Padilan, 2012). The identified main barriers are clustered along the four categories: technical, economic, political, and social as shown in Fig. 1.

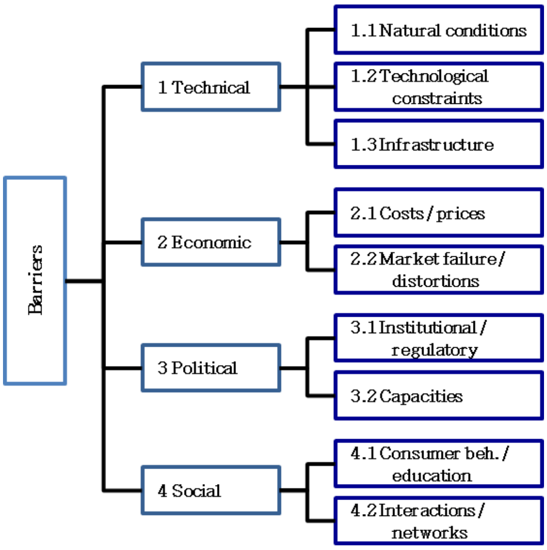

Figure 1: Clustering of barriers in categories and main barriers.

Using this overview as framework, the barriers within the case studies are analyzed. Following Negro's approach, the mentioned sub-barriers are associated to the main barriers to evaluate the importance of each (Negro, Alkemade, & Hekkert, 2012). In addition the case studies are seperated according to the studied countries to underline the differences of developed and LDCs. This enables more specific measurements to remove these barriers in LDCs.

Results – Case study analysis

Tab. 1 reveals the results of the evaluation of the case studies along the barriers of Fig. 1 for DCs and newly industrialized countries (NICs), Tab. 2 for LDCs. The more important one specific barrier in one specific country the more "+" are indicated. An "o" means only slight importance and "-" shows that the barrier is removed for this sub category.

[1] According to the UN

Table 1: Results for DCs and NICs.

	DCs				NICs				
Barrier	USA	GER	UK	AUS	BRA	CHI	MEX	SA	MLY
1.1				+		- +		o	
1.2	o	+		+		+ +			+
1.3				+	o	+			
2.1		o	+	+	+	+	+	+	+
2.2	+ +	+	+	+ +	+		+ +	+ +	+
3.1	+ +	- -	+	+	+	+ +	+ +	+	+
3.2	+			+	+				
4.1	+ +	-	+ -	+		+		+	+ +
4.2	+	- +	+	+					+
Source	1, 2, 3, 4	5, 6, 7, 8	5, 9, 10	11, 12, 13	14, 15	16,17, 18, 19	20	21	22

USA: United States of America, GER: Germany, UK: United Kingdom, AUS: Australia, BRA: Brazil, CHI: China, MEX: Mexico, SA: South Africa, MLY: Malaysia.

Source: 1: (Sovacool, 2009a), 2: (Sovacool, 2009b), 3:(Sovacool, 2009c), 4: (Sovacool, 2009d), 5: (Lipp, 2007), 6: (Klessmann, Held, Rathmann, & Ragwitz, 2011), 7: (Umweltbundesamt, 2007), 8: (Forschungsstelle für Umweltpolitik, 2007), 9: (Brennand, 2004), 10: (O'Keeffe & Haggett, 2012), 11: (Wright, 2012), 12: (Effendi & Courvisanos, 2012), 13: (Martin & Rice, 2012), 14: (do Valle Costa, La Rovere, & Assmann, 2008), 15: (Pereira, Camacho, Freitas, & Silva, 2012), 16: (Sun & Feng, 2012), 17: (Ling & Cai, 2012), 18: (Liu, Lund, & Mathiesen, 2011), 19: (Huo & Zhang, 2012), 20: (Lokey, 2009), 21: (Pegels, 2010), 22: (Ali, Daut, & Taib, 2012)

Table 2: Results for least developed countries.

	LDCs					
Barrier	TZ	ETH	BNG	NEP	SAs	PAK
1.1						
1.2	+			+	+	+ +
1.3	+	+			+	+
2.1	+ +	+ +	+	+	+	+ +
2.2	+			+		+ +
3.1		+ +	o	+	+	+
3.2		+	+	+	+	+
4.1	+ +	+ +	+ +	+ +	+ +	+ +
4.2			+	+		o
Source	23, 24	25	26	27, 28	29	30, 31

TZ: Tanzania, ETH: Ethiopia, BNG: Bangladesh, NEP: Nepal, SAs: South Asian countries, PAK: Pakistan (last two are not LDCs, but studies looking at rural electrification).

Source: 23: (Ahlborg & Hammar, 2012), 24: (Rickerson, Hanley, Laurent, & Greacen, 2012), 25: (Mulugetta, 2008), 26: (Alam Hossain Mondal, Kamp, & Pachova, 2010), 27: (K.C., Khanal, Shrestha, & Lamsal, 2011), 28: (Gurung, Kumar Ghimeray, & Hassan, 2012), 29: (Palit & Chaurey, 2011), 30: (Mirza, Ahmad, Harijan, & Majeed, 2009), 31: (Bhutto, Bazmi, & Zahedi, 2012)

Tab. 1 and 2 show that natural conditions are in general no limiting factors for REs according to the literature review. In DCs as well as in LDCs renewable sources are sufficiently available. The intermittency as technological constraint is mentioned for US as well as for Germany and China. In addition, in China and in LDCs (excluding Bangladesh) the technological constraints refer to the availability and understanding of RE technologies. This can be seen as an often occurring barrier for RE in LDCs. Infrastructure in DCs and NICs is a minor hurdle and points out the denied grid access for RE operators. For LDCs, infrastructure as barrier has the same importance as technological constraints. It means that the basic infrastructure to install and operate RE plants is lacking and not only the grid-access.

The economic barriers are consistently higher rated than the technological. The higher levelized cost of electricity (LCOE) of RE compared to the LCOE of the relatively cost effective conventional large scale power supply is pointed out as important barrier in DCs and NICs. REs face the same barrier in LDCs, but the conventional power supply in these countries is more expensive (especially in rural areas with off-grid diesel power plants), which leads to a lower cost gap between RE and fossil plants. The high initial investment effort is an additional barrier for RE, which is crucial in LDCs due to lack of private capital and high capital costs (mentioned for Tanzania, Ethiopia, and Pakistan). Market failure and distortions as barrier are based on lock-in dilemmas and / or monopolistic market structures in DCs and NICs. Especially countries with a powerful established utility and strong connection to fossil resource exploration are concerned (e.g. USA, Australia, South Africa, Mexico). Market barriers for LDCs are not as important as for DCs and NICs. The exclusion of new private companies is mentioned to be the highest barrier in DCs.

The institutional and regulatory barriers are part of the political barriers. They are especially important for the success of REs in DCs as well as in NICs. The example of Germany shows that a proper regulation (eg. feed-in law) can be the main driver for the implementation of RE despite all other barriers. Many of the analyzed countries are still lacking a proper regulatory framework, in addition they even subsidize conventional power sources (e.g. USA, Mexico, China). LDCs face similar problems on the institutional level. In terms of capacities, LDCs have often weak administrative systems, which slow down the support of REs. In DCs, a missing centralized authority – means differentiate legislation in different federal districts of one country – complicates the bureaucratic processes. For NICs, the political capacities have no influence on the implementation of RE.

Finally, the social barriers are analyzed. In each investigated LDC, consumer behavior and education represents a strong barrier. This is mainly based on the lack of well trained workers and educated consumers, which have no awareness regarding RE. In DCs a lot of proper qualified workers are available, but in some countries the people have a lack of interest or comprehension, while in NICs the people seem to be excluded from the entire decision process whether to use RE or not. The last barrier is defined by networks or interactions among groups and people, this barrier is not mentioned for NICs. In DCs citizens initiatives have often started to push the implementation of REs. Nevertheless, opposition currently arises especially against wind power due to its visual impact (e.g. Germany, UK). In LDCs missing networks among communities to share experience or knowledge can be seen as main barrier on this level.

Discussion

To respond to the first research question, the general structure of barriers and sub-barriers is illustrated in the method section. For the second and third question, the analysis of the country case studies reveals clear differences in barriers for implementing REs between DCs / NICs and LDCs. Thus it is very important to target the specific impediments in LDCs to effectively support REs there and not only copying the measurements of DCs or NICs.

The first major barrier in LDCs is the lack of education and awareness. Without removing this, proper installation, operation, and maintenance cannot be assured, which are very crucial for sustainable implementation of REs (cf. Yadoo & Cruickshank, 2012). Education programs in schools and technical colleges should improve the qualification of local staff. The second major barrier includes the high initial cost combined with lack of investment capital or high capital costs. Micro finance schemes target this barrier by enabling private investors to invest into REs (cf. Gradl & Knobloch, 2011). Looking at these two barriers and potential solutions explains the imperfection of taking only experiences from DCs into account. DCs have traditionally proper access to trained workers and capital, therefore the aforementioned measurements (especially micro financing) can only evolve by looking at LDCs and their needs.

The scope of this work is limited to the dimension of the sub-barriers and their evaluation is relatively undetailed. Future research should therefore analyze the dimensions of the sub-barriers and use them for comparison. By this, more detailed solutions for removing barriers of implementing REs can be given.

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