DIPLOMA THESIS

An analysis of promotion strategies for renewable electricity (RES-E) in BRIC countries

Executed for the purpose of obtaining the academic degree of

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Under the supervision of

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Abstract

This diploma thesis discusses recent and current policies promoting renewable electricity in the BRICs. The objective is to give a thorough overview of the most important support mechanisms which have been implemented in those countries and to analyze those measures in terms of effectiveness and efficiency. The focus hereby lies mainly on wind power, solar photovoltaic and to a lesser extent biomass electricity, since those technologies have experienced the strongest support by the BRIC governments. Besides effectiveness and efficiency, also the actual total investments in renewable electricity are briefly addressed. For the conclusion the key findings of the policy evaluation will be summarized.

Kurzfassung

Diese Diplomarbeit behandelt staatliche Instrumente und Mechanismen zur Förderung von Erneuerbaren Energien im Elektrizitätsbereich in den BRIC-Staaten (Brasilien, Russland, Indien und China). Das Ziel dieser Diplomarbeit besteht darin, einen Überblick der wichtigsten Fördermaßnahmen und Strategien zu erstellen und diese hinsichtlich Effektivität und Effizienz zu analysieren. Der Schwerpunkt liegt hierbei auf die am stärksten geförderten Technologien wie Windkraft, Photovoltaik sowie auch Biomasse. Weiters werden auch die Gesamtinvestitionen in diesen Ländern kurz angesprochen und eine Verbindung zwischen diesen und der zugehörigen Politik hergestellt. Abschließend werden die Fördermechanismen länderübergreifend verglichen und analysiert.

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List of abbreviations and acronyms

General abbreviations/acronyms

Abbreviation/acronym	Meaning
RE	Renewable electricity
RES	Renewable electricity source
RES-E	Renewable energy source - Electricity
RET	Renewable electricity technology
BRIC	Acronym for Brazil, Russia, India and China
EIA	U.S. Energy Information Administration
IEA	International Energy Agency
REN21	Renewable Energy Policy Network for the 21^{st} century
WEC	World Energy Council
UNEP	United Nations Environment Programme
IRENA	International Renewable Energy Agency
BNEF	Bloomberg New Energy Finance
GWEC	Global Wind Energy Association
EPIA	European Photovoltaic Industry Association
UNFCCC	United Nations Framework Convention on Climate Change
IMF	International monetary fund
FIT	Feed-in tariff
RPS	Renewable portfolio standard
REC	Renewable energy certificate
PPA	Power purchase agreement
FYP	Five year plan
PEI	Policy effectiveness indicator
OPTRES	Assessment and optimization of renewable support schemes in the European electricity market (EU-research project)
RAI	Remuneration adequacy indicator
TCI	Total cost indicator
WACC	Weighted average cost capital
LCOE	Levelized cost of electricity
PV	Photovoltaics

Abbreviations/acronyms for Brazil

Abbreviation/acronym	Meaning
PROINFA	Programme of Incentives for Alternative Electricity Sources
MME	Ministry of mines and energy
ANEEL	Brazilian electricity regulatory agency
BNDES	Brazilian Development Bank
BASA	Banco da Amazônia
FNDE	Fundo de Desenvolvimento do Nordeste (Northeast Development fund)
BNB/FNE	Fundo constitucional do nordeste
CEF	Fundo Constitucional do Centro-Oeste
CCEE	Electrical Energy Commercialization Chamber
ACR	Ambiente de Contratação Regulada (Brazilian regulated electricity market)
ACL	Ambiente de Contratação Livre (Brazilian free electricity market)
FEC	Firm energy certificate
EPE	Empresa de Planejamento Energetico (Energy Research Company)
PRODEEM	National Programme for Energy Development of States and Municipalities
PROÁLCOOL	Programa Nacional do Álcool

Abbreviations/acronyms for Russia

Abbreviation/acronym	Meaning
ATS	Administrator of the Trading System (Администратор торговой системы)

Abbreviations/acronyms for China

Abbreviation/acronym	Meaning
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NPC	National’s People Congress

Abbreviations/acronyms for India

Abbreviation/acronym	Meaning
MNRE	Ministry of New and Renewable Energy
CERC	Central Electricity Regulatory Commission
SERC	State Electricity Regulatory Commission
NLDC	National load dispatch center
PXIL	Power Exchange of India Limited
IEX	Indian Energy Exchange
BIPV	Building Integrated Photovoltaics
GBI	Generation based incentives

Abbreviations/acronyms for currencies

Abbreviation/acronym	Meaning
R$	Brazilian Real
Rs.	Indian Rupee
CNY/RMB	Chinese yuan / Renminbi
Rub	Russian ruble
US$	U.S. Dollar
€	Euro

Introduction

Government policies and support schemes for renewable energy are one of the key-factors for the successful and rapid deployment of RE technologies. The first policies supporting renewable energy sources (RES) were introduced in the 1990s in a few countries. In 2013 altogether 127 countries had implemented RES support schemes (1). Among Brazil, Russia, India and China, also commonly referred to as the BRICs, several renewable energy policies were implemented in recent years which tremendously pushed forward the deployment and development of renewable energy technologies. By the end of 2012 those four countries accounted for more than one third of the total global RE capacity. Within the BRICs and even worldwide, China has now the largest renewable power capacity and also accounts for the highest investments in new renewable energy (RE) capacities (1). Brazil, India and Russia are also among the top players in the global renewable energy market.

There are numerous possibilities for governments to support and set incentives for the deployment of RETs and all BRIC countries have implemented multiple policies simultaneously to increase the share of renewable energy in their electricity mix. The effectiveness of each policy, which describes to which extent a previously set target has been met during the time the policy was in force, is depending on various technological and economical factors such as the maturity of respective technology, current market situation, technical and economical deployment potential, learning rates etc.. The policy effectiveness can be measured with different indicators, which give a cross-country-comparable insight on the performance of policy schemes. Also several other criteria can be analyzed for the evaluation of RE policies, such as efficiency, equity, feasibility, deployment status etc. which together draw a more precise picture of the performance of policies.

Diploma thesis objectives and methodology

This diploma thesis deals with renewable energy promotion measures as well as energy strategies and policies currently applied in the BRIC countries. The objective is to analyze the different policies in those countries, particularly with respect to effectiveness and also briefly efficiency. This includes a thorough overview of the current policy situation in each country as well as an assessment of those policies.

The methodical approach consists of two main parts: data investigation and analytics. Most of the data used in the calculations regarding installed capacities, electricity generation data and potentials are obtained from the EIA (U.S. Energy Information Administration), IEA (International Energy Agency), WEC (World Energy Council) and REN21 (Renewable Energy Policy Network for the 21st century) as well as from government organizations and reports from the GWEC (Global Wind Energy Council) and EPIA (European Photovoltaic Industry Association). Information and data regarding investments and financial issues were obtained mainly from UNEP (United Nations Environment Programme), BNEF (Bloomberg New Energy Finance), IRENA (International Renewable Energy Agency) as well as from government documents and scientific papers.

Thesis structure

The first chapter gives an overview of common renewable energy policies and support mechanisms and also definitions for policy effectiveness and efficiency used in literature as well as of the respective calculation methods used in this thesis for the evaluation of discussed policies. The second chapter is dedicated to the current RE policy situation in the BRIC countries and gives some insight to a selection of the most important governmental support mechanisms implemented in the timeframe 2003-2013. The third chapter deals with the analysis of policy effectiveness for each country and technology. Also the policy efficiency and economic issues will be discussed in this chapter. The fourth chapter concludes this thesis with a comparison of policy performance among the BRICs and some general conclusions about the previous and future developments regarding RE policies. All data used for calculations and figures are obtainable in the appendix. All figures in this thesis were generated by the author.

1. Overview and evaluation of renewable energy policies

Several support mechanisms for RETs nowadays are implemented on a global scale. Policies and support schemes typically applied in the electricity sector are inter alia feed-in tariffs, RES portfolio standards, tradable renewable energy certificates, auction systems, subsidies, tax incentives, credits and cash grants. In the BRIC countries usually several of those mechanisms are in force simultaneously. Additionally medium- and long-term energy strategies developed by the national governments set targets and provide a general roadmap for RE capacity deployments.

1.1 Overview of common renewable energy policies

Feed-in tariff (FIT)

Feed-in tariffs are currently in force worldwide and basically function as a performance-based incentive, offering a higher security level for investors and power generators by assuring a certain purchase price per generated kWh from particular RETs for a certain period (commonly 15-20 years). The tariffs are usually set by the government separately for each supported technology and depend on multiple factors like plant location and grid congestion, technology maturity and costs etc.. Finding a suitable tariff is a key issue, since low tariffs cannot push forward RES deployment whereas high tariffs result in windfall profits. In some cases, a tender is used to determine proper tariffs. Several variations of FITs exists, e.g. fixed tariffs with regular adjustments to inflation, decreasing tariffs which adjust to the decreasing costs of electricity generation over time and feed-in premium systems which provide fixed additional revenues to the electricity market price. Financing FITs can be executed in various ways, e.g. by taxes, electricity price surcharges, emission penalties etc.. In early 2013, FITs were implemented in 71 countries, among them also three BRIC countries, namely Brazil, China and also India, which forms an exception since it has implemented FITs step-by-step in provinces and not on central level (1). Russia is also running a FIT-like program; however it has some unique and uncommon features which will be discussed later.

Renewable portfolio standard (RPS)

A renewable portfolio standard is a policy instrument which obligates electricity producers to produce and/or procure a certain share of their electricity volume from renewable energy sources. RPS can be implemented either as non-binding and voluntary agreements or as binding obligations with penalties. RPS can be accompanied by a renewable energy certificate system (REC), where RE certificates can be traded and allow companies to meet RPS obligations also by accumulating RECs instead of actually generating electricity from RETs. RPS have been implemented in 22 countries in 2013 and among the BRIC countries, China and India are currently working with RPS (1).

Auction and tender

Some governments use auctions and tenders in order to deploy new capacities of renewable energy. An auction is usually organized by a governmental authority which calls for offers for a certain installment capacity. The exact bidding procedure differs in each country, some auctions demand potential providers to meet certain requirements in advance, e.g. a fixed share of locally manufactured plant parts, specific technologies etc.. From the offers one ore multiple projects are selected and commonly a long-term Power Purchase Agreement (PPA) is signed. Auctions or tenders can be found in all BRIC countries and the main Brazilian RES support system relies on auctions.

Subsidy

Other policy mechanisms used in the renewable electricity sector are subsidies. Several types of subsidies exist which can have a direct (cash grants and transfers) or passive impact (tax policy, market restrictions etc.). The exact definition of subsidies is not clear; the IEA defines subsidies as "government measures that artificially lower the price of energy paid by consumers, raise the price received by producers or lower the cost of production"[1] while the International monetary fund (IMF) definition of subsidies is the following: "A consumer subsidy is defined as the difference between a benchmark price and the price paid by energy consumers (including both households for final consumption and enterprises for intermediate consumption)."[2] The global subsidy expenses estimated by the IEA amount 544 billion US$ for fossil fuels in 2012 and 101 billion US$ for renewable energy (2). The expenses estimated by the IMF for fossil fuels and electricity "on a pre-tax" basis amounted to 480 billion US$ in 2011. On a "post-tax"-basis "which also factors in the negative externalities from energy consumption"[3] the expenses reached more than 1.9 trillion US$. Subsidies are subject to a controversial discussion, since fossil fuel subsidies impede investments in renewable energy by distorting the markets, yet the subsidy expenses for fossil fuels continue to rise. In all BRIC countries subsidies for fossil fuels are currently implemented in the policy environment as well as for renewable energy.

[1] (81), p.6.
[2] (80), p.7.
[3] (80), p.1.

Energy strategy and renewable energy target

All BRIC countries have defined long-term strategies for the deployment of RETs and set targets for renewable energy shares in the electricity mix. Strategies provide a policy outline and influence the decisions regarding the selection of appropriate support mechanisms. China and India both formulate their strategies in Five Year Plans (FYP), which contain specific targets and annual plans for economical and political key issues. Along with the FYP, further strategic plans for specific technologies are accompanying the policy environment. Brazil and Russia also have introduced mid-term strategies with a planning horizon of ten to twenty years respectively.

1.2 Policy evaluation methods

The performance and impact of renewable energy support policies can be evaluated with several indicators. The International Renewable Energy Agency (IRENA) discusses four criteria in its "Evaluating Renewable Energy Policy"-paper, which are effectiveness, efficiency, equity and institutional feasibility. Along with these criteria there are also several other criteria which can be analyzed e.g. finance sourcing, political aspects, social impact, etc. (3). This diploma thesis deals with two criteria, the policy effectiveness and efficiency.

Policy effectiveness indicator (PEI)

The policy effectiveness indicator was created in 2006 in the course of the research project "Assessment and optimization of renewable support schemes in the European electricity market" (OPTRES) which was supported by the European Union and was updated for the "RE-Shaping"-project in 2010 (4).

The PEI gives some insight on the performance of policies regarding the achievements in increasing the renewable energy supply. An effectiveness indicator basically shows how successful a predefined target (e.g. certain increase of RE share in the electricity sector) was reached. However, targets which are set by governments can either be ambitious or easy to fulfill. Since the indicator should allow a useful cross-country comparison of policy success, a reasonable reference quantity has to be used as the predefined target.

The calculation method utilized in this diploma thesis was obtained from the RE-Shaping's D17-report. In this report the policy effectiveness indicator is defined as (4):

$$E_n^i = \frac{Q_{n(norm)}^i - Q_{n-1(norm)}^i}{POT_{n-1}}$$

where:

E_n^i...Policy effectiveness indicator for RET i in year n

$Q_{n(norm)}^i$...Normalized renewable final energy of RET i in year n

POT_n...Reference quantity: Additional realizable mid-term potential in year n until 2020

Since the electricity generation from various RETs is subject to weather-related variations, such as drought and windless periods as well as other external factors, the final energy generation from each year has to be normalized. The normalization rules for electricity generated from hydropower and wind power are given by the *Directive 2009/28/EC* (5).

The normalization rule for hydropower plants is:

$$Q_{n(norm)} = C_n \cdot \left[\sum_{i=n-14}^{n} \frac{Q_i}{C_i} \right] / 15$$

where:

n...Reference year

$Q_{n(norm)}$...normalized electricity generation in year n by hydropower plants

C_i...Total installed capacity of hydropower plants at the end of year i in MW

Q_i...Actually generated amount of electricity in year i by all hydropower plants in the respective country in GWh

The normalization rule for wind plants is:

$$Q_{n(norm)} = \frac{C_n + C_{n-1}}{2} \cdot \frac{\sum_{i=n-m}^{n} Qi}{\sum_{j=n-m}^{n} \left(\frac{C_j + C_{j-1}}{2} \right)}$$

where:

n...Reference year

m...number of years preceding year n for which capacity and production data are available (up to 4)

$Q_{n(norm)}$...normalized electricity generation in year n by wind power plants

C_i...Total installed capacity of wind power plants at the end of year i in MW

Q_i...Actually generated amount of electricity in year i by all wind power plants in the respective country in GWh excluding pumped storage units

The IEA introduced an adaption of the PEI in 2011 labeled policy impact indicator (PII), which uses another benchmark level of power generation. Instead of the realizable mid-term potential, the PII uses the World Energy Outlook (WEO 450) projection (which focuses on the stabilization of the global carbon dioxide concentrations at 450 ppm) as the reference quantity.

Policy efficiency

The policy effectiveness indicator by itself can only provide limited information since it tells nothing about various important issues such as the economic efficiency, future developments, social impacts of policies, deployment status etc.. The same issue arises for other indicators as well.

To get a more thorough evaluation of policies, the efficiency is also discussed in this thesis. Briefly described, the efficiency of policies is the relation between the invested efforts and the actual output. In terms of renewable energy the invested efforts are for example the government expenditures for respective policies and the output could be the additionally installed capacity. The amount of required data for the indicator calculation differs strongly depending on the calculation method and for some indicators several assumptions have to be made in advance. The IEA introduced the remuneration adequacy indicator (RAI) in its 2011 update to Deploying Renewables (6) as a development of the remuneration level indicator. Basically two remuneration types are considered when calculating the RAI, one being "up-front remuneration" which include cash rebates and tax incentives and second being generation remuneration in US$/MWh which include revenues from feed-in tariffs, markets and certificates (6). The calculation of the RAI requires several assumptions and has considerable data requirements, such as investment costs for specific technologies, operation & maintenance expenses, the weighted average cost capital (WACC) etc.. Another discussed indicator in the 2011 update to Deploying Renewables is the total cost indicator (TCI), which sets the government policy support costs in relation with the incentivized additional electricity generation. Like the RAI also the TCI requires a considerable amount of data for calculation. In particular the feed-in tariff payments and premiums in BRIC countries differ significantly within provinces, states and certain time frames, which actually makes it necessary to acquire a large amount of data for each province and time period. Countries like India for example have implemented a great number of support schemes in each state and union territory which requires a more detailed analysis for more precise results. Also the electricity market structure differs within each country which makes the calculation of the total government expenditures more difficult.

In this thesis the total cost indicator for wind power policies was calculated for Brazil, China and India. The calculation of the TCI for solar PV is quite intricate, since it is difficult to allocate gains in solar PV electricity generation to certain policies due to the large number of specific support mechanisms and consequently the government expenditures can only be roughly estimated. Nonetheless, the TCI for solar PV in China was calculated with some simplifying assumptions to get a comparison between efficiencies of wind and solar PV policies. The applied method of calculation was the following: First the additional generation share is calculated as the ratio of difference in annual generation between two consecutive years and the total annual electricity generation.

$$Q_{share}^{i} = \frac{Q_{n}^{i} - Q_{n-1}^{i}}{Q_{total}}$$

where:

Q_{share}^{i}… additional generation share of RET i
Q_{n}^{i}…electricity generation in year n by RET i
Q_{total}…total electricity generation in year n

Second, the total premiums of support policies are put in ratio with the total wholesale electricity value. The calculation of the total premiums was done by multiplying the tariffs with the corresponding electricity generation incentivized by the respective policy. Disaggregating the generation data and assigning the amounts to the correspondent policy is the most problematic part in this calculation, since data with a high level of detail is scarce. The wholesale electricity value as the reference value for the TCI is difficult to estimate, since the electricity markets in the BRIC countries are complex. For China and India, the wholesale electricity price was based on thermal electricity prices. For the Brazilian market, the LCOE of large hydropower plants, which form the major electricity generators, was obtained for calculation. Finally the TCI compares the amount of additional electricity generation share from certain RETs to the total expenses (as the percentage of the wholesale electricity value) (3).

The actual increase of installed capacity of RETs depends on various factors such as policies currently in force, technological development, maturity and costs as well as remaining potentials. Investments which lead to an increase of the renewable energy share in the energy mix, differ with regards to various aspects as financial source, process stage, time horizon etc.. The REN21 Global Status Report 2013 distinguishes between five process stages (1):

1. Technology research
2. Technology development
3. Manufacturing
4. Project Roll-out
5. Mergers & Acquisitions

94% of new investments globally were assigned to utility-scale and small-scale projects in the roll-out stage (1). Those investments include money from venture capital, private equity, public markets and asset finance. It is those investments together with government support payments which are actually accountable for the deployment of new RET capacities. The key role of policies is to set incentives and establish an attractive environment for potential investors. In particular for technologies with a high levelized cost of electricity, which is the required electricity price for projects to return costs and enable a return on capital equal to the discount rate, support policies are the main drivers for growth. The significance of support mechanisms for the deployment rate can clearly be seen in the rapid developments in the field of solar PV and wind power in China recently.

Since policy instruments are important drivers for investments, public and private expenses for renewable energy are closely correlating with the design of those instruments. Comparing the total investments, which are highly dependent on current policies, to the actual capacity increase gives some information on whether or not a policy is suitable for attracting investments and about the investment efficiency in general. Unexpected high investment volumes with rapid capacity increase possibly signal a policy with windfall profits, while high investments with low increase in RE deployment (for example due to severe delays in construction) could indicate a policy flaw. Low investment volumes on the other hand could be caused by too low remuneration offers or too many restrictions and other shortcomings in policy design.

However, from the government perspective, the actual expenses paid by the government in relation to newly deployed capacities or additional electricity generation are most important. As already mentioned, due to complex and intermingled policy structures and lack of detailed data, the calculation of government support expenses is a difficult task. Where suitable data could be found, the efficiency in terms of the total cost indicator was calculated and discussed. Policies with insufficient data are discussed using investment data. The UNEP together with BNEF and the Frankfurt School of Finance & Management provides detailed investment data on a yearly basis in their annual publication “Global trends in renewable energy investment”.

2. Current situation of electricity sector and RE policy environment

The electricity sectors in all BRIC countries, except Brazil, currently rely on a high share of fossil fuels (coal, gas and to a less extend oil). Simultaneously the electricity demand grows continuously and causes a higher consumption rate of fossil fuels each year, despite efforts to increase the deployment rate of RETs. This issue is particularly evident in China and India where the usage of fossil fuels rose dramatically in the past decade. On the other hand, investments and deployment rates in the field of renewable energy also gained momentum during the past decade, mainly because of the introduction of several renewable energy support policies in each country and technology developments. Today all four BRIC countries have implemented renewable energy support schemes, targeting at different technologies such as wind power, solar PV, biomass and hydropower. The latter marks an exception since large hydropower plants are already competitive from the economic point of view; however the impact on both ecology and society is partly drastic. Policies for hydropower are targeting at rather small hydropower stations (around 10-50MW) which have less impact on the environment.

The implemented policy instruments in BRIC countries are more or less corresponding to the discussed mechanisms in the first chapter, in some cases with modifications. The first notable policies for renewable energy were introduced in the early 2000s and their number has increased significantly since then. It is notably, that the majority of policies apply to the common RETs such as wind, solar, biomass and (small) hydropower; extraordinary or experimental technologies such as ocean wave power, tidal power, special solar power technologies etc. are not (yet) covered in support schemes.

This chapter gives an overview of the developments in the electricity sector in each country as well as detailed information on the most important RE support mechanisms. The electricity generation data is mostly obtained from the *EIA International Energy Statistics* database, the information on policies is mainly obtained from ministerial and governmental organizations as well as from the *IEA/IRENA Joint Policies and Measures database* and scientific papers.

2.1 Electricity sector in Brazil

The renewable energy share in the electricity sector in Brazil has been around 90% since the 1980s, mainly because of hydropower plants, which provided 80% of the entire generated electricity in 2011. The development of the electric energy mix in Brazil since 1980 can be seen in Figure 1.

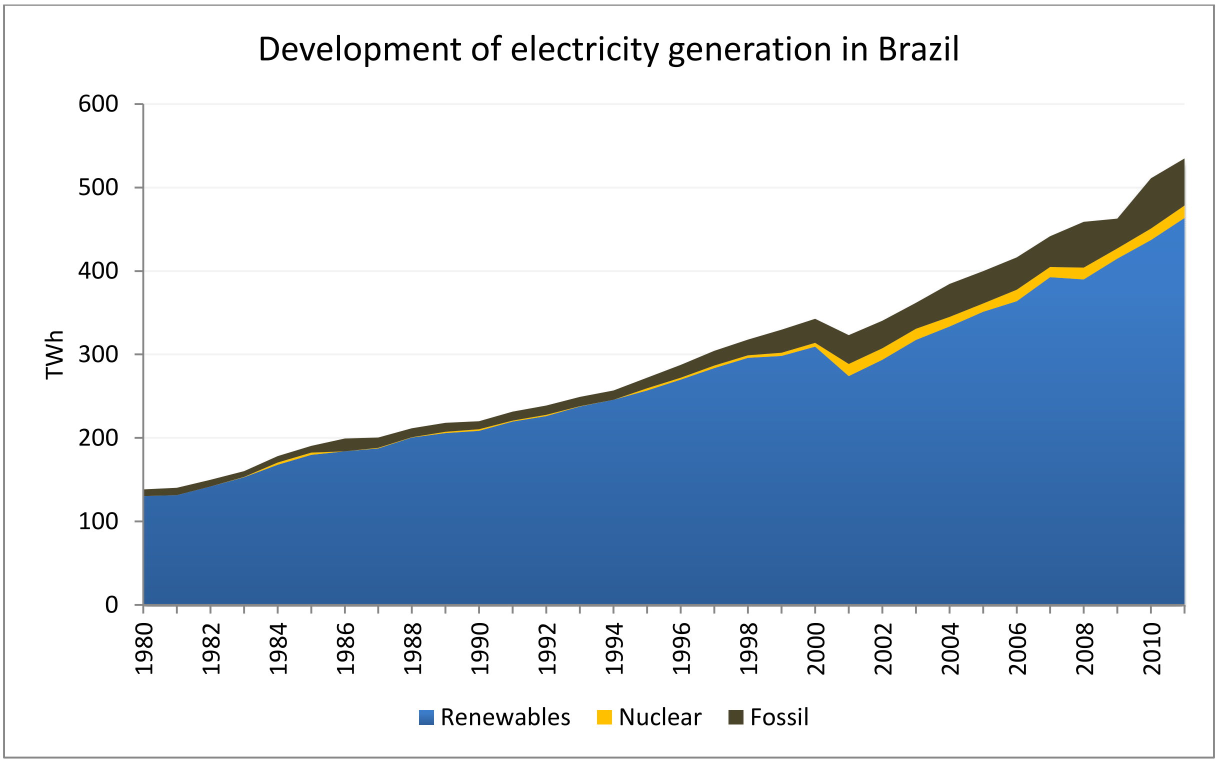

Figure 1: Development of renewable and non-renewable electricity generation in Brazil (Source: own compilation on base of (7))

The share of electricity generated from large hydropower plants amounts to above 90% of the total generated electricity from RES and thus hydropower is the major source for renewable energy in Brazil. Other significant electricity suppliers are fossil fuels, nuclear energy, biomass and wind power (see also Figure 2).

The benefit of having one of the "greenest" electricity systems in the world comes together with some risks. The high dependency on hydropower led to a serious energy crisis in 2001 and 2002, which came as a result of several years with above-average aridness; however a nationwide blackout was prevented because of a quota-based emergency reduction of electricity demand. The decline in electricity generation during this time is clearly visible in Figure 1.

To diversify the energy mix and lower weather-related risks, the incentive program PROINFA was launched in 2002 with the goal to provide at least 10% of the total renewable electricity generation from wind power, biomass and small hydropower plants.

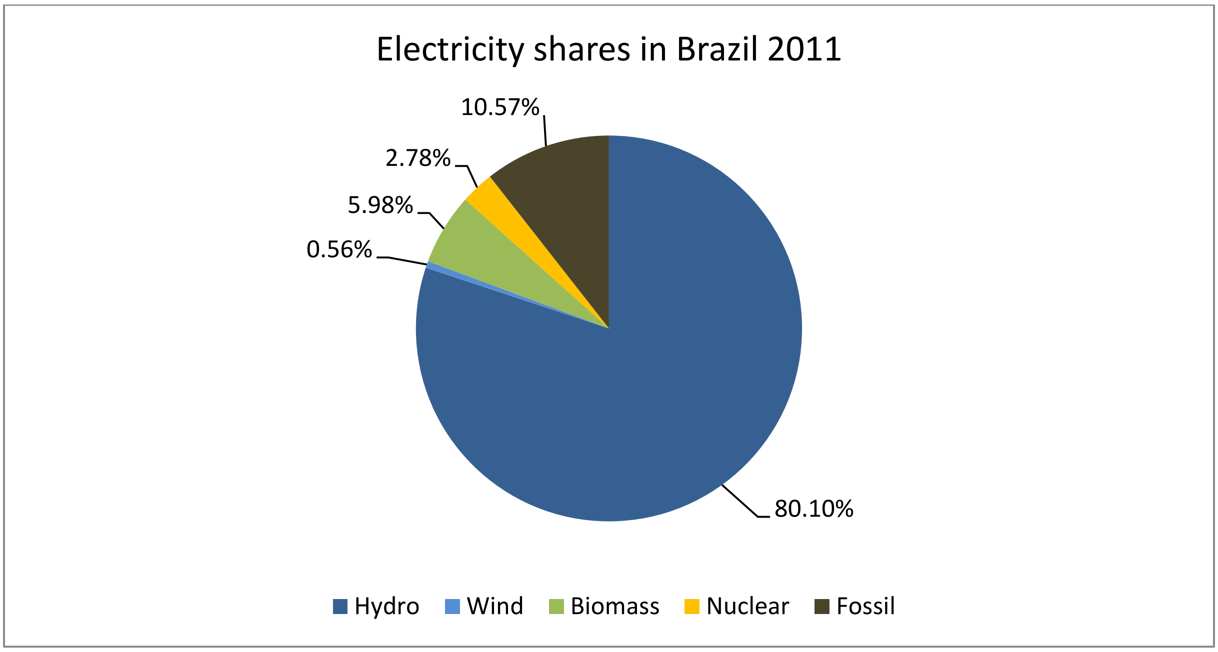

Figure 2: Electricity shares in Brazil 2011 (Source: own compilation on base of (7))

As shown in Figure 2 and Figure 3, the greatest share of the non-hydropower renewable electricity is provided by biomass power plants, mainly sugarcane bagasse plants; however the deployment of wind power plants begins to gain momentum. Biomass has a peculiar position in Brazil, since it is also extensively used in the mobility sector as fuel. Brazil has implemented multiple programs concerning the use of ethanol blended to gasoline as well as biodiesel production. Wind power besides biomass is the second technology experiencing great interest by government and investors.

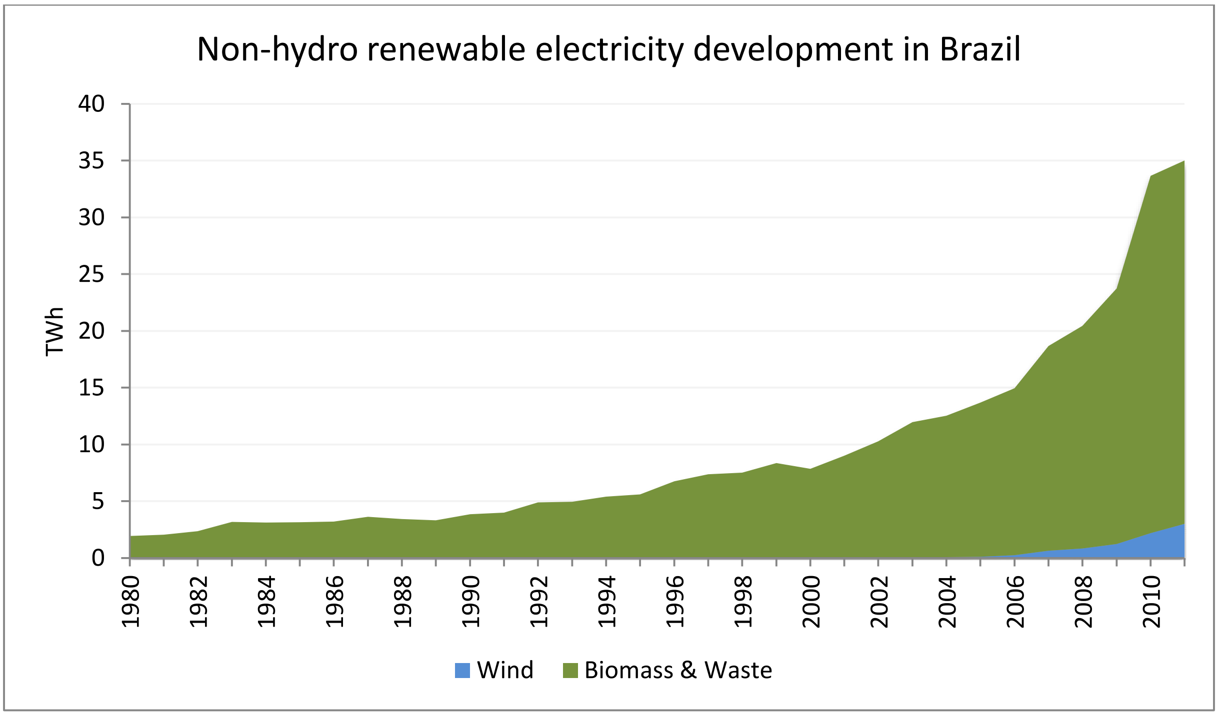

Figure 3: Development of non-hydro renewable electricity in Brazil (Source: own compilation on base of (7))

2.2 Policy situation in Brazil

Several policies and support schemes regarding the deployment of RES are currently in force in Brazil. In the early 2000s the main support mechanism was PROINFA, which consisted of a combination of feed-in tariffs and quota. Later on, since 2005 Brazil switched to an auction system for wind power, biomass and solar power as well as hydropower.

2.2.1 PROINFA (Programa de incentivo às fontes alternativas de energia elétrica)

The incentive program PROINFA (Programme of Incentives for Alternative Electricity Sources) was established in 2002 with the approval of law 10,438/2002 and is considered as the cornerstone of RE-business in Brazil. The main goals of this program were (8):

- Diversification of the Brazilian energy mix and increase of security of energy supply
- Reduction of greenhouse gases emissions
- Support of local labor market through (partly) local manufacturing
- Deployment of 3.300 MW of installed capacity, distributed equally among wind power, biomass and small hydropower plants (less than 50 MW capacity) by the end of 2008

The program is divided in market regulatory and financial support measures. The market regulation laws are established by the Brazilian parliament, by the Ministry of Mines and Energy (MME) and by the Brazilian electricity regulatory agency (ANEEL). The financial support programs are subject to various banks and agencies, namely the Brazilian Development Bank (BNDES), Banco do Brazil, Banco da Amazônia SA (BASA), Fundo de Desenvolvimento do Nordeste (Northeast Development fund FNDE), Fundo constitucional do nordeste (BNB/FNE) and Fundo Constitucional do Centro-Oeste (CEF) which together provided 6.21 billion R$ (Brazilian Real) equivalent to approx. 2.5 billion US$ (8). The contracts in coordination with PROINFA were signed with Eletrobrás (Centrais Elétricas Brasileiras S.A.), a state-owned conglomerate of six subsidiary companies, six distribution companies, the Electric Power Research Center and Eletrobrás Eletropar which forms the biggest power utility company in Latin America.

Eletrobrás support under the PROINFA program includes (8):

- Power-purchase agreements between producers and Eletrobrás with a runtime of 20 years
- Guaranteed refund of 70% of the contractual revenue during the funding contract period
- Representation of producers at the Electrical Energy Commercialization Chamber (CCEE)

The power-purchase agreements are quite similar to feed-in tariff systems applied in Europe and guarantee investors the purchase of electricity from their renewable power plants for a period of 20 years (initially in the 2002 version the timeframe was set to 15 years but in 2003 law 10,762/2003 amended the original law and prolonged PPA contracts to 20 years) (9). However, the “feed-in tariff” provided by PROINFA is not fixed but tied to a price index (10). Based on the average national rate for supply to end consumers, the government added a bonus of 50% for biomass, 70% for small hydro power plants and 90% for wind power (11). The costs of these contracts were collected from all consumers, except low-income consumers, through a levy.

The contracts also obliged investors to spend 60% of the project expenditures for supplies from local manufacturers. This restriction was intentionally established to boost the local labor market; however it created a deadlock for wind power since there has been only one local supplier at the introduction of PROINFA (12).

The financial support for deploying new plants was provided from various banks and funds, with almost half of the support coming from the Brazilian Development Bank (3.46 billion R$), which granted incentivized financing up to 80% of the eligible investments and allowing amortization over 12 years (initially 70% over 10 years). Other banks like BASA and different funds financed projects via the issuance of convertible debentures (8).

The projected development of the installed capacity of the RET under PROINFA can be obtained from Table 1. By the end of 2008, 144 power plants should have been contracted in total with PROINFA, 64 small hydro power plants, 27 biomass thermoelectric plants and 54 wind power plants which together amount to the projected 3.300 MW of additional installed capacity. The fixed prices were 157,5 US$/MWh for wind power, 96 US$/MWh for small hydropower and 70 US$/MWh for biomass (12) (9).

	Projected capacity expansion in MW by technology					
Source	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
Small hydro	132,34	151,00	483,60	398,60	15,70	1.181,24
Wind	208,30	10,20	93,45	810,17	300,80	1.422,92
Biomass	414,44	84,90	15,00	0,00	66,50	580,84

Table 1: Projected capacity expansion of RES (small hydro, wind, biomass) with PROINFA (8)

However, the projected development could not be achieved, due to various problems which occurred during the support period. The original plan to divide the additional capacities equally between the three mentioned RETs turned out to be not applicable, as biomass projects were deployed less than expected. The supplier selection process has been heavily criticized, because projects with older environmental permits had more priority in the selection stage which resulted in a black market for environmental licenses (12). Also the requirement for local manufactured supplies, in particular for wind power plants, was difficult to meet due to the lack of local companies and capacities providing the necessary supplies (particularly the turbine production was problematic). Grid connectivity turned out to be also problematic, in particular in the Midwest and Northeast regions. The program goals could not be reached in time, so PROINFA was extended and the deadline for construction was postponed to 2012. The actual additionally installed capacity on the basis of the PROINFA program in 2012 can be obtained from Table 2.

	Actual capacity in 2012 in MW (only PROINFA)
Small hydro	1152,4
Wind	963,99
Biomass	533,34

Table 2: Actual additionally installed capacity on the basis of PROINFA (13)

Initially PROINFA was designed with two stages; the first one being the deployment of 3.300 MW of additional installed RES capacity and the second one targeted at increasing the RES share of the three mentioned RETs up to 10% of the total annual electricity consumption within twenty years. However in 2004 a new government came to power which changed the power sector structure and introduced an auctioning system which will be described in the following chapter.

2.2.2 Electricity auctions and the 2004 reforms

In 2003, Luiz Inácio Lula da Silva was inaugurated as president and the new government introduced a new regulatory framework which switched from the PROINFA quota/feed-in tariff system to an auction system. Law Nº 10.848, which became effective on March, 15th 2004 defined a new electricity sector model dividing the wholesale market into two parts, the first one being the free market (ACL) and the second one being the regulated market (ACR). On the free market, contracts are directly signed between consumer and seller while on the regulated market (for example small costumers like households) prices have to be set by bids (14)(15). On both markets, all loads have to be fully covered by energy contracts. This rule is verified on a monthly basis by the CCEE, which certifies that the past accumulated 12 month-consumption (measured in MWh) does not exceed the agreed upon amount in the contract, otherwise penalties would have to be paid. Also all contracts have to be covered by a parameter called "firm energy certificate" (FEC), which indicates the physical coverage capability by the seller. This parameter is calculated by the MME using statistical methods and is based on the expected contribution of a power plant to the energy security of supply for a given supply reliability level (16)(17). Each plant is reviewed regularly (thermal power plants on a yearly basis, wind power and hydropower plants up to every 5 years and 4 years respectively) and in case of deviations from the calculated parameter, penalties (depending on the electricity source) can be charged. For the regulated captive market, contracts can only be procured via auctions, which are organized by the Brazilian electricity regulatory agency (ANEEL).

There are two types of auctions carried out by the government. Regular auctions are held for procurement of energy to meet the energy load of distribution companies. Reserve energy auctions are organized to increase the energy supply security and the costs are split among all consumers in both markets. The auctions are also divided by delay interval, which determines the allowed time-interval between contracting and delivery of electricity. There are currently three auctions with different time-intervals, the A1-, A3- and A5 auction, with a delay time of one year, three years and five years respectively. The objective of A1 auctions (also referenced as LEE), which are applied to already existing capacities, is to set the short- and medium term tariffs, while A3- and A5 (also referenced as LEN or LFA) auctions should introduce new generation facilities and therefore allow investors more time to establish new capacities. The contract durations vary depending on the auction type, A1 auction contract durations are decided by the government (between 1 and 15 years), while A3 and A5 long-term contracts are fixed at 15 years for thermal plants and 30 years for hydropower plants (17)(16). Also the contract types may vary. Standard financial contracts include an energy price bidding by the generator depending on his FEC and the seller has to provide the contracted volume of energy at the agreed upon price. Energy call options are an alternative to standard financial contracts, where the consumer pays a monthly fixed amount of $/MW for the plants availability and the consumer can (but is not obligated to) buy electricity at a determined strike price ($/MWh), which is comparable to a leasing-contract (16).

The electricity auction design for regular auctions consists basically of three steps. Before the actual auction, the EPE (Empresa de Planejamento Energetico (Energy Research Company)) collects potential projects for the auction, while the Ministry of Mines and Energy sets several parameters, namely initial price, price ceiling, forecasted demand, a reference supply, a price decrement and demand reduction rule (18). Those parameters are necessary for the auction process and only the initial price is revealed to the bidders. At the first stage, the bidders offer their proposal of how many megawatts (GWh/year/8760) they are willing to provide at the current price level (19). If the accumulated energy offer exceeds the confident reference supply, the price level is reduced according to the pre-set price decrement by MME and again offers are given by the bidders. The reference supply exceeds the forecasted demand by MME by a certain scaling factor (>1), so there is still enough margin left for price competition in the second stage. Once the bidding process reached the reference supply level, hence the quantity allocation process has finished, the second stage begins. This time, the generators have to bid their price for the contract based on the quantity determined in the first stage. The bids cannot exceed the price level determined in the first stage and the bidding is carried out simultaneously, so the generators do have an incentive to lower their prices. The winning bidders then are contracted with the proposed price from the second stage (19).

Reserve energy auctions are an option for governments to contract additional energy supply also if it exceeds the forecasted demand. The aim of reserve energy auctions is the increase of energy supply security and also the promotion of particular (renewable) technologies. The participation in this type of auction does not presuppose a FEC and the contract period is 15 years (except for wind power with 20 years). The auction is held to determine a fixed feed-in tariff and the costs for the contracted energy is to be paid by all consumers on both markets through a charge uplift (16). Reserve energy auctions are particularly interesting for generators without FECs who want to sell their product at fixed prices. FECs are difficult to calculate for wind power generators because the energy production is highly volatile and energy supply deviations from the FEC are penalized, hence reserve energy auctions are the better option for risk-avoiding generators.

The auction system turned out to be quite useful for decreasing electricity prices from RES by creating competition. For example the wind power prices in auctions of 2011 decreased to a third of the FIT paid by PROINFA. Similar, albeit not do drastic, developments are also visible for biomass (12).

2.2.3 Ten year plan for energy expansion

The “Plano Decenal de Expansão de Energia” is yearly published by EPE and focuses on the developments of energy demand, non-renewable and renewable electricity generation and transmission. This plan deals with various energy sources, non-renewable as well as renewable. Focusing on the RETs the following targets are defined in the current ten year plan (2012-2022) (20):

- Increase of hydro electricity capacity from currently around 85GW to 119GW in 2022
- Increase of wind power capacity to 17,463 GW in 2022
- Increase of biomass capacity to 13,769 GW
- Share of non-hydro renewable energy sources in 2022: 20,8%
- Expansion of the electricity grid

It is notable, that solar power is currently not considered as a contributing option to the electricity grid due to its relatively high costs. The solar energy potential however is high with a global irradiation between 1.200 and 2.400 kWh/m²/year, which exceeds the potential in countries with already existing significant solar capacities such as Germany and Spain. The costs for both, photovoltaic and solar thermal plants are currently higher than those of wind and hydropower and therefore not competitive. However, falling prices of photovoltaic technology may increase the feasibility of solar power so that market entrance is possible within the next ten years (20).

The ten year plan foresees investment expenditures of 200 billion R$, equivalent to around 90 billion US$ (20). The expenditures for new plants are predicted with 122 billion R$ (approx. 55 billion US$), 61,3% of this sum for the deployment of hydroelectric plants, 37,6% for small hydropower, wind power and biomass. The remaining 78 billion R$ (35 billion US$) are already assigned to authorized plants contracted in auctions with 43,5 % of this amount for hydropower and 45,2% again for small hydropower, wind and biomass (20).

Besides electricity generation, the ten year plan also discusses in detail the Brazilian electricity transmission system as well the effects of the deployment of new capacities on the society. Biodiesel and ethanol is also addressed within the plan.

2.3 Electricity sector in Russia

The renewable electricity share in Russia has been almost constantly around 20% throughout the past two decades. The development of the electric energy mix in Russia since 1992 can be obtained from Figure 4. It must be also noted though, that the overall electricity generation (from RETs and non-RETs) also remained fairly constant within a boundary between 800 and 1000 TWh; in this regard, Russia forms an exception within the BRIC countries. The share of nuclear power also increases constantly and its extension is also a major part in the energy strategy of Russia 2030 (21).

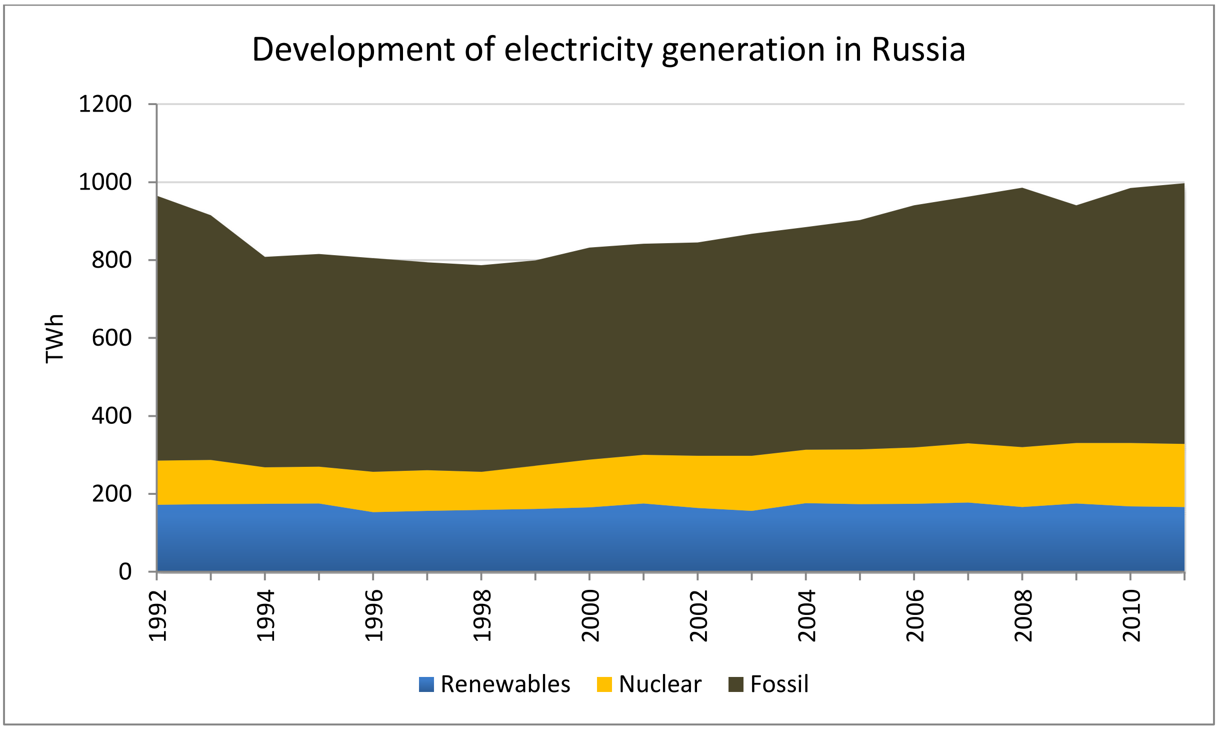

Figure 4: Development of renewable and non-renewable electricity generation in Russia (Source: own compilation on base of (7))

Like in all four BRIC countries, the major renewable electricity source in Russia is hydropower with a share among the RETs at currently 98%. The electricity shares in Russia in 2011 can be obtained from Figure 5 which clearly shows the dominance of fossil, nuclear and hydro-electricity in Russia. Among the non-hydropower RETs, there are some biomass and geothermal electricity capacities, however at very low level although Russia has the highest biomass and geothermal electricity generation potential among BRIC countries (6). However at present these potentials are left almost untapped.

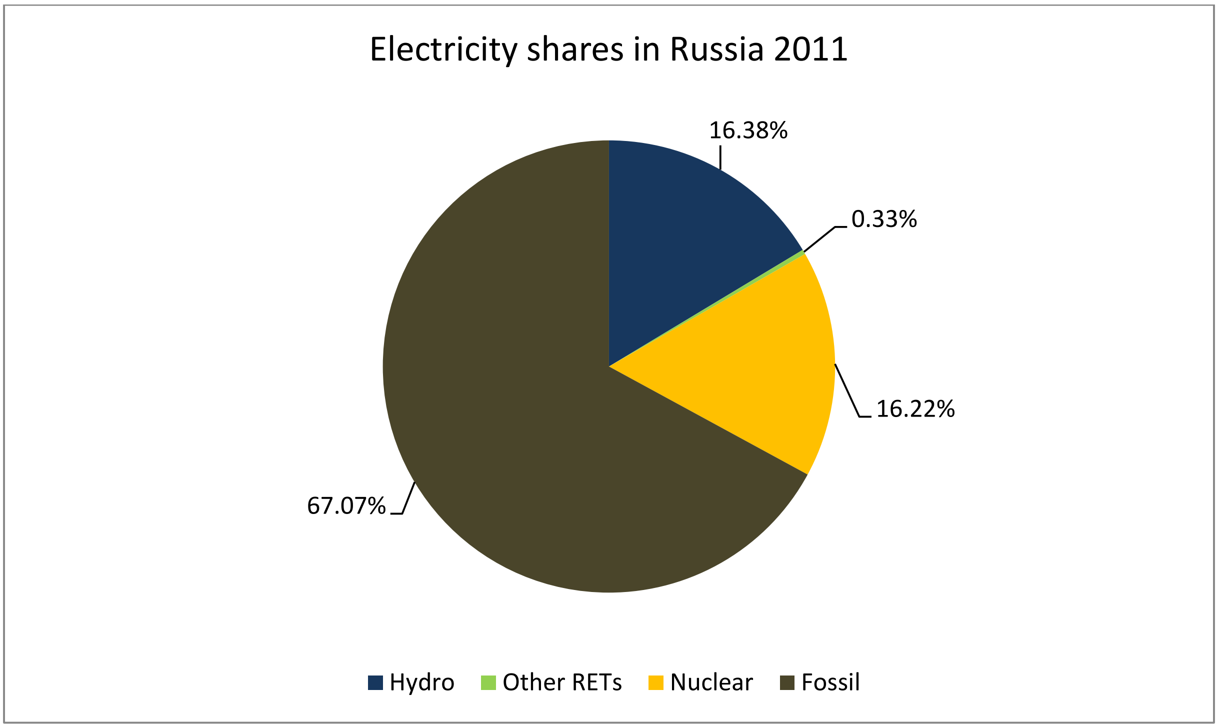

Figure 5: Electricity shares in Russia 2011 (Source: own compilation on base of (7))

Russia has vast fossil resources and also low fuel costs and therefore the majority of electricity is generated from coal, oil and gas (164.348 GWh, 27.362 GWh and 519.202 GWh respectively) (22). Regarding the extension of renewable electricity and the reduction of fossil fuel use, the energy strategy 2030 sets several strategic initiatives (21):

- Deployment of nuclear power plants in the European part of Russia
- Deployment of hydropower plants in the Eastern region
- Large-scale energy savings and increase of efficiency of energy generation
- Development of other RETs

The share of non-fossil electricity production (that is nuclear and renewable electricity) should be increased from currently 32% to at least 38%.

As the world leader in gas exports and the third-largest oil producer in 2012, the dependency of the Russian economy on conventional energy sources is very high. Coal, gas and oil as well as nuclear energy will remain the key aspects of the energy policy in Russia in the future as the energy strategy 2030 shows.

2.4 Policy situation in Russia

The energy strategy only sets guidelines for the energy policy development. Russia has one distinct support mechanism for renewable electricity, the “Decree No. 449 on the Mechanism for the Promotion of Renewable Energy on the Wholesale Electricity and Capacity Market” (23) issued on May 28th 2013 by the Government of the Russian Federation. The decree is an amendment to the federal law No. 35-FZ “On the Electric Power Industry” from March 26th 2003 and basically acts as a capacity-based RES-E support scheme. The second important state program for the electricity sector is the program on energy conservation and energy efficiency for the period up to 2020, which became effective with the approval of decree № 2446-p in December 2010 and foresees an investment of 9,5 trillion rubles for energy saving programs (24). According to this program, renewable energy sources (except hydropower plants with an installed capacity larger than 25 MW) should generate 4,5% of the total electricity (import and export not included).

2.4.1 Decree No. 449 on the Mechanism for the Promotion of Renewable Energy on the Wholesale Electricity and Capacity Market

The decree No. 449 came into effect on June 11th 2013 introducing a rather unconventional support mechanism for RES-E, since it is based on capacity supply and not on electricity output of RE facilities. It applies on the liberalized electricity wholesale market zones in the western and southern parts of Russia; non-price regions (with regulated wholesale markets) and isolated regions (Kaliningrad, Arkangelsk, Komi and the Far East) are not covered.

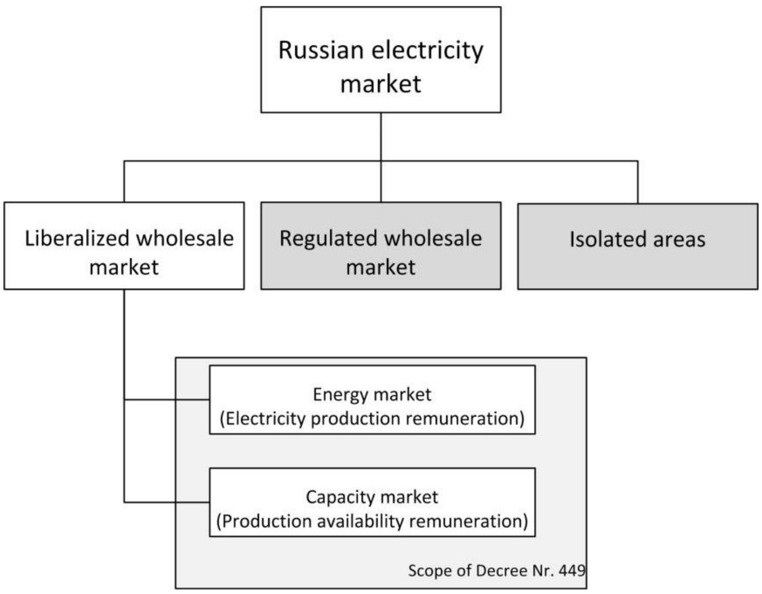

Figure 6: Russian electricity market structure (Source: own compilation)

As shown in Figure 6 the liberalized wholesale market consists of the energy market, which again is divided into two price zones (zone 1 (European Russia and the Urals) with a trade volume of 80% on the spot market and zone 2 (Siberia) with a 20% trade volume on the day-ahead spot market) (25) and the capacity market. Decree Nr. 449 primarily targets investors on the capacity market but also bases the capacity remuneration price paid to the investor partly on the expected revenue of the supported project on the energy market.

The basic support scheme concept of Decree Nr. 449 is shown in Figure 7. The selection process for new RE technology investments and projects to be supported by capacity payments is coordinated by the Administrator of the Trading System (Администратор торговой системы, ATS), which organizes the wholesale market trade of electric energy. The process is carried out in two rounds. In the preliminary round, potential investors have to submit a bid with several project relevant information such as utilized RE-technology, (planned) capital costs, share of locally produced contents etc.. Only projects with a projected installed capacity above 5 MW (which is the lower limit for wholesale market participants to enter the market) are allowed to take part in the support scheme. Also a variety of limitations have to be considered, particularly the capital cost limit which is defined by the Government for each RE technology for each year. Also the operating costs are set by the Government; however these costs are only relevant for the capacity payments and not subject to competition in the selection rounds. The local content requirements are also set by the Government for each technology. Failures in achieving the demanded share of locally produced components are penalized by reducing capacity payments (23).

Projects which fulfill the requirements in the preliminary round are selected by the ATS and enter the second round. The ATS may only accept projects, if the cumulative amount of newly installed capacity does not exceed the limits for RES capacity set by the government. In case of a capacity surplus, projects with the lowest capital costs are selected by the ATS (23).

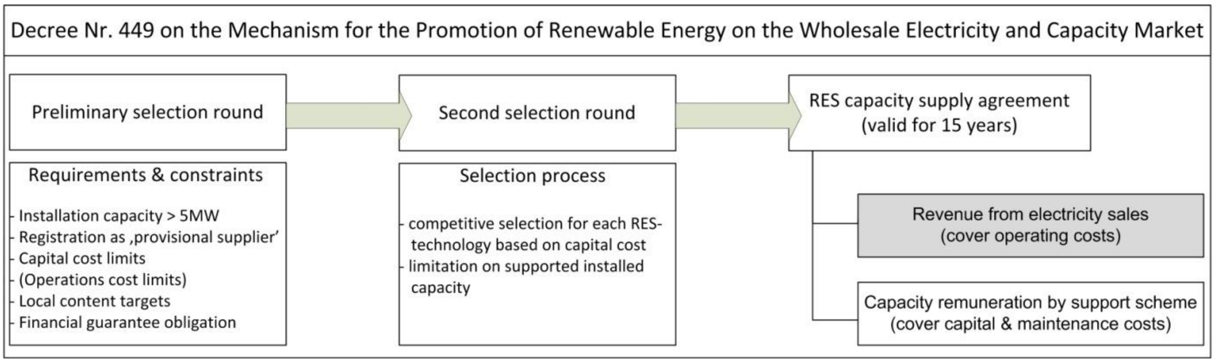

Figure 7: Project selection process set by Decree Nr. 449 (Source: own compilation)

Once an RES project is accepted by the ATS, a RES capacity supply agreement can be signed. The contract obligates the investors not only to supply a certain minimum amount of electricity (determined by a capacity factor), but also to interrupt the supply if ordered by the System Operator.

This requirement applies specifically to RE technologies taking into account the high volatility of RES electricity generation due to uncontrollable (weather-related) factors. In contrast to RE technologies, conventional plants such as thermal power plants have to guarantee to be available with a certain supply rate on a hourly basis when ordered by the System Operator, which can be very challenging for RES.

The period duration of capacity supply agreements under the support scheme is 15 years. In this timeframe, the capacity of the newly installed plants is remunerated at a certain capacity price, which is calculated in three steps as shown in Figure 8.

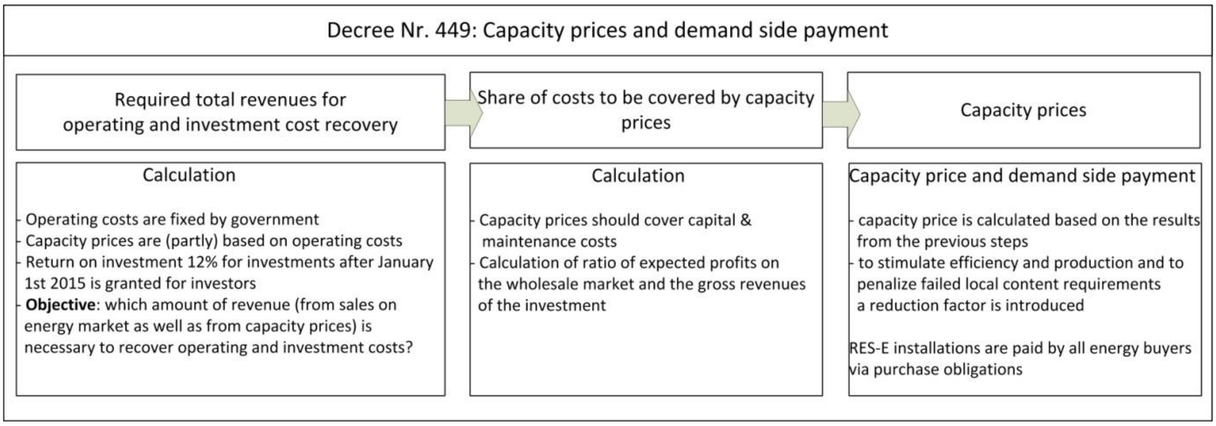

Figure 8: Capacity price determination (Decree Nr. 449) (Source: own compilation)

As a first step, the ATS has to calculate the total revenues required for a project to cover the operating and investment costs. Also, "Decree No. 449 indirectly provides investors with the right to recover the investment costs set out in their bids, together with a certain return on investment, as well as standard operating costs."[4] The basic rate of return on investment is set in Decree Nr. 449 and amounts 14% for power generating facilities selected by the ATS and operating before January 1st 2015 and 12% for facilities operating after January 1st 2015 (26).

In the second step, the ratio of the expected wholesale market profits and the gross revenues of the power-generating facility are calculated. The expected earnings in year i are calculated with the following formula (26):

$$\Pi_i = CF \cdot T_i \cdot (\frac{FP_i}{CC} - EPC)$$

[4] (23) p. 14.

where:

Π_i...Forecasted earnings in year i

CF...Capacity factor (equals ratio of actual output to potential output and amounts 0,14 for solar power, 0,27 for wind power and 0,38 for hydropower)

T_i...number of hours in year i (8784h for leap years and 8760h for other years)

FP_i...forecasted wholesale market price based on bids from buyers and suppliers

CC...consumption coefficient

EPC...fixed electricity production costs (1 rub/MWh for solar- and windpower, 10 rub/MWh for hydropower)

Finally, the capacity price paid to investors under the support scheme is depending on the two values calculated in the previous steps and can also drop due to penalties (in case of a shortage of locally produced components or insufficient electricity supply).

The support scheme is paid by energy buyers on the wholesale market via a quota obligation introduced with article 21 §2 of the Federal electricity law (27).

Since the developments in the policy framework for renewable energy in Russia are still in the initial stage, the effects of those measures have to be analyzed at a later point in time.

2.5 Electricity sector in China

Chinas electricity mix is currently relying strongly on non-renewable energy with an 80% share of fossil fuels, in particular coal as China has huge resources of hard coal (5.010.000 Mt)(28). Since the first RES policies were introduced in 2003 the electricity generation from renewable energy continuously rises, however the demand increase for electricity exceeds the growth of RES which leads to a dynamic rise of fossil fuel demand. Figure 9 shows the development of the electricity mix in China from 1980 to 2011. In just ten years the electricity generation rose fourfold from 1000 TWh in 2000 to around 4000 TWh in 2010. Fossil fuels accounted for 80% of the total electricity generation in 2011 (3595 TWh), while large hydropower was the second largest producer with a share around 15% (see also Figure 10). Other renewable energy sources were almost negligible with a share of just 2,5%, however onshore wind power showed a strong increase recently.

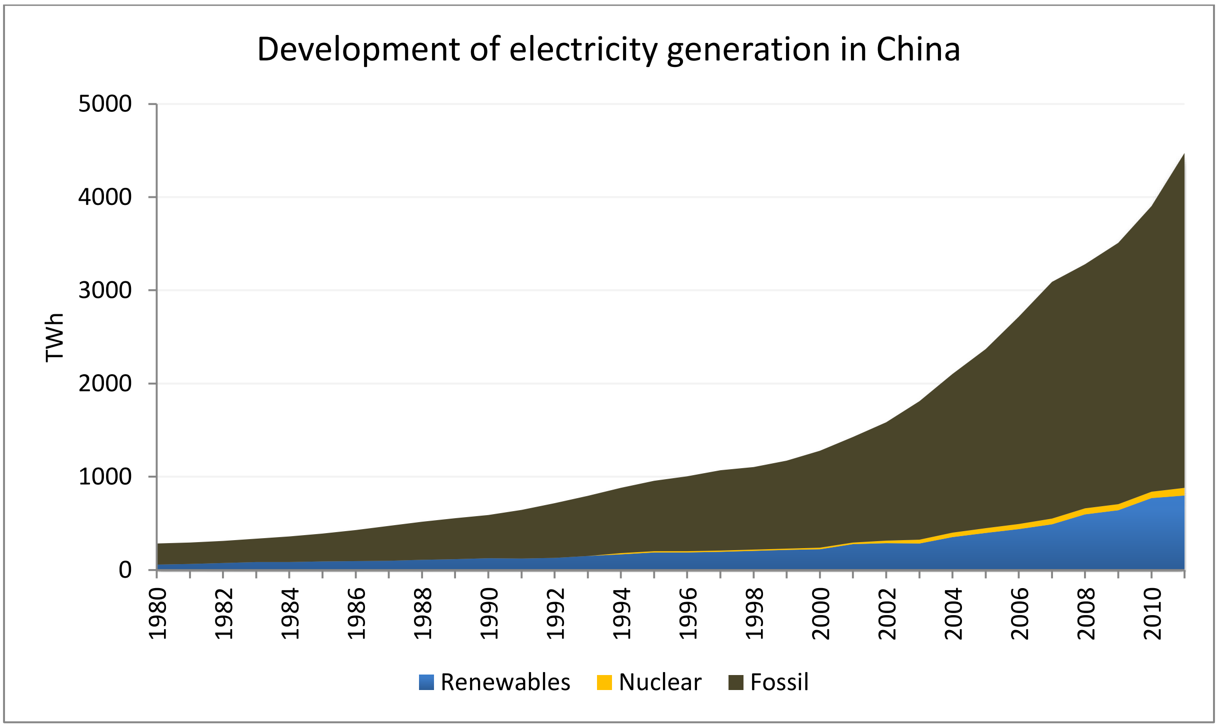

Figure 9: Development of renewable and non-renewable electricity generation in China (Source: own compilation on base of (7))

Within renewable energy sources, hydropower is the main source in China with a share of approximately 86%. Small hydropower, in China defined as hydropower stations with less than 5 GW of installed capacity, accounted for nearly 160 TWh in 2009 which reflect 30% of the total hydropower generation in this year (29).

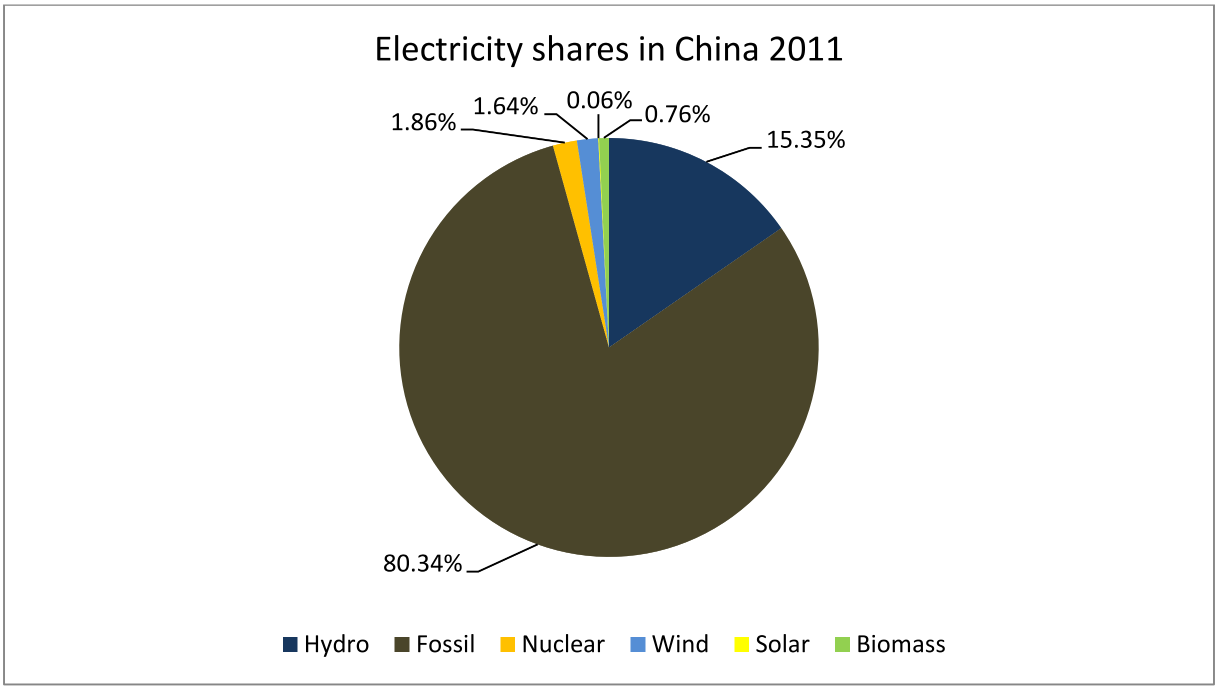

Figure 10: Electricity shares in China 2011 (Source: own compilation on base of (7))

Most recently the deployment of wind power and solar PV in China gained momentum through high volume investments and governmental support programs, so a strong increase of the non-hydro renewable share is to be expected within the next years (see also Figure 11). This is also reflected in the targets for the twelfth five-year plan, where wind power is considered as the second largest renewable energy contributor behind hydropower in 2015.

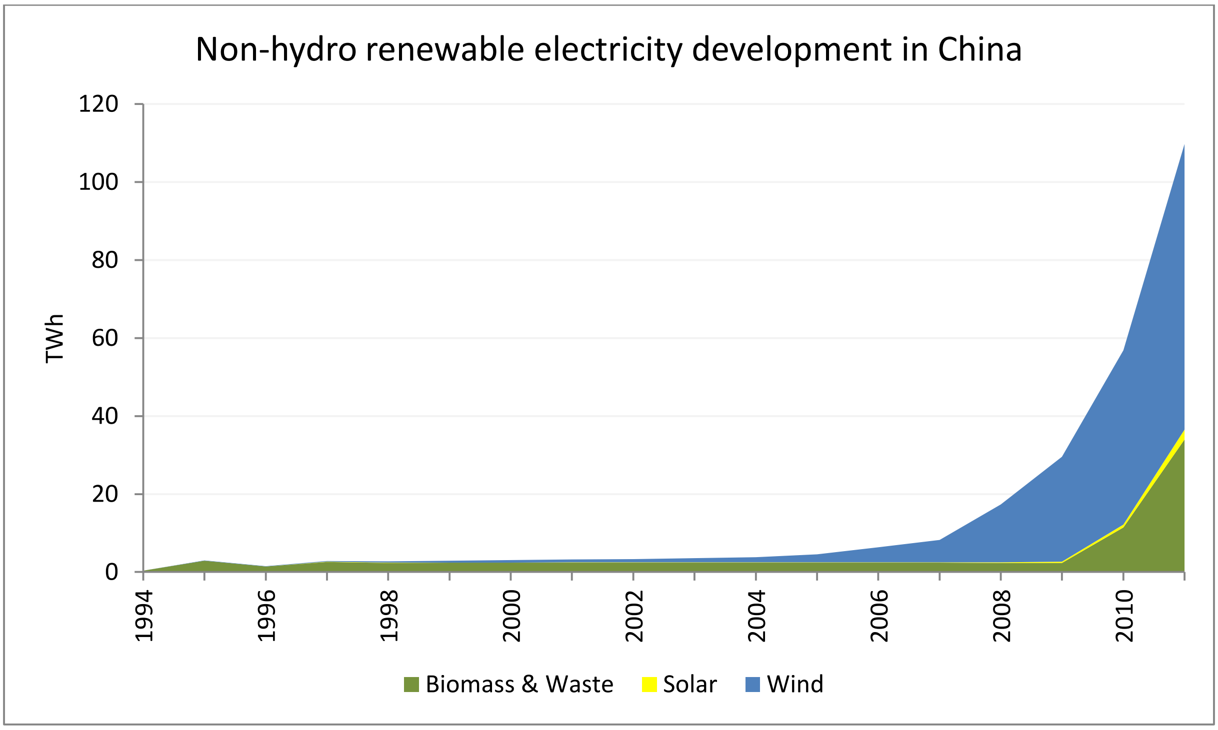

Figure 11: Development of non-hydro renewable electricity in China (Source: own compilation on base of (7))

2.6 Policy situation

China has a large number of RES-E support schemes targeting at multiple RE technologies, in particular wind-, solar-, hydropower and biomass. Since 2011, the twelfth five-year plan for renewable energy is in force, which sets the targets for the installed capacity of several RES technologies as shown in Table 3.

RES technology	Additional capacity until 2015 in GW
Hydro	61
Wind	70
Solar	20
Biomass	7.5
Geothermal	0.1

Table 3: China Twelfth five year plan targets (30)

Mainly three types of policies are applied in China (31):

1. Feed-in tariffs
2. Renewable portfolio standards (RPS)
3. Subsidies

Due to the high number of RES support schemes and programs currently in force, only a selection of the most important policies will be discussed. Figure 12 gives an overview of the main support measures for RES in China.

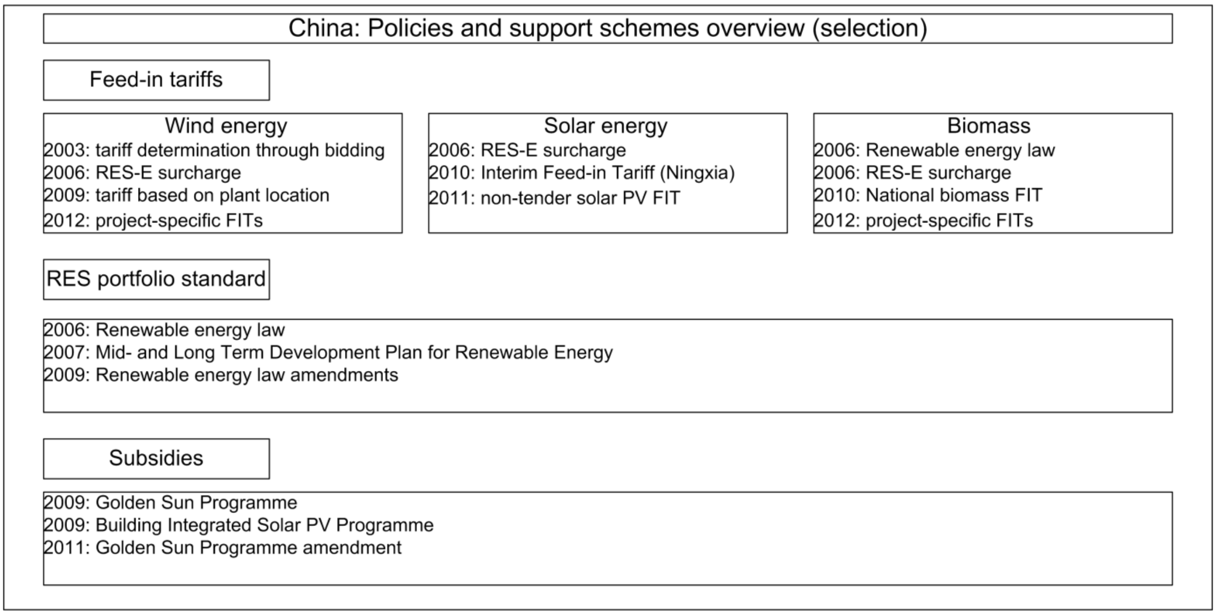

Figure 12: Selection of policies and support schemes in China (Source: own compilation)

2.6.1 Feed-in tariffs in China

China has implemented feed-in tariffs mainly for three RE technologies:

1. Wind power
2. Solar PV
3. Biomass

Wind power FIT

The first FIT was introduced with the wind power concession program in 2003 for large-scale wind power plants (100-200MW). The tariff was determined for each project individually by bidding and its amount depended on the proposed electricity generation price and on the share of locally produced components. The FIT payment duration was set for 30.000 full load hours (equivalent to approximately 10-15 years); after this period, the average current local FIT will be paid (32). One disadvantage with this type of FIT was the high competition among generators, which led to speculative bids (33).

In 2009 the FIT scheme was changed by the NDRC (National Development and Reform Commission) and tariff prices were set depending on the wind power plant location. The NDRC distinguished four separate regions with different FITs (depending on wind resources and investment frameworks) and the set tariffs amount to 0.51, 0.54, 0.58 and 0.61 Chinese yuan (RMB) per kWh (33).

In 2012 the Ministry of Finance, the NDRC and the NEA (National Energy Administration) launched a tariff subsidy program, which will affect new wind power and biomass projects. The first support batch includes over 200 projects and 912 MW of new installed wind power capacity (34).

Offshore wind power is still in its inception phase and is supported by tendering. The bidding prices are higher than the onshore FIT and vary between 0.62-0.74 RMB/kWh (35), however the deployment of offshore wind power is still very limited with a cumulated installed capacity of 389.6 MW in 2012.

Solar PV FIT

The national FIT for non-tendered solar PV was set by the NDRC in 2011 and amounts to 1 RMB/kWh for projects which started in 2011 or later and 1.15 RMB/kWh for projects which went online before 31st December 2011. For tendered solar PV projects, the bidding price cannot exceed 1 RMB/kWh (32)(31). This tariff scheme was revised with the issuance of the NDRC's "Notice on Improving the Development of Solar PV Industry by Utilizing the Price Leverage Effect"(36). The revision takes into account, that the level of solar radiation differs within the regions (the western regions benefit from higher irradiance but are also low-populated which makes grid-connection difficult and expensive) and similar to the wind power FIT scheme from 2009, the revised tariff scheme distinguishes between three area-types with different tariffs (0.9 RMB/kWh for Type I-areas with high irradiance, 0.95 RMB/kWh for Type II areas and 1 RMB/kWh for other areas) (36).

A special tariff was set by the NDRC in 2010 for four large solar PV plants (40 MW capacity) in the Ningxia region with 1.15 RMB/kWh (32).

Biomass FIT

In 2010 the NDRC increased the feed-in tariff (runtime of 15 years) from 0.25RMB/kWh introduced as part of the Renewable Energy law in 2006 to 0.75RMB/kWh (35). Also 48 biomass projects with a total installed capacity of 78.5 MW were included in a tariff subsidy program (34).

2.6.2 RES-E surcharge

In addition to FITs, in 2006 a renewable electricity surcharge was introduced by the NDRC. Initially the surcharge amounted to 0.001 RMB/kWh and was increased in 2009 (0.004 RMB/kWh), 2011 (0.008 RMB/kWh) and recently in September 2013 (0.015 RMB/kWh) (31)(32).

2.6.3 RES portfolio standards

In 2007 the “Mid- and Long-Term Development Plan for Renewable Energy” was issued by the state council and introduced a “Mandatory Market Share”[5] which required grid companies and generators to procure 3% and 8% respectively of non-hydro renewable power in 2020 (1% and 3% in 2010) (37). Due to several problems (non-existing monitoring and focus on installed capacity but not generation which led to underdeveloped grid-integration of wind farms and the failure of half of the 14 generators to meet the specified targets), a plan change draft (Regulations for Management of Renewable Power Quotas) was issued in 2012. It obliges the largest 14 power generators to a non-hydro renewable energy share of 6.5% of their total electricity generation (instead of installed capacity), the four grid companies to purchase a share of non-hydro renewable electricity (between 4.8% up to 9.9%) and it will also establish province-level renewable electricity consumption targets (approx. 5%). The progress in reaching the set targets will be monitored by the NEA (National Energy Administration). However, this update on the plan is still in discussion in 2013 (37)(31).

2.6.4 Renewable energy law

The Renewable Energy Law introduced the first RES promoting framework in China in 2006. It defined a RES target and implemented a feed-in tariff system particularly for RES. It also required grid companies to purchase electricity from RE generators and the provision of grid connection.

[5] (35), S. 92.

The issuance of the Renewable Energy Law tremendously pushed forward the installed wind capacity, which increased from approximately 4 GW in 2006 to 73.2 GW in 2011. However, several problems occurred with this fast growth like poor grid connection of wind power plants due to lack of coordination between generators and grid companies, which led to reduced electricity output. Therefore, in 2009 the National's People Congress (NPC) passed amendments to the Renewable Energy Law which added an enhanced renewable power generation quota system and improved the payment system for RES incentives through a special fund (37).

2.6.5 Subsidies

Subsidies are mainly granted for solar PV projects. China has implemented two large subsidy programs, one being the Building Integrated Solar PV Program established in 2009 and the other being the Golden Sun demonstration project also from 2009 with amendments passed in 2011. The Building Integrated Solar PV Program is targeted at grid-connected rooftop and building integrated solar PV projects. It provides subsidies based on the installed capacity of the respective project, which are determined on an annual basis. The premiums decrease each year since the costs of PV are declining. In 2009, the premiums amounted to 20 RMB/W for building integrated PV and 15 RMB/W for rooftop PV and decreased to 9 RMB/W and 7.5 RMB/W respectively (31).

The Golden Sun program subsidizes grid-connected and also off-grid solar PV projects. In the first version, the program offered a subsidy covering 70% of the installation costs for off-grid PV and 50% of installation, transmission and distribution costs for grid-connected PV systems (restricted to a maximum of 20 MW per province). In 2011 amendments were added to this program, which switched to a tariff scheme with 5.5 RMB/W for on-grid and 7 RMB/W for off-grid systems (31)(32).

2.7 Electricity sector India

The developments in the electricity sector of India are quite similar to China, although on a much lower scale. In 2011 the renewable energy share was 16.4%, mainly thanks to hydropower, however a strong increase of fossil fuel use for electricity generation is evident in Figure 13. The energy deficit in India amounts 9-11%, so despite the heavy use of conventional energy (coal, gas and oil) the electricity demand exceeds the growth in supply.

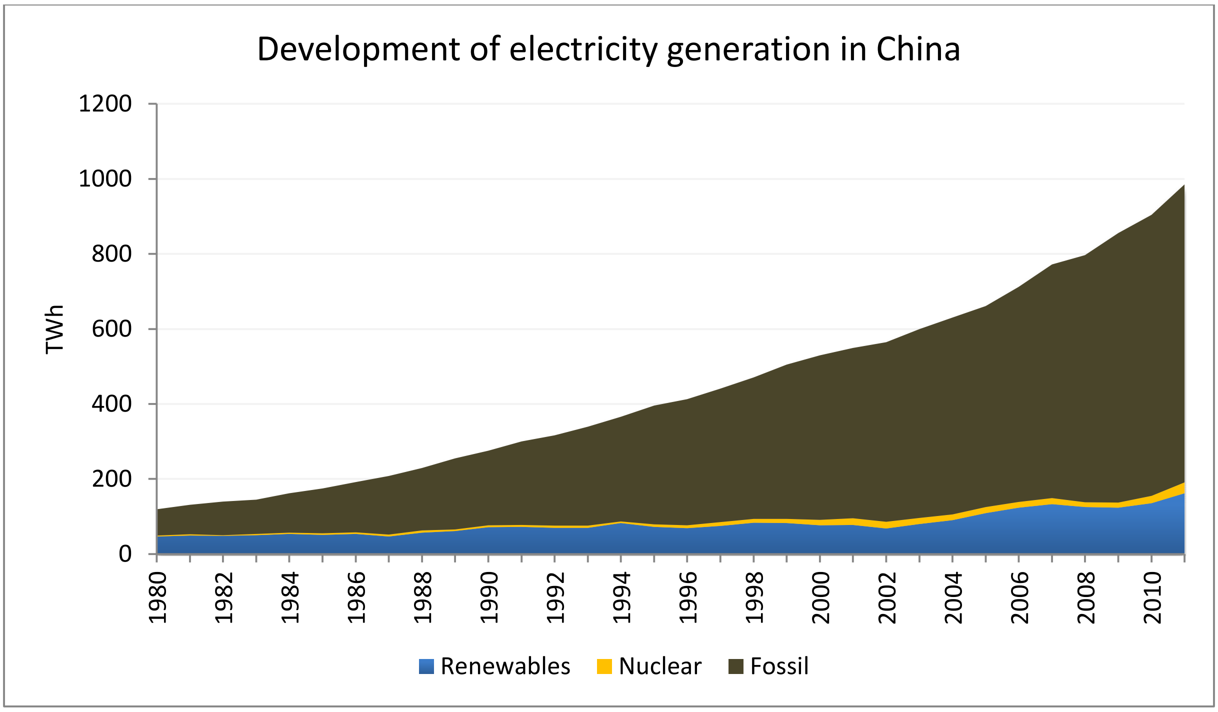

Figure 13: Development of renewable and non-renewable electricity generation in India (Source: own compilation on base of (7))

As in all BRIC countries, hydropower is the largest provider of renewable electricity, however most recently, wind power and solar PV developed rapidly because of several governmental initiatives. The electricity mix from 2011 can be obtained from Figure 14. Non-hydro renewable technologies turned up in the early 2000s with the introduction of the Electricity Act and since 2006 the deployment rate of wind power and solar PV took off, which were accountable for almost 20% of the total renewable electricity in 2011.

India faces some difficult and important issues, the major being the access to electricity. 200.000 villages, which account for one third of all villages in India, did not have access to the electricity grid in 2013. In other words, 600 million Indians suffer from lack of access to the electricity grid (38). Electricity access is one of the key issues in India and renewable electricity technologies such as solar PV could provide a sustainable solution for the coverage of rural areas.

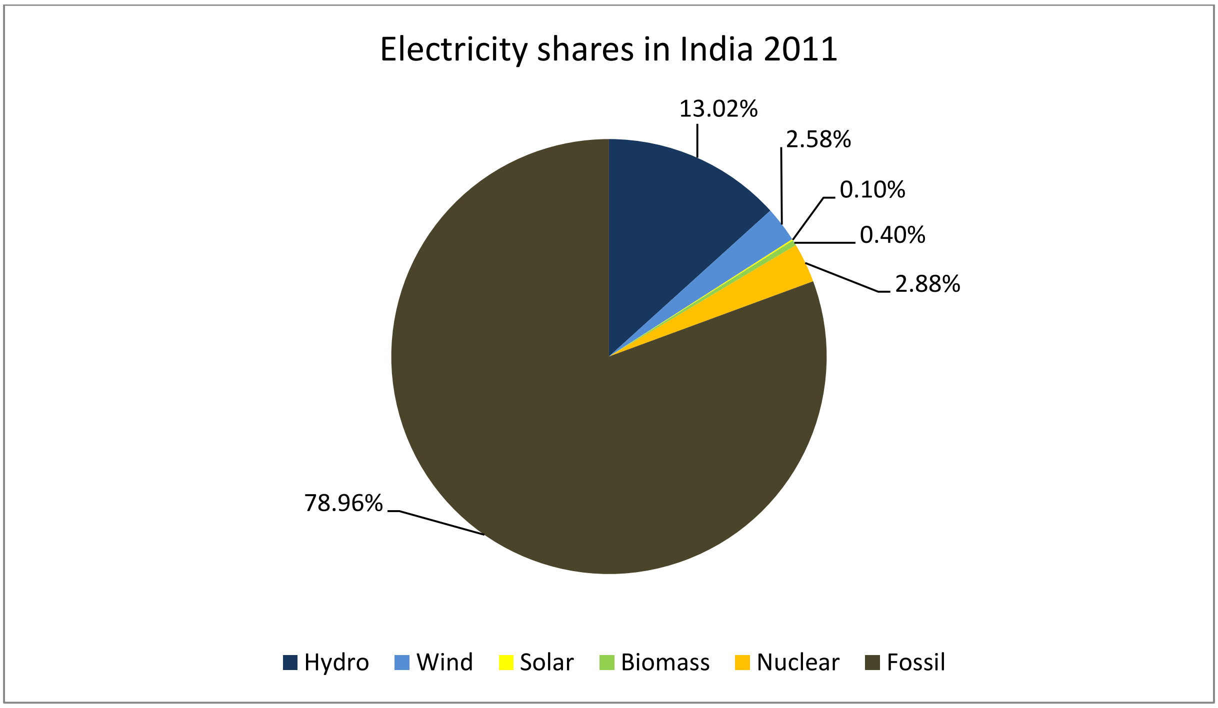

Figure 14: Electricity shares in India 2011 (Source: own compilation on base of (7))

Wind power, as can be seen in Figure 15, is by far the most dominant technology among non-hydro RETs with a non-hydro-generation share of more than 80%. Since 2010 when the Jawaharlal Nehru National Solar Mission was introduced in India, solar PV has gained tremendous momentum and the installed capacity doubled within one year in 2012.

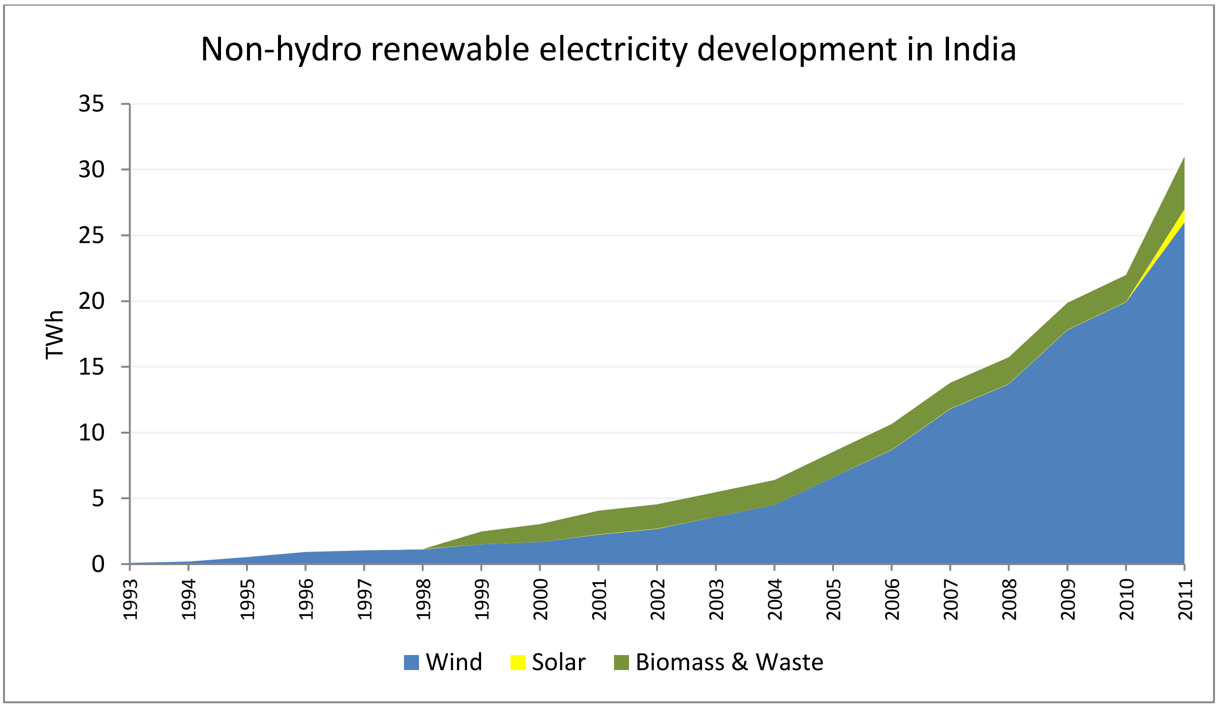

Figure 15: Development of non-hydro renewable electricity in India (Source: own compilation on base of (7))

2.8 Policy situation in India

Like China, several RES-E support policies are currently in force in India, particularly for wind power, solar PV and solar thermal power. The 12th five-year-plan currently in force (2012-2017) furthermore focuses also on biomass/bagasse power and small hydro power plants and the targets defined in the FYP are shown in Table 4.

RES technology	Additional capacity until 2017 in MW
Small hydro	2.100
Wind	15.000
Solar	10.000
Biomass & Bagasse	2.700

Table 4: India - Twelfth five year plan targets (39)

In 1992, the Ministry of Non-Conventional Energy Sources which was renamed in 2006 to Ministry of New and Renewable Energy (MNRE) was established, which marks the starting point for renewable energy development in India (besides large hydro power plants, which already existed earlier). An overview of some support schemes is given in Figure 16.

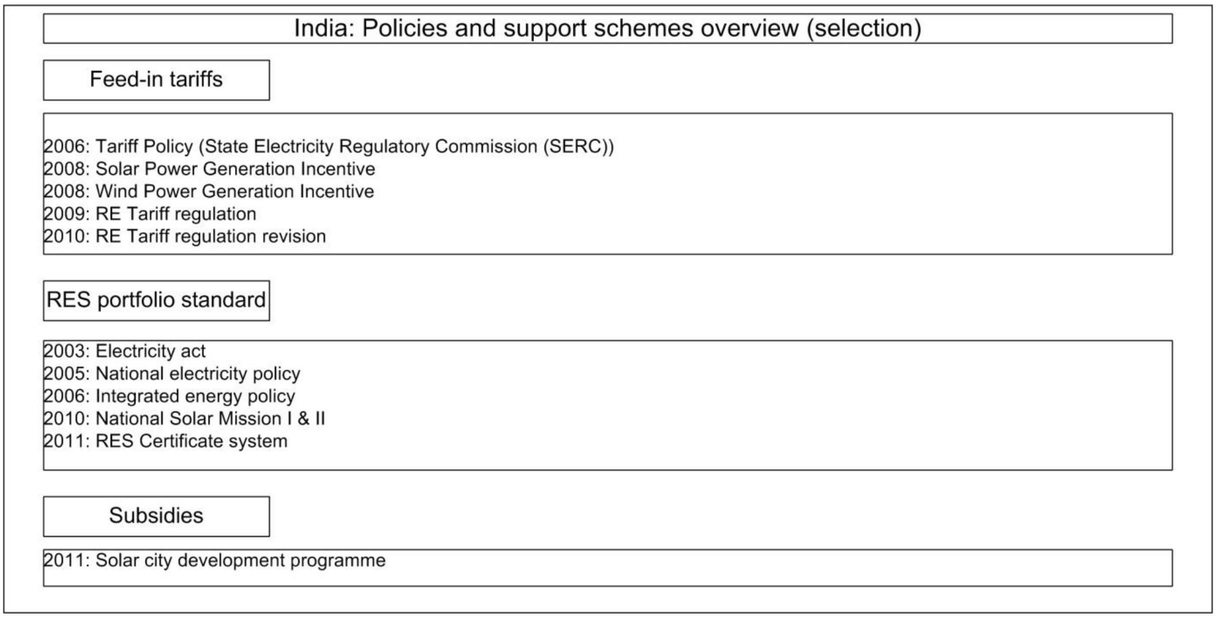

Figure 16: Selection of policies and support schemes in India (Source: own compilation)

It must be noted, that India has a very large number of RES-support policies implemented on state level (which can be tracked at: http://www.ireeed.gov.in) and this thesis limits its analysis to a few central and country-wide applied measures.

2.8.1 Feed-in tariff

The tariff policy was introduced in 2006 and established a new RES support system by implementing a renewable power purchase obligation along with a preferential tariff system (40). Together with the Electricity Act 2003 those two policies were the key drivers for the beginning of RE growth in India.

For wind and solar power in particular, India has introduced generation based incentives (GBI). Wind power plants connected to the electricity grid were incentivized with 0.5 Rs. per kWh with a ceiling of Rs. 10.000.000 (equivalent 138.000 US$) per MW in ten years, solar power with Rs. 12.41 per kWh (38) (41). For wind power, the plant has to feed electricity into the grid for at least 4 years. The GBI for wind power was in force from 2009-2012 and has been reinstated in 2013 (42). In the strategic plan for 2011-2017 issued by the Ministry of new and renewable energy (MNRE) it is explicitly stated, that the expenditures for the GBIs should be reduced by the implementation of RPOs and RECs (43).

The Central Electricity Regulatory Commission (CERC) which sets guidelines for tariffs for power companies has also set a feed-in tariff for generated electricity from wind power which differs within the states and depends on economic factors such as loan interest rates, operation & maintenance expenses, depreciation as well as on location and resource based criteria such as wind power density (44). The tariff for the majority of wind electricity suppliers, however, is set by thirteen State Electricity Regulatory Commissions (SERCs) which altogether determined 22 tariff rates for 13 states. The states of Haryana, Maharashtra and Uttarakhand are sub-divided into four tariff regions each. The tariffs vary between 3.20 Rs./kWh (0.06US$/kWh) and 6.14 Rs./kWh (0.115 US$/kWh) (41). Detailed data on those tariffs including the application area are obtainable from the appendix.

2.8.2 Renewable Portfolio Standard

The Jawaharlal Nehru National Solar Mission was introduced in 2010 by the Indian Government. Its objective is the deployment of 20 GW of solar energy within the country by 2022, both on centralized (grid-connected) and decentralized (offgrid) level, the installation of 20 million solar lighting systems in rural areas, the increase of solar thermal collector area to 20 million square meters and the establishment of local solar technology manufacturers. Through research and development and large-scale deployment, the objective is to reduce the solar costs to grid parity. The mission consists of three phases, where each of those phases is evaluated in terms of progress, capacity increase and technological and financial aspects. The target for the first phase (2010-2013) is the deployment of 1-2 GW of installed solar power capacity, phase II (2013-2017) aims at 4-10 GW additional capacity and finally at the end of phase III in 2022 a total of 20 GW new cumulative installed capacity is targeted.

The deployment of solar power plants is promoted through Renewable Purchase Obligations together with a solar tariff system which was fixed at US$ 0.36/kWh as a biennial FIT for 2010-2011

(45). With incentives and government pilot programs, local manufacturers should be attracted to deploy their production in India. Those incentives would include zero import duty on material and equipment, attractive loan conditions, etc. The required funds are provided from the national budget as well as from UNFCCC framework funds (46). The government provided 189 million US$ for the National Solar Mission in 2010/2011 (38).

2.8.3 Renewable Certificate System

A REC-system has been implemented in 2011 in addition to the RPO. RECs are market-tradable commodities which reflect the amount of energy produced from RETs and are intended to enable states to meet their RPO either by electricity generation from RES or by buying RECs. In particular, for states with low potential for renewable energy harnessing, RECs make it easier to fulfill the RPOs and simultaneously states with high renewable energy potential reduce their purchase costs for renewable energy (45). Several institutions and agencies are responsible for REC market activities. The Central electricity regulatory commission (CERC) provides the regulatory framework for the REC system in India and determines inter alia price floors for REC trading. To avoid extreme price fluctuations (low prices due to certificate-surpluses or overcharging due to low energy supply), the CERC has introduced a price floor between US$ 0.24/kWh and US$ 0.32/kWh (45). RECs are issued by the National load dispatch center (NLDC) for each MWh generated from RETs which is fed to the electricity grid. RECs can be traded at exchanges, such as the Power Exchange of India Limited (PXIL) and the Indian Energy Exchange (IEX) (47). As already mentioned, RPOs are the drivers for REC trading. The RPO targets in 2012-2013 ranged from 1% in Meghalaya up to 10.25% in Himachal Pradesh. The performance of the REC market system after one year was mediocre. The number of RECs issued to renewable energy generators was around 850.000, which corresponded to approximately 2.5% of the total RPO obligation. Some issues in the establishment and performance of the REC market are uncertainties regarding REC demand and difficulties with the estimation of return for power generators (47). Currently FITs are favored by power generators and investors since they provide more security regarding the return on investments.

2.8.4 Tax benefits

For wind power one important tax benefit, the accelerated depreciation was in force until 2012. Accelerated depreciation allows companies or asset owners to write off the asset value much more quickly and thus lower the taxes to be paid. The accelerated depreciation was applied to wind power projects and accounted for a significant share of deployed wind power capacity in India, which becomes clearly visible when analyzing the investment and deployment developments after 2012. The accelerated depreciation for wind and solar power was 80% and has been reduced for wind power to 15% (48).

3. Policy effectiveness and efficiency analysis

3.1 Brazil

The main drivers for the development of renewable electricity in the last decade in Brazil were basically two governmental policies. PROINFA, established in 2002 under the Cardoso presidency, was the first policy to support other RETs than large hydropower plants and based on a feed-in tariff scheme in combination with some quota obligations. With the new government under President Lula da Silva the auction system was introduced in 2004 together with a restructuring of the Brazilian electricity system. Together with those two policies, several other programs were implemented, for example the "Luz para todos" electrification program, which was launched in 2003 following the "Luz para Campo" and PRODEEM programs and focused on the electrification of rural areas through network expansion, however the influence of those programs on the actual RET capacity installments are passive.

The developments in renewable energy deployment in Brazil for the period 2006-2012 can be obtained from Figure 17. Hydropower capacity deployments exceeded those of all other technologies, however wind power deployment gained momentum recently. It also has to be noted, that large hydropower plants also contributed to the high deployment rate of hydropower in comparison with wind or biomass, which may distort conclusions on the performance of policies for non-hydro technologies. Large hydropower projects have significantly lower LCOEs than other RETs (49) and can already compete with conventional energy sources, however the Brazilian government aims to diversify the energy mix as mentioned before, to reduce the dependency on weather variations. Biomass with its heavy use in the mobile sector, where the ethanol blend requirement for gasoline amounts 25%, shows a more volatile development in the electricity sector.

Focusing on the non-hydro renewable electricity sector, the installed capacities of biomass and wind power are shown in Figure 18. Wind power shows a more dynamic trend but has also experienced some struggles most recently due to construction delays of transmission lines and sub-stations together with a weak economy resulting in lower investments. Nonetheless higher investments and deployment rates are expected within the next years (50).

It is notable that solar power has not shown any noteworthy developments in the past years although Brazil has many high-solar-irradiation areas and far better conditions than for example Germany, which remained the world-wide leader of installed solar PV capacity in 2013. In Brazil solar power is widely used for solar heating and in 2010 Brazil ranked fifth worldwide in terms of total installed solar thermal capacity (51). However for solar electricity the costs are currently too high, resulting in failures to successfully win bids for solar PV in national auctions. One exception could be recorded in 2014, were the first auction exclusively for solar technology was held at state level in Pernambuco and 122.82MW of solar projects could be contracted (52).

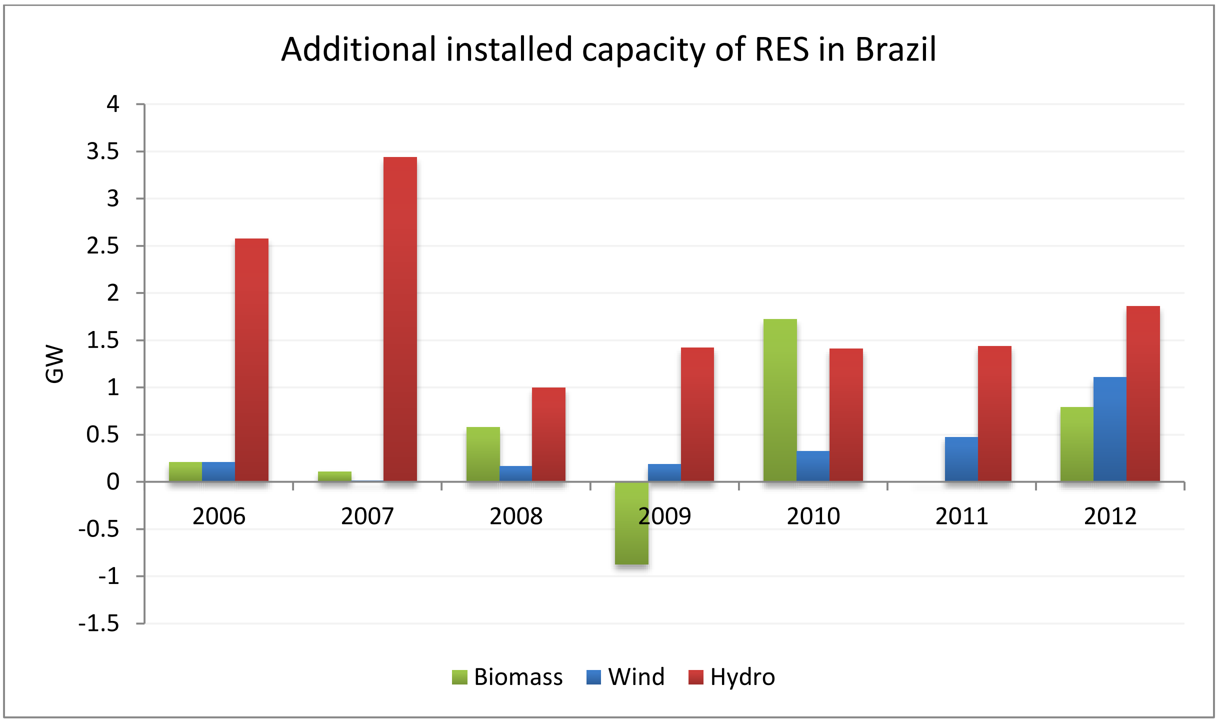

Figure 17: Installed capacity additions of renewable energy in Brazil (Source: own calculation on base of (7), (53), (48))

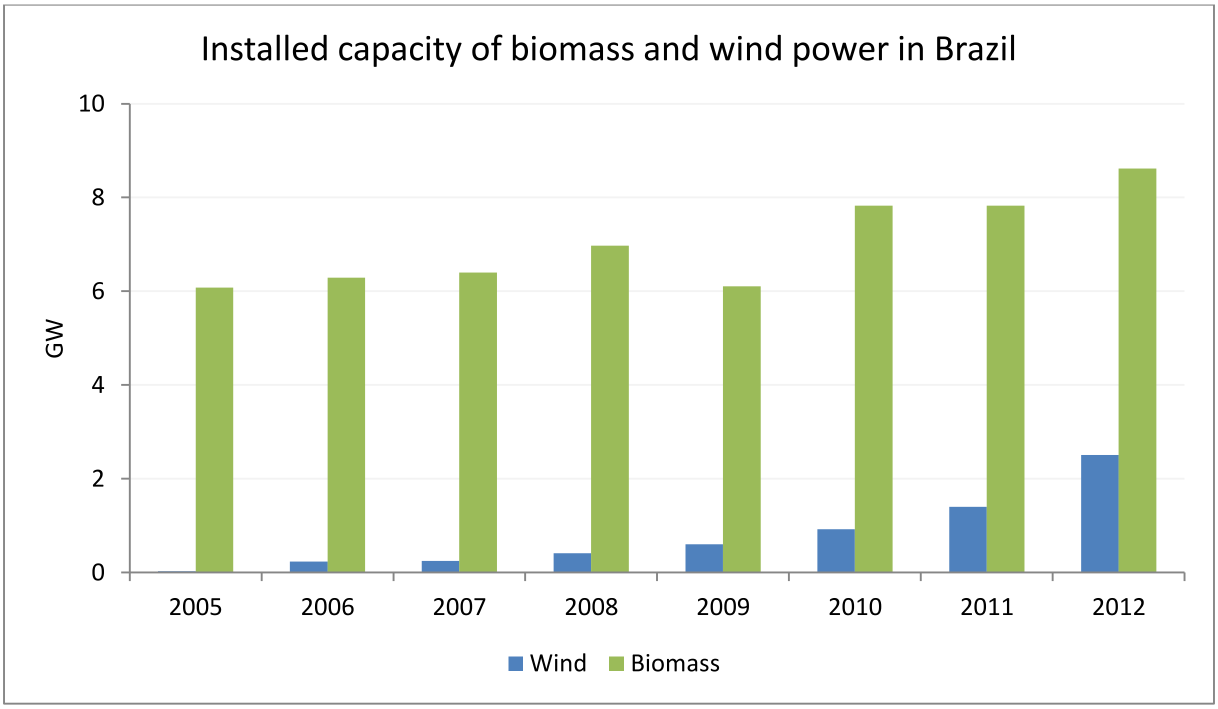

Figure 18: Installed capacity of biomass and wind power in Brazil (Source: own compilation on base of (7), (48), (20))

To analyze the effectiveness of the support politics of Brazil, the policy effectiveness indicator is calculated according to the method applied in the EU project RE-Shaping. For this diploma thesis, the data on electricity capacity and generation from RETs in Brazil is obtained from the international energy statistics provided by the U.S. Energy Information Administration. Data for the years 2011, 2012 and the projected data until 2020 is obtained from the calculations by MME and EPE in the ten year plan "Plano Decenal de Expansão de Energia".

The policy effectiveness indicators (PEI) calculated for the past years (until 2012) give an insight on the development performance of RETs on the basis of the respective policy. Additionally the indicators are calculated for the coming years (until 2020) based on the estimations by MME and EPE. For the calculation, the electricity generation data for each RET in the timeframe 2012-2020 was predicted as the product of capacity in the respective year (obtained from MME, EPE) and the average full-load-hours during a certain timeframe (for hydro power: 1980-2010, for wind power: 2005-2012, for biomass: 2005-2011).

The renewable energy technologies solar power (both PV and thermal), geothermal power and tidal/wave power were not taken into consideration, since those technologies were not covered by the discussed support schemes and currently are not competitive enough to enter the market, besides the PEI for all those technologies was nearly zero.

3.1.1 Hydropower

Figure 19 shows the development of the policy effectiveness indicator for hydro power in Brazil over the period from 2001-2020 (except 2013 because it marks the borderline between actual and predicted data and showed unrealistic results). The average effectiveness is 3,6% and 7,3% for the period 2001-2012 and 2013-2020 respectively. The hydro power developments in the years 2002-2010 for small hydropower plants can be almost solely assigned to PROINFA since the first A5 auction for new hydroelectric plants took place in December 2005 (54) with an initiation time of five years; hence the first small hydroelectric plants which can be assigned to the auction system appear around 2010. Since only limited data is currently available for the evaluation of the effectiveness of the auction system, the future development of the PEI is estimated as mentioned in the previous subchapter. Compared to the performance of PROINFA, the auction system seems to have a higher effectiveness. The medium prices (R$/MWh) for hydroelectric plants are continuing to decrease which also enables the government to purchase and contract more supply. However it has to be noted, that construction costs of hydropower plants are depending on the local environment, plant capacity and the use of power (base-load or peak-load) (55). PROINFA has focused solely on the installation of small hydropower plants, which do have higher construction costs; auctions however also permit the contraction of large plants, so the exclusion of large hydro projects from the PROINFA program can be regarded as one reason for its apparently worse effectiveness. Nonetheless, the total share of hydro energy in the electricity mix of Brazil with approximately 80% is far beyond the shares in the rest of BRIC.

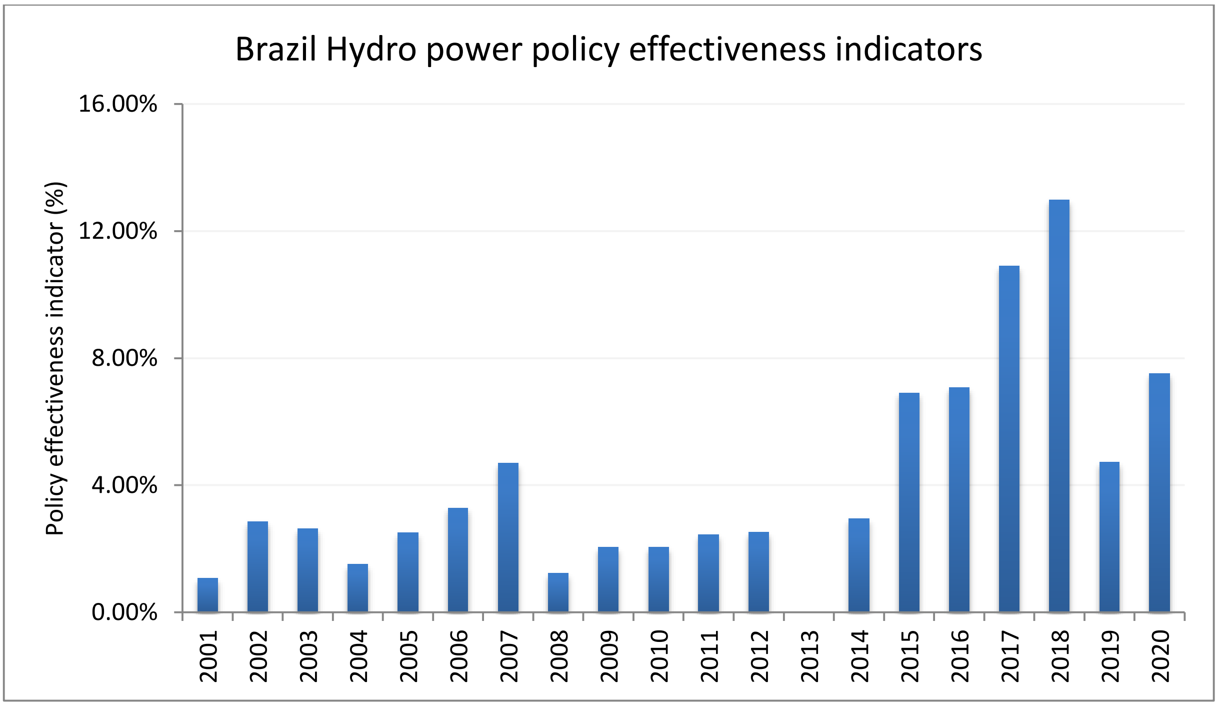

Figure 19: Policy effectiveness indicators for hydropower in Brazil (except 2013) (Source: own calculations)

3.1.2 Wind power

The (significant) deployment of onshore wind power plants in Brazil began in 2006, driven mainly by the incentive program PROINFA. As can be obtained from Figure 20, the (predicted) policy effectiveness indicator continuously increases until 2015. The policy effective indicator in the PROINFA period is very low compared to the predicted effectiveness of the auction system. This has several reasons: at the time PROINFA was launched, only one manufacturer for wind power plant supplies was located in Brazil, however PROINFA required 60% of the total project costs to be supplied by local producers which led to severe delays in the construction of wind power plants (12). Another effect which has to be considered is the technological development and cost reduction over the years. Since wind energy has become more economically competitive in recent years, the growing market competition is leading to decreasing bid prices in the auctions. For example, the medium contract price for wind power projects decreased from 0.065 US$ in 2010 to 0.054 US$ in 2013. The wind policy system attracted eleven international manufacturers which have deployed facilities in Brazil providing a strong manufacturing base in 2012 (48).

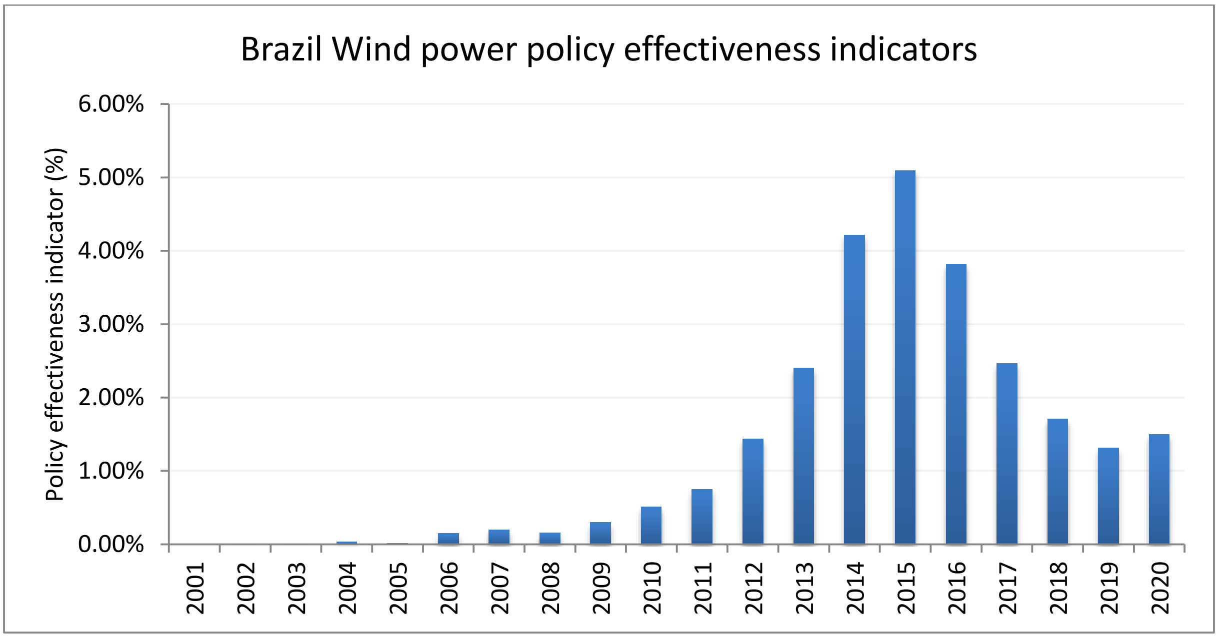

Figure 20: Policy effectiveness indicators for wind power in Brazil (Source: own calculations)

3.1.3 Biomass

Biomass, besides wind power and small hydro power, was the third technology supported by the PROINFA program. However considering the recent investment developments with the strong focus on wind energy, the biomass development is weaker and more volatile; even the government projections show a PEI below 1% for the coming years. It has to be noted though, that Brazil has programs for biomass usage in the mobility sector, for example PROÁLCOOL, a program for the promotion of bio-ethanol fuels.

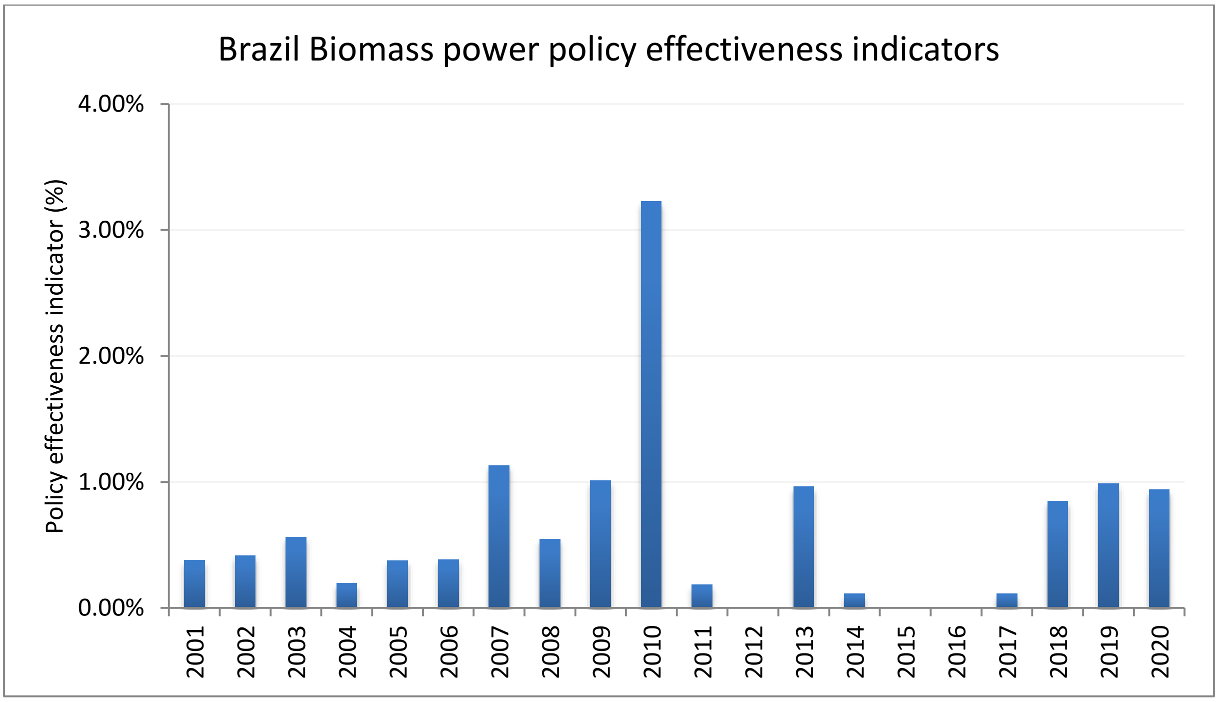

Figure 21: Policy effectiveness indicators for biomass in Brazil (Source: own calculations)

From the point of effectiveness, the transition from the feed-in tariff system established by PROINFA to the auction system resulted in a higher effectiveness, at least for wind and hydro power. Biomass with its high significance for the mobility sector forms an exception within the RES, hence it has to be considered that the government indeed supports the usage of biomass but not only for electricity generation.

3.1.4 Investment and efficiency analysis

Wind power attracted the most investments throughout the past years as can be seen in Figure 22. It is notable, that the wind electricity prices in Brazil are among the lowest in the world (9). The auction system along with falling turbine manufacturing prices and improvements in technology were the key drivers for the deployment of new wind power plants. Issues with grid-connectivity and construction delays have hindered a better performance in the wind sector. Also the financing process takes some time, so successful bids are registered with around two years delay in the investment reports (56). Investments in other technologies (except large hydropower) have been very low recently which partly can be explained with the slowdown of the Brazilian economy in 2011-2012 with the GDP-growth falling from 7.5% in 2010 to just 0.9% in 2012 and the slow recovery in 2013 to 2.2%[6].

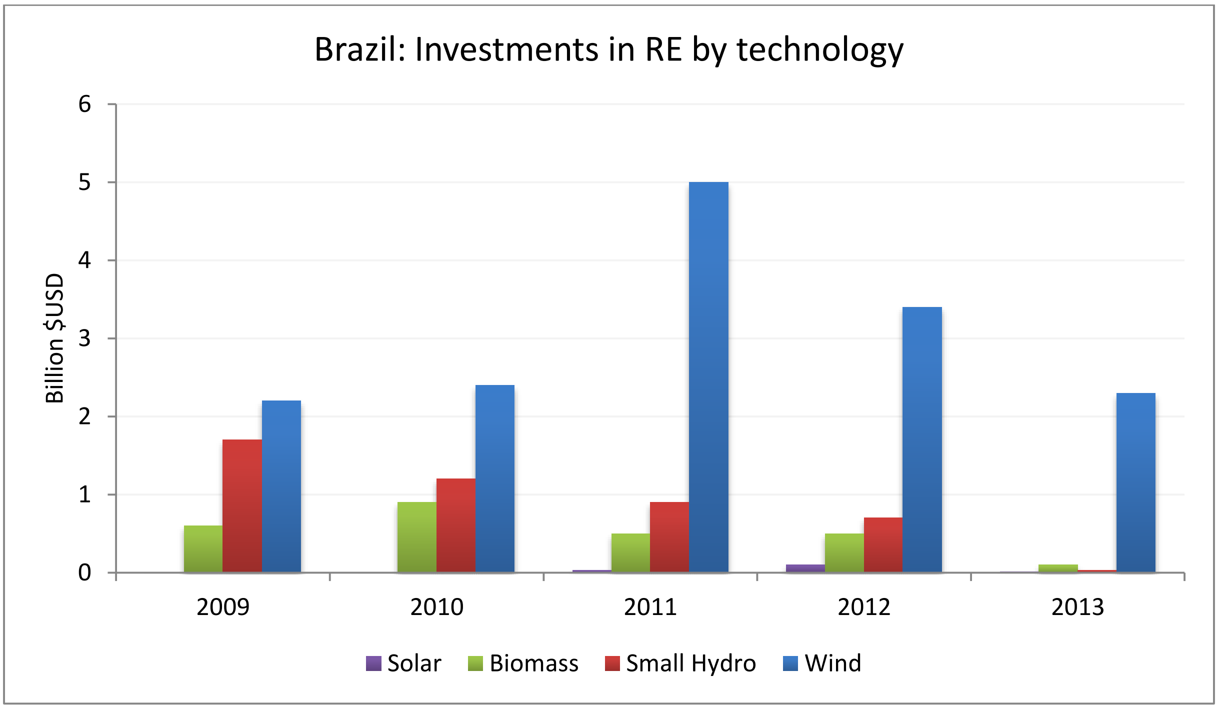

Figure 22: Investments in renewable energy sources in Brazil
(Source: own compilation on base of (57), (58), (59), (60), (56), (50))

[6] GDP Data obtained from the World Bank database at http://data.worldbank.org/country/brazil

To get some insight on the expenditures for power purchase agreements in the wind electricity sector, the total cost indicator for PROINFA and the auction system was estimated. The calculations only include the extra payments for the power purchase agreements and do not consider other benefits like fiscal incentives such as reduced income taxes, lower interest rates on loans (in particular for loans from BNDES) etc. or improvements in infrastructure and grid connection. Since information on the average wholesale electricity price is difficult to find due to the complex structure of the electricity market, the levelized cost of electricity for the main power source, large hydropower plants, is considered as the reference.

Looking at the total cost indicators in Figure 23, the auction system (which is reflected in the values from 2009-2011) shows a higher efficiency than PROINFA. This is partly due to advancements in technology and falling prices but also to the auction system itself, which makes it easier to find a suitable tariff and promotes competition.

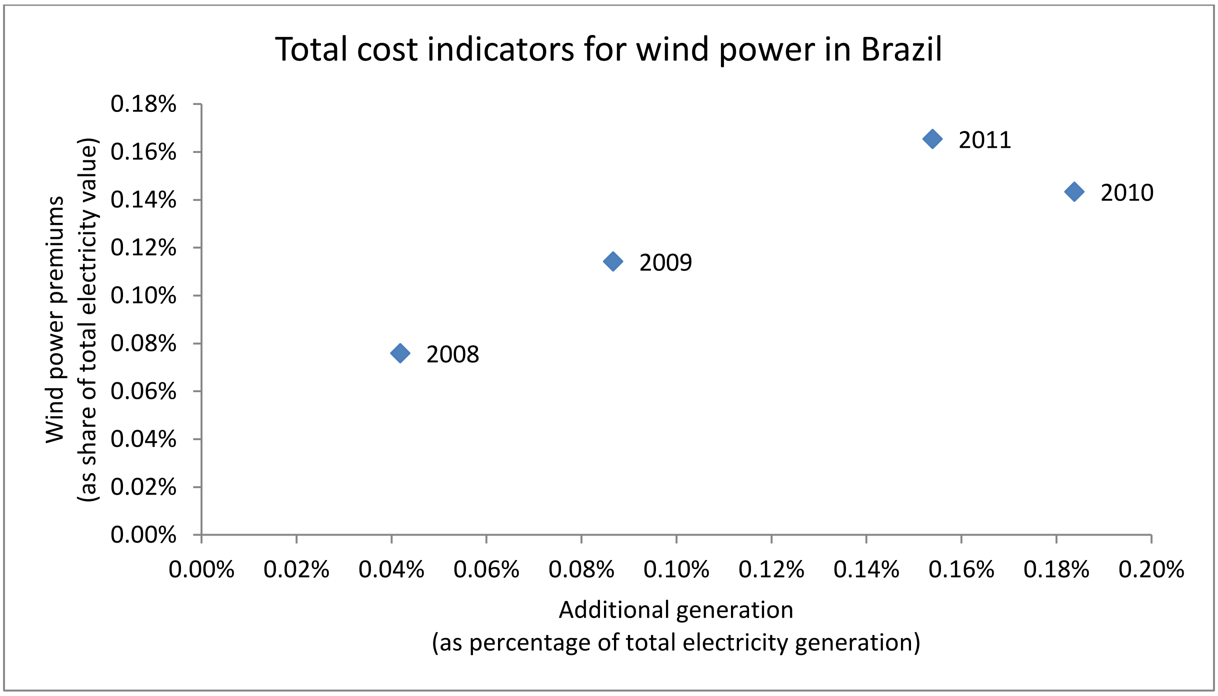

Figure 23: Total cost indicators for wind power in Brazil (Source: own calculations)

3.2 Russia

The developments regarding renewable energy in Russia are rather moderate. Hydropower has experienced some expansion recently as can be seen in Figure 24, whereas other RETs have shown almost no changes. However most recently in 2013, Russia held its first auction for renewable energy and awarded solar power projects with 504 MW of total capacity and wind power projects with a capacity of 110 MW. A second auction with 1.645 MW for wind power and 496 MW for solar power is planned for June 2014 (61).

Russia has huge potentials for renewable energy. According to the IEA projections for the 2020 generation potential, Russia ranks first in biomass and geothermal electricity potential among the BRIC and second in terms of total renewable energy potential. Nonetheless, Russia has implemented very few incentives to support renewable energy, which partly can also be explained with the huge resources of conventional fossil fuels and the government focus on the expansion of nuclear energy.

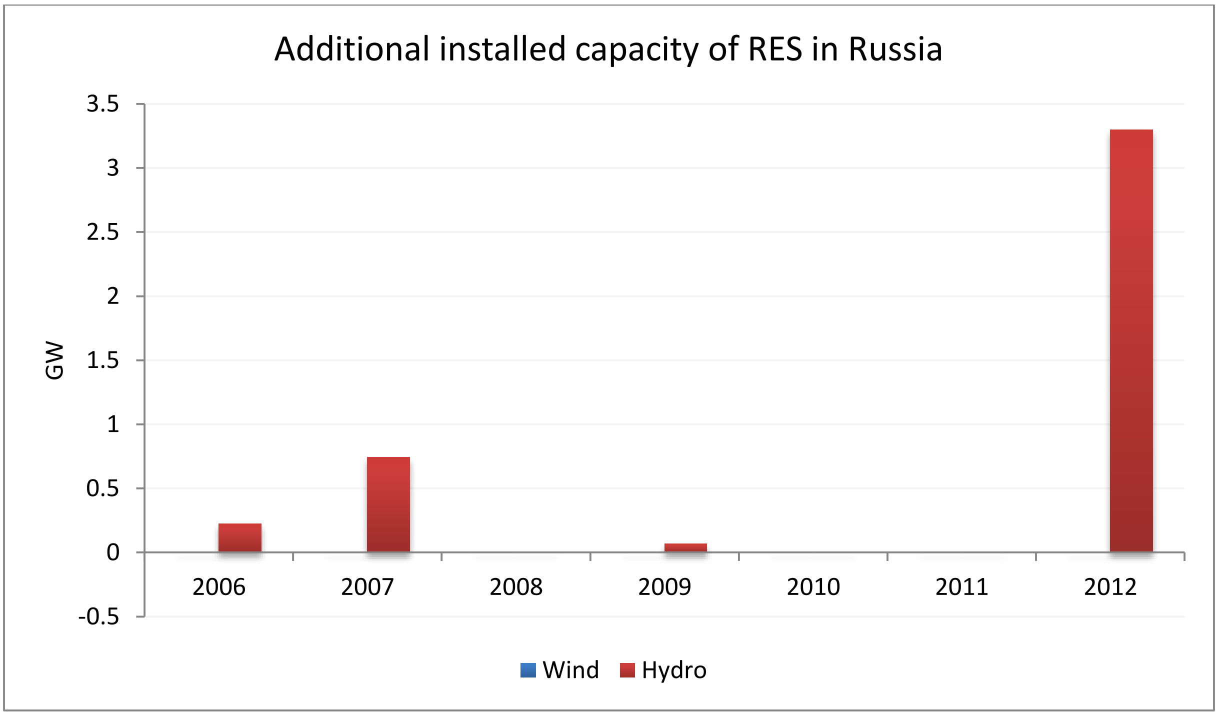

Figure 24: Installed capacity additions of renewable energy in Russia (Source: own calculation on base of (7), (56), (62))

Considering the weak developments in the field of renewable energy, a policy effectiveness analysis will not deliver useful information since the calculated PEI was zero for all technologies, except for large hydropower.

3.3 China

China's development of renewable energy is supported by a great variety of policies, laws and programs on country, province and local level.

Most recently the deployment of wind power plants and solar PV has risen significantly because of various incentives offered by the Chinese government. On the solar market, the feed-in tariff launched in 2011 has shown tremendous success with a twentyfold increase of the installed capacity of solar PV in just three years as can be seen in Figure 26. The feed-in tariff was accompanied by subsidy programs such as the Golden Sun Program.

Hydro power capacity additions exceeded those of wind power until 2009 as shown in Figure 25, since 2010 wind power marks the quickest developing technology in China. The rapid deployment can be explained with falling costs for wind power on the one hand and high investment volumes thanks to an attractive policy environment for wind technology on the other hand along with the large remaining potential for wind power. Solar PV appears to go through the same development as wind power with some years delay. Biomass also shows some positive developments after the tariff increase in 2010.

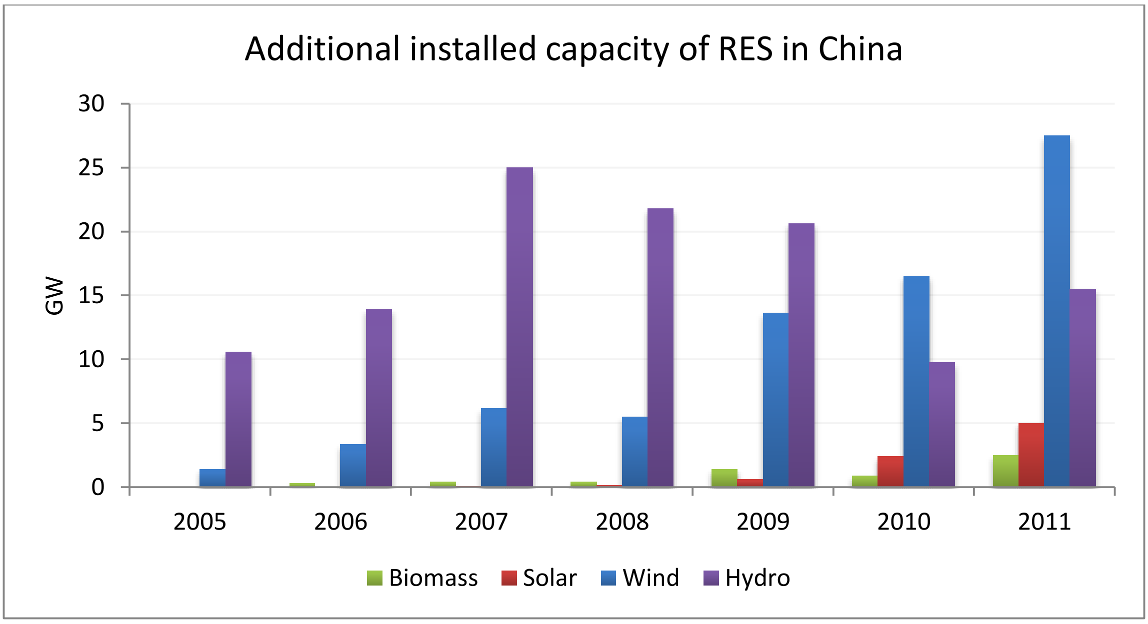

Figure 25: Installed capacity additions of renewable energy in China (Source: own calculation on base of (7))

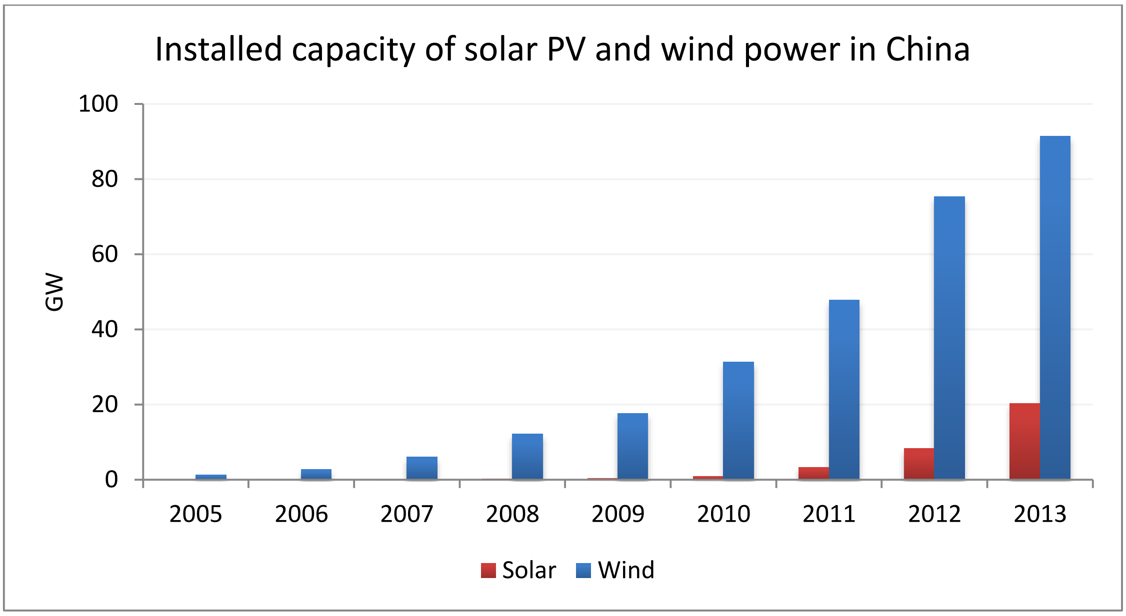

Figure 26: Installed capacity of solar PV and wind power in China (Source: own compilation on base of (7), (63), (53), (64))

It is noteworthy that China does not only increase its renewable energy capacities but invests in new capacities of RETs in other countries as well and has also become the number one supplier for solar PV accounting for 50% of world-wide production in 2010 together with Taiwan (65). China also finances and builds hydroelectric power plants and infrastructure and was accountable for 46% of the additional hydroelectricity capacity in Cambodia, Laos and Myanmar (66). RE has thus become an important economic factor, not only locally but also in terms of international trading and economy.

3.3.1 Wind power

With the introduction of the first RET support mechanisms in 2003, wind power business quickly grew in China. By December 2013 the share of cumulative wind power capacity amounted 28.7% of the worlds total wind energy installed capacity, ranking China in the top position world-wide (63). The deployment of on-shore and more recently also off-shore wind power plants continues, however the one important issue arose with the quick growth: curtailments due to lack of grid connections. Wind power plants were mainly deployed in the so-called "Three Northern Area", a region in the north of China fairly distant from the electric load area on the coastline creating a grid-connection bottleneck which led to a 20% curtailment rate in some areas (67).

The main drivers for wind power deployment from a policy perspective are feed-in tariffs. The inception phase for wind power was marked with a tender system where bid winners were granted a fixed feed-in tariff for the first 30.000 full-load-hours with a certain ceiling (32). In 2009 a major change in wind power support was executed with the transition to a FIT-system. This change significantly pushed forward the deployment rate of wind power and brought China to the leading position on a global scale. The policy effectiveness of those policies (tender until 2009 and FIT from 2010) is shown in Figure 27. A significant increase of the effectiveness since 2010 is visible and across the BRICs, China's effectiveness indicators for wind power is the highest with currently above 2%. It is particularly notable, that the generation potential for wind power in 2020 is by far larger than in any other BRIC country and almost four times higher than in Brazil as the country with the second largest wind power potential.

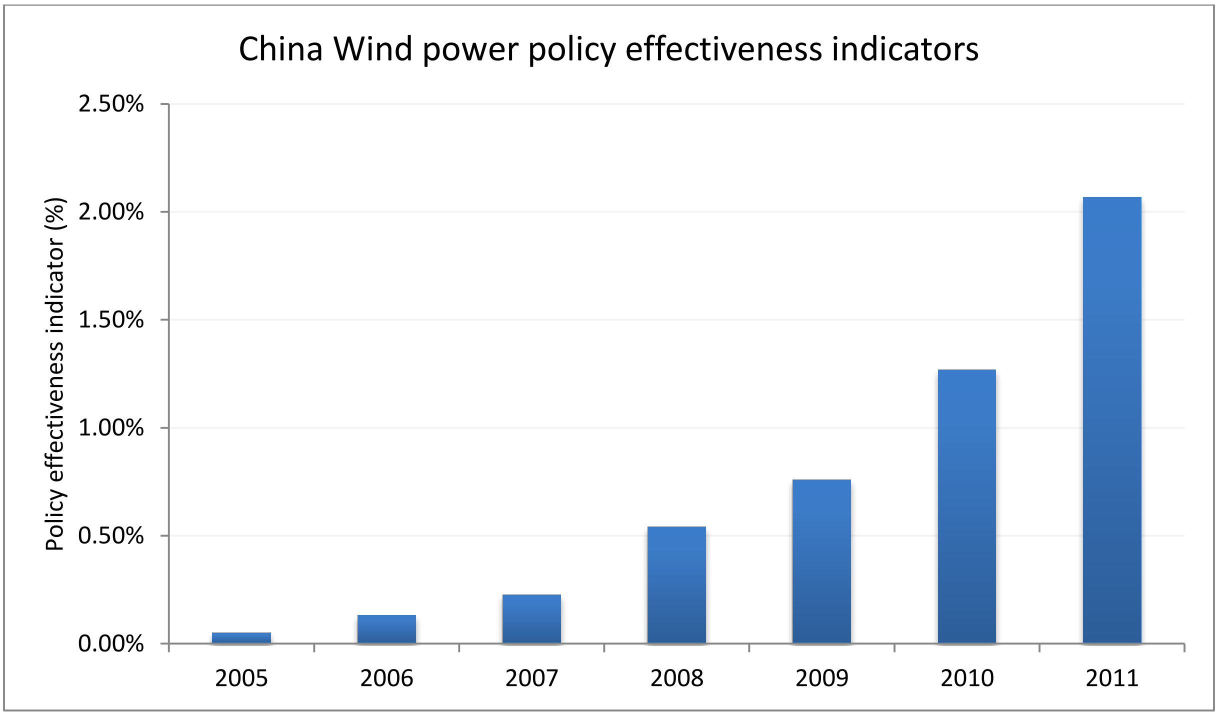

Figure 27: Policy effectiveness indicators for wind power in China (Source: own calculations)

3.3.2 Solar power

The support mechanisms implemented for solar power in China are manifold. Tax incentives, surcharges and subsidies were applied to the solar electricity sector in the first decade of 2000 followed by a feed-in tariff in 2011. The effectiveness indicator for solar PV can be obtained from Figure 28 and it clearly shows the effectiveness increase since the introduction of the feed-in tariff system. I must be noted though, that the FIT was launched after the inception phase in the previous years where the technology was still immature. With increasing maturity the technological costs decreased significantly, for example the PV module price for crystalline silicon PV in China dropped to less than one third from around 3 US$/W in 2009 to approximately 0.75US$/W in 2012 (49). Besides the deployment within China, also China's global leading role in solar PV manufacturing is an important driver for technology advances and high-volume investments and also allows significant cost reductions.

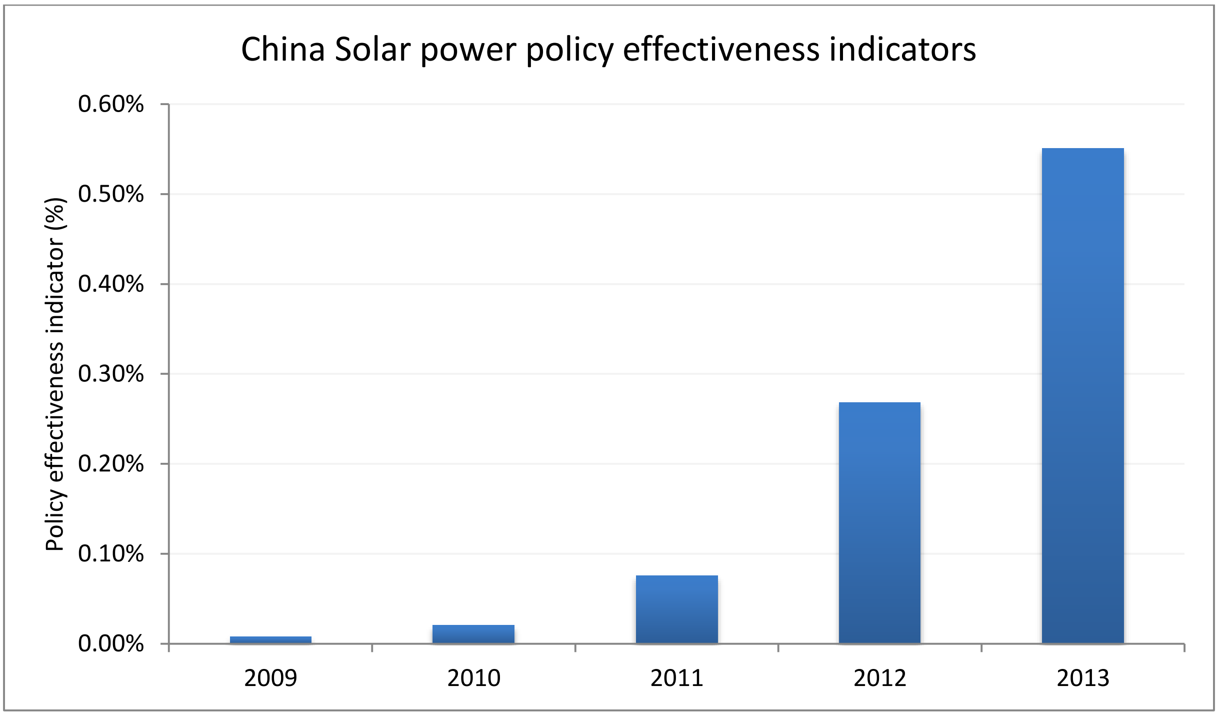

Figure 28: Policy effectiveness indicators for solar power in China (Source: own calculations)

3.3.3 Investment and efficiency analysis

Figure 29 shows new investments in four renewable energy technologies in China. Investments in wind and solar power are stable on a high level which is also reflected in the developments in terms of installed capacity. Looking particularly at the solar market, high investment volumes occurred after the introduction of the feed-in tariff system in 2011. The attractiveness for investments in the solar sector was quite low prior to 2011 due to lack of sufficient government incentives. The Building Integrated PV-system program (also referenced as the "Golden Roof Program"), which provided subsidies through capital premiums as well as the Golden Sun Program created some interest in the solar sector, however there were some inconsistencies among those policies due to different development concepts (68). Another problem which appeared with the support of solar PV was the overheated situation in the solar industry where the number of companies in the solar sector increased fivefold within four years resulting in price wars and losses due to overcapacities (68). However, those issues were already treated by the Chinese government.

A decline in investments for solar PV occurred after 2012 due to a cut-back in tariffs provided by the Golden Sun program. After a peak in 2010, wind power investments continued to remain in the range of 25-30 billion US$. Grid connectivity for new wind power plants were and are still an important issue, albeit measures have already been taken to counteract this problem, for example with the introduction of national technical requirement standards in connection with wind power grid connectivity (67). Small hydropower investments were quite low in comparison to wind power and solar PV, however investments for large hydropower plants are extensive. In 2012 Chinas investment in large hydropower plants (14 GW of newly installed capacity) was around 21 billion US$, which corresponds to around 63% of total new investments worldwide in 2012 in large hydropower plants (56).

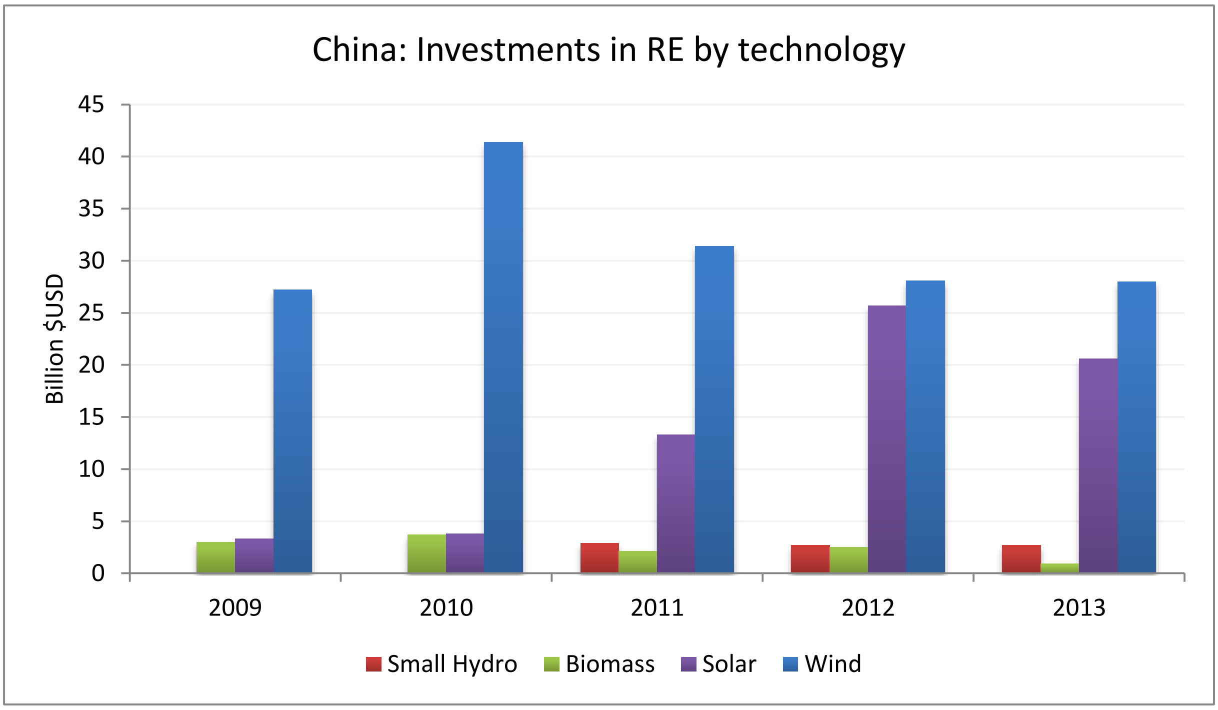

Figure 29: Investments in renewable energy sources in China
(Source: own compilation on base of (57), (58), (59), (60), (56), (50))

The feed-in tariff introduced in 2009 for wind power is dependent on the actual location of the wind power plant and ranges between 0.51 RMB/kWh and 0.61 RMB/kWh. Data on support expenditures from 2002 to 2008 are obtained from (69). To calculate the government expenses on wind power feed-in tariffs in the period 2009-2011, first the generated electricity in the four category regions (which have different FITs) was estimated. Due to lack of detailed generation data in the provinces, the installed capacities of respective provinces were multiplied with the average full-load-hours in the period 2009-2011. The actual government subsidy then was calculated as the difference between FIT and coal-based electricity price times the generated electricity. The government premiums in relation with the additional wind power generation are represented as the total cost indicator in Figure 30. Since 2008 the increase of additional generation continuously rose, however the power premiums also increased almost linearly indicating a rather minor gain in policy efficiency.

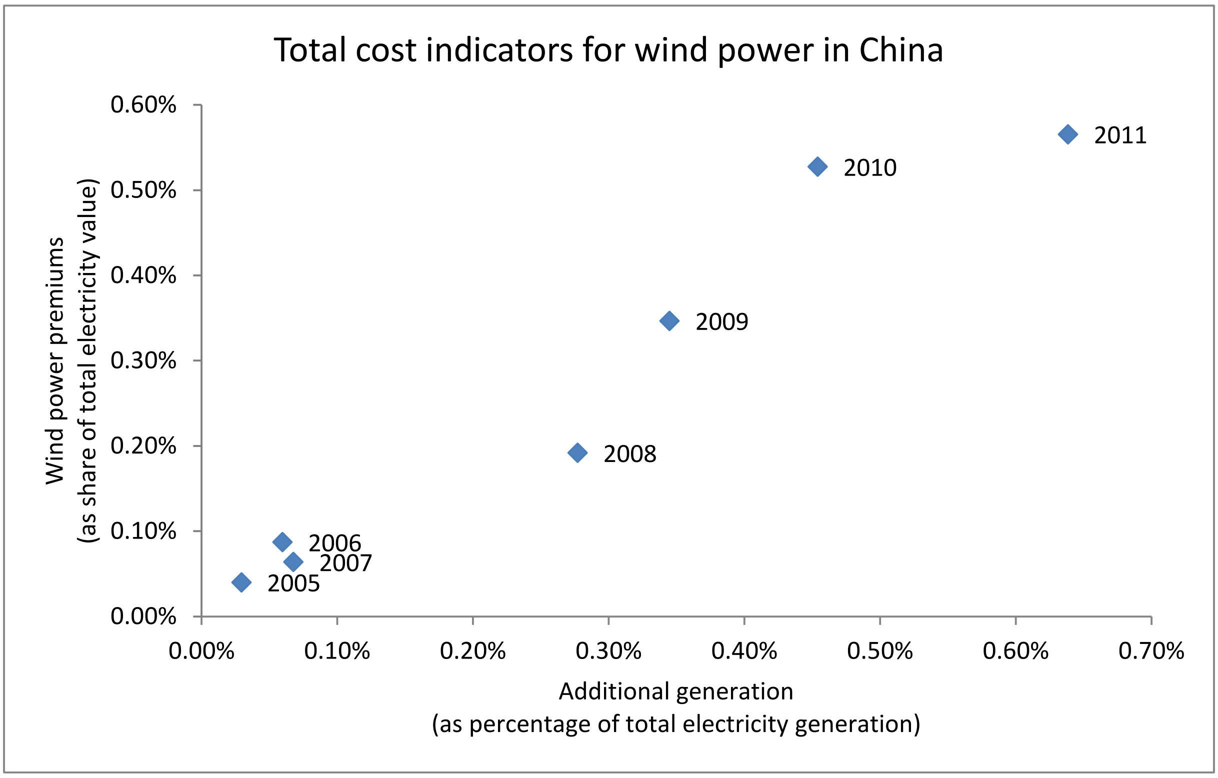

Figure 30: Total cost indicators for wind power in China (Source: own calculations)

The calculation of total government support costs for solar PV is more difficult since a nation-wide FIT was introduced as recently as 2011. Before 2011, programs such as the Solar PV Building subsidies and the Golden sun program along with the RES surcharge were accountable for new installation capacities, however due to the subsidy structure the calculation of exact government expenditures is a complex task. According to a media announcement the Golden Sun program required a government investment of 20 billion RMB (70). The BIPV subsidy program which incentivized an additional capacity of 100 MW would require around 2 billion RMB, assuming a subsidy tariff of 20 RMB/W. All in all, the government expenses for solar technology including the two subsidy programs and RES surcharge would amount to approximately 22 billion RMB. Solar PV with its high deployment costs in comparison with wind power requires more governmental funding. From the tariff composition which is quite similar to the wind power FIT system, it can be assumed that China is trying to repeat the successful developments for the solar sector.

3.4 India

The policy structure in India is characterized with a large number of RES support policies. The great majority of support measures are applied on state level accompanied by some central policies. As in China, the main focus for the deployment of new RETs lies on wind power and solar PV. The developments in terms of additional installed capacity in India can be obtained from Figure 31. The characteristics are quite similar to China; wind power deployment surpassed hydropower plant deployment in 2007, solar PV is growing quickly since 2011.

The trend for wind power and solar PV installations in India is also clearly visible when considering the developments of the installed capacity of non-hydro renewable energy sources. As of 2013, wind power is by far the most commonly used energy source with an installed capacity of more than 20 GW. Biomass has still maintained the second position in terms of installed capacity, however the deployment rate of solar PV surpassed those of biomass in 2012 and the solar PV installed capacity is likely to excel that of biomass within the next few years.

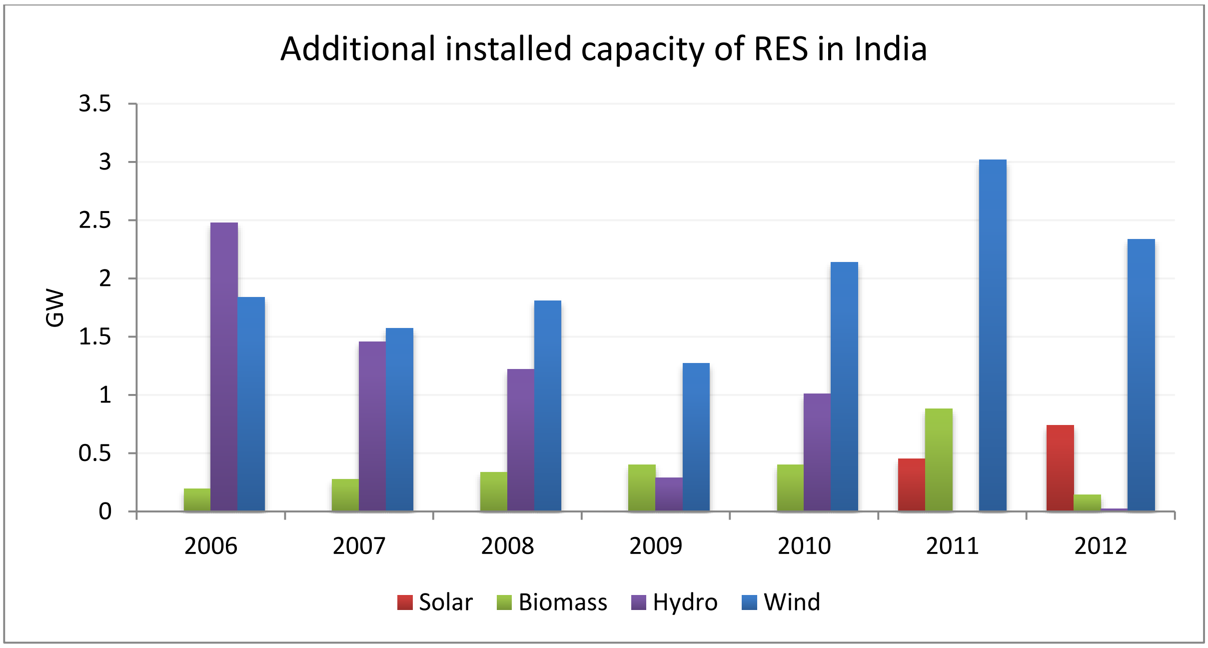

Figure 31: Installed capacity additions of renewable energy in India (Source: own calculation on base of (7), (48), (63), (71), (72))

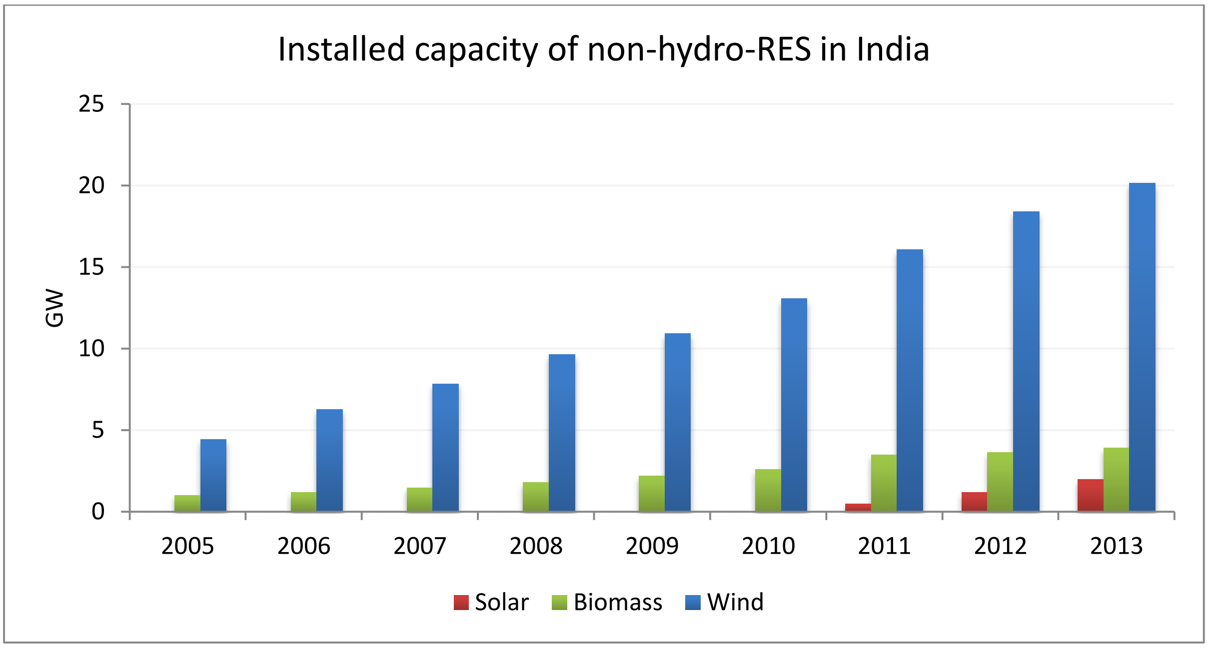

Figure 32: Installed capacity of non-hydro RES in India (Source: own compilation on base of (7), (63), (41), (48), (71)(53))

3.4.1 Wind power

Wind power has become an important economical factor in India, as it is the third largest market on a global scale with a large industry with for example 20 turbine equipment manufacturers (38). The success of wind power in India was possible thanks to government support, beginning with the enactment of the Electricity Act in 2003. Wind power in particular was then supported directly with the introduction of state-wise tariffs in 2006 and generation based incentives (GBI) in 2009. The conditions for the deployment of wind power plants are excellent in India, since many states such as Tamil Nadu (with almost 7 GW of installed capacity in 2012 (38)), Gujarat, Maharashtra and more have excellent wind potentials.

Looking at the policy effectiveness indicator for wind power in India (Figure 33), we see an increase in effectiveness since 2009 which can be (partly) explained by the generation based incentives issued in the same year, however the impact of the increase in technological maturity and decreasing costs should not be overseen.

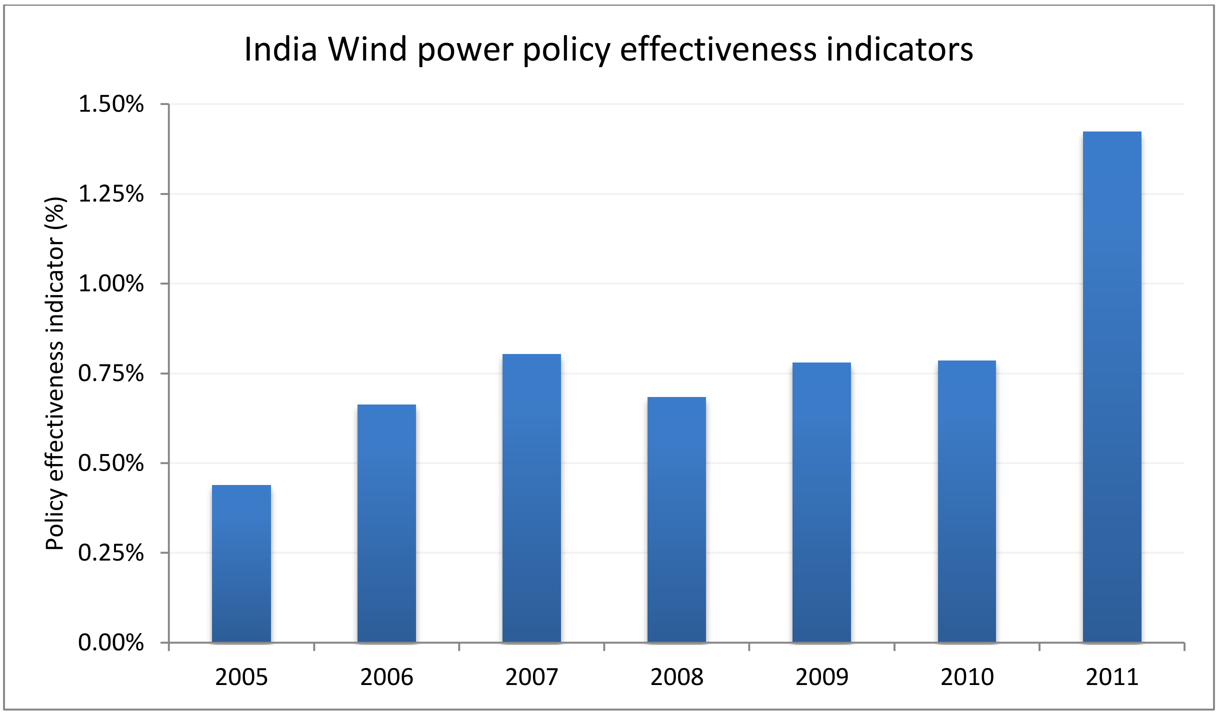

Figure 33: Policy effectiveness indicators for wind power in India (Source: own calculations)

3.4.2 Solar power

Indias solar insolation is high and ranges at 5.000 trillion kWh per year (38). The majority of installed solar capacity is found in Gujarat (824 MW) and Rajasthan (442 MW). Several factors are accountable for the recent drive in solar power deployment. The decreasing costs for PV panel production in China and the U.S., together with government support programs such as the Jawaharlal Nehru National Solar mission and increasing grid power prices are the main reasons for the recent success of solar PV. Solar energy performs so well in India, that grid parity, the point where the generation costs of solar power plants equal the purchase costs for energy from the grid, can be achieved. Grid parity for solar PV in India is expected in the period 2017-2019 assuming an increase of conventional electricity costs of 4% per annum and a solar price decrease of 5-7% per annum (38) (73).

Despite the high deployment rate and government support programs, some challenges remain for the Indian solar market. The solar industry in India has to compete with the world-market leaders China and Taiwan, still lacks technological knowledge on certain segments and depends on imports for manufacturing (e.g. wafers) (38).

The policy effectiveness indicator for solar PV in India is shown in Figure 34. Since the inception phase for solar PV deployment just has ended, first useful values for the solar PEI appear as recently as 2011. In the past three years the effectiveness indicator doubled indicating a good approval of the implemented policies. The recent developments can be accounted to the National Solar Mission as the most prominent solar policy with the largest scope, however several other factors influence the policy performance as already mentioned before.

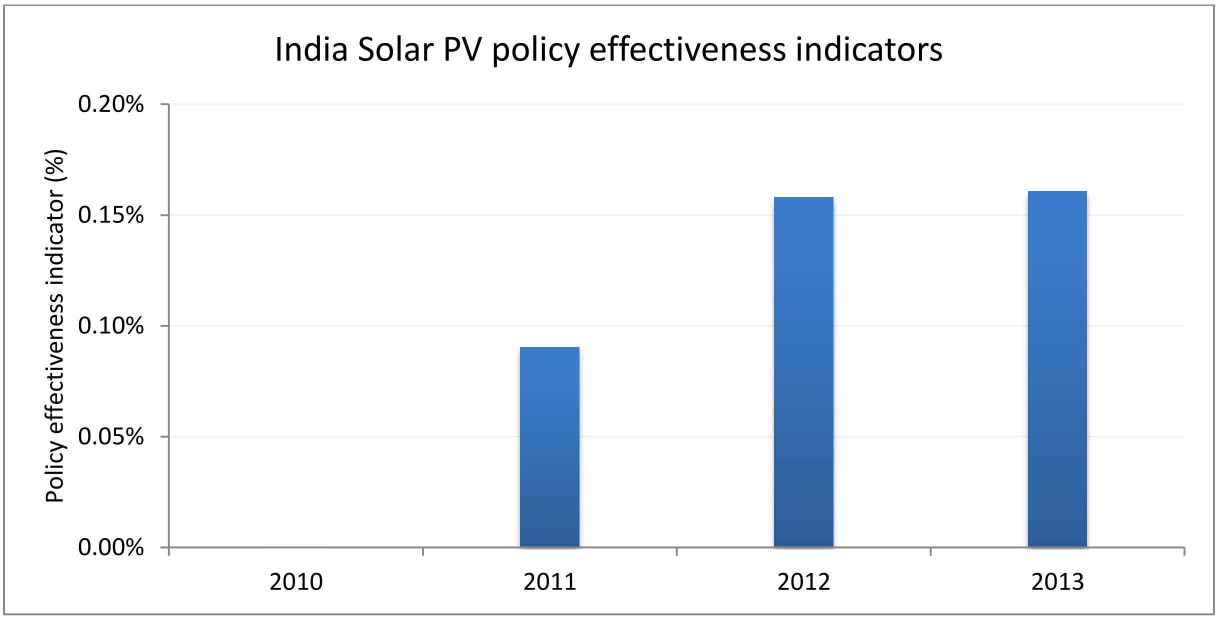

Figure 34: Policy effectiveness indicators for solar PV in India (Source: own calculations)

3.4.3 Biomass

The policy effectiveness indicator for biomass electricity remained near zero for the period 2005-2010. In 2011 a sudden increase of the PEI to 0.54% can be calculated from the given data, however this is not reflecting a possible increase of installed capacity (which remained at approx. 40 GW) but rather an increase of generation runtime in this year. The emphasis in the Indian renewable energy sector clearly lies on wind power and solar PV.

3.4.4 Investment and efficiency analysis

Figure 35 shows the renewable energy investment developments in India from 2009 to 2013. In the whole period, wind power investments exceeded those of other RE technologies. Since 2010 notable investments in the solar sector are recorded; in 2011 the overall investments reached a peak-level. Since 2012 a decrease in investments occurred, which can be traced back to the phase-out of the generation based incentives for wind power in 2012 and to the reduction of the rate of accelerated depreciation from 80% to 15% (48). The government reinstated the GBI-program again in 2013 and an increase in wind power investments along with a higher deployment rate can be expected for 2014-2015. A similar explanation can be found for the investment reduction for solar power in 2012-2013 as this period marks the transition from phase I to phase II in the National Solar Mission. The sought 2 GW of installed capacity in the period 2010-2013 have already been financed and deployed and the next phase starting 2013 now targets at a deployment of up to 10 GW of grid connected solar power (46). All in all, an increase in RET investments is to be expected in the next few years, however the investment trends in the period 2010-2013 explicitly show the high dependency of RETs on government policies. With lack of incentives, reduced investments along with lower deployment rates come into effect almost immediately.

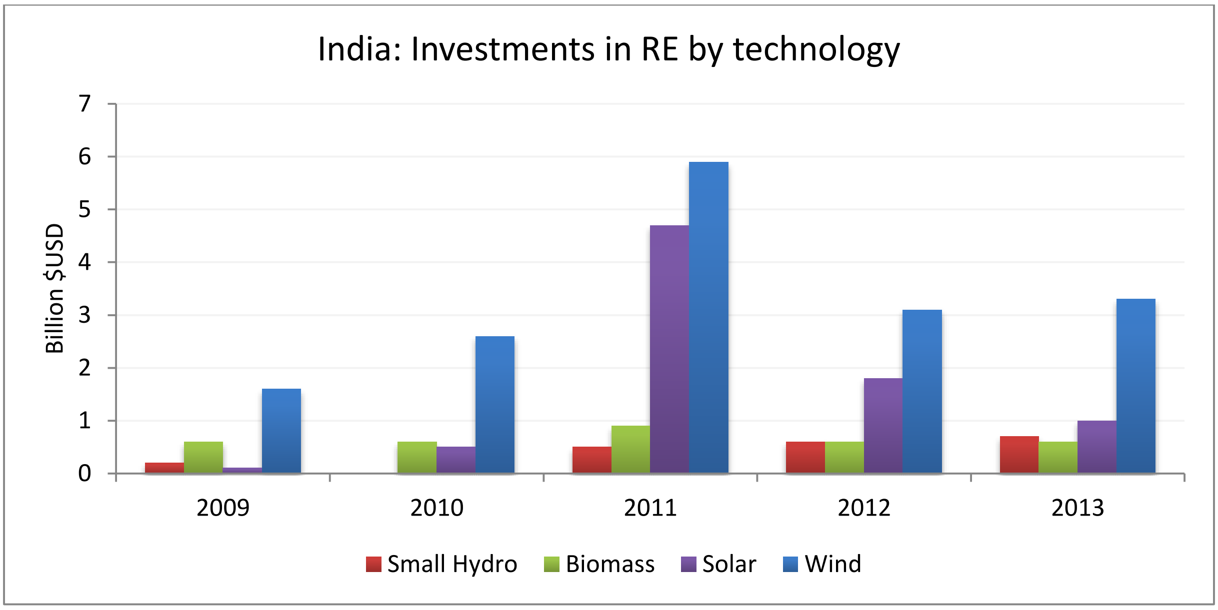

Figure 35: Investments in renewable energy sources in India
(Source: own compilation on base of (57), (58), (59), (60), (56), (50))

The shown TCI in Figure 36 includes the government expenditures on the generation based incentives and the state-wise feed-in tariffs. Since state-wise data on wind electricity generation was not available, the tariff used in the calculations was assumed as 4.3 Rs./kWh, which considers the largest installed capacities being deployed in Gujarat and Rajasthan.

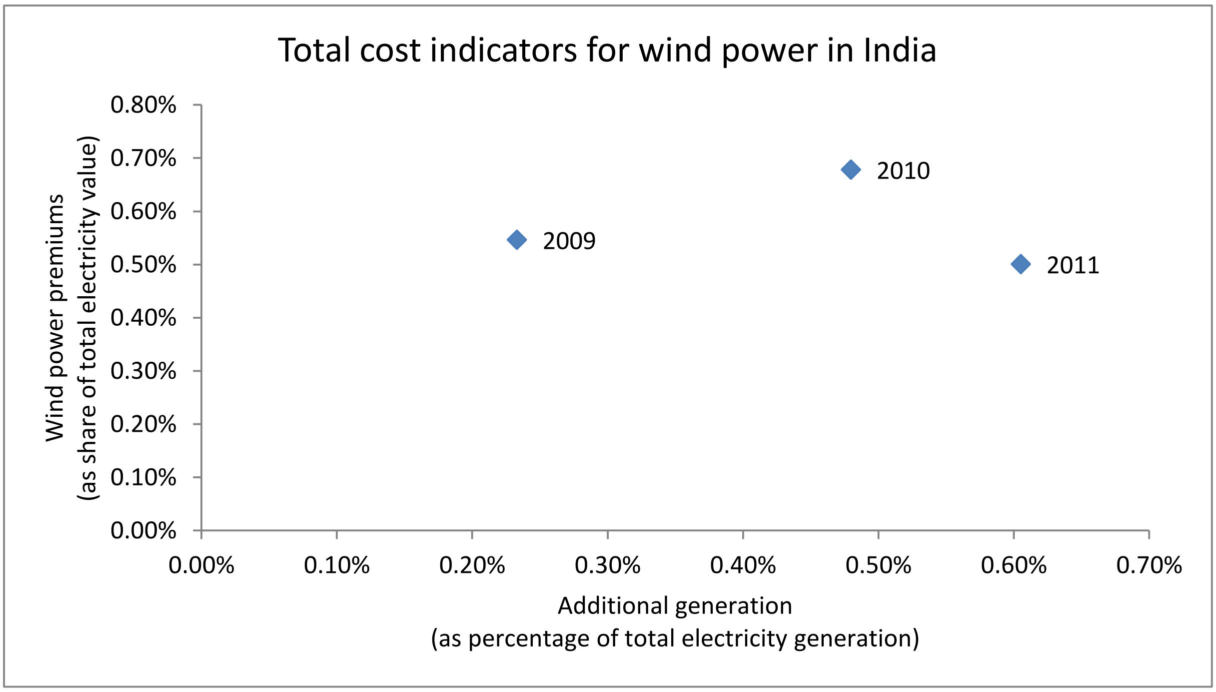

Figure 36: Total cost indicators for wind power in India (Source: own calculations)

4. Conclusions

To compare the performance of renewable energy strategies of the BRIC governments, first a short review of the initial situation is given. All BRIC countries except Brazil rely heavily on conventional energy sources for electricity generation. Also, all countries still show a tendency to increased usage of fossil fuels due to the fast growth of electricity demand and huge and cheaply available resources. However all countries have developed and implemented some support policies for renewable electricity and the total installed capacity of RET has increased in each country. China has outrun all other BRIC countries by far in terms of deployment rate and shown tremendous success with wind power and solar PV. India has also focused on the same technologies, however the deployment rate was lower. Wind power was also one the key technologies in Brazil, albeit the deployment was relatively low in comparison with China. Despite all efforts to foster technologies such as wind power, solar power and biomass, the vast majority of renewable electricity was provided by hydropower. The reasons are evident: hydropower provides electricity at low costs with low or even without government funding while it can serve as base-load and peak power and shows less volatility in generation. However the social and environmental impact of (in particular) large hydropower plants is large and it is complicated to weigh the positive benefits and negative impacts of hydroelectricity. Regarding non-hydropower RETs, wind power is the dominating technology. All four BRIC countries have deployed new capacities of wind power. China has surpassed the United States of America in terms of installed wind power capacity in 2010 and since then maintained the global lead in this sector. A second important technology, with again China as the global leader in terms of production, is solar PV. China and India have both introduced several policies to support solar PV, which also has become a very important industrial factor, in particular for China as the world's largest producer of solar PV cells.

4.1 Policy environment

As already discussed, the BRICs have implemented several renewable energy support policies simultaneously.

Brazil has switched from a FIT-like system (PROINFA) to an auction system and in particular for wind power, the electricity price decreased to one of the lowest in the world. Along with those two policies a great number of additional benefits were awarded to renewable electricity producers such as favorable interest rates on loans and tax reductions etc.. Also electrification programs such as "Luz para Todos" play an important role for the connection of new renewable capacities to the electricity grid.

Russia with its decree No. 449 recently implemented a unique renewable support mechanism with capacity based incentives, however it is yet too early to analyze the impact of this policy. It has to be noted though, that the major source for electricity in Russia will remain fossil fuels and nuclear power along with hydropower. An important issue for Russia is increasing energy efficiency, which not only would have positive impact on the environment but also would save up to 3-5 billion US$ of government budget if the technical potential for energy efficiency in the non-residental sector was achieved (74) (according to a World Bank Goup study, Russia could cut its energy consumption by 45% in total; in the electricity sector a 31% reduction on fuel consumption could be achieved (74)). China, today among the top players in renewable energy, established a great number of different support policies and applies almost all common renewable energy policies such as FITs, RPS, Tenders, Subsidies, preferential taxes and loan interest rates. Together with a strong manufacturing basis, China not only managed to achieve the highest deployment rates of renewable energy in the world, but also benefits strongly from exports. In particular the developments in the solar sector, with high demand in Europe (Germany, Spain and Italy) which occurred at the same time as Chinese solar PV producers began to expand along with (controversial) export subsidies, boosted the Chinese share in the global solar PV market (75).

India has a similar policy framework as China and also established a very large number of renewable energy policies on different levels. The range of support mechanisms covers FITs, RPS, RECs, subsidies and tax benefits. In particular the renewable energy certificate system is unique among the BRICs, however the results from the establishment of the REC market was rather moderate with just 12.3% of the total renewable capacity accredited by the national load dispatch center (NLDC) for REC trading (47).

4.2 Policy effectiveness

The effectiveness indicators give an insight to the performance of governmental support policies in terms of additional renewable electricity generation. A cross-country comparison for the wind power sector is given in Figure 37. Brazil, China and India could all achieve an increasing effectiveness indicator which reflects a higher deployment rate and increase of renewable electricity generation in those countries. China surpassed India in terms of effectiveness in 2010 and since then remained on the top position among the BRIC. Brazil shows continuous developments, however at a much lower rate than in China.

For solar PV the policy effectiveness for India and China is compared, as Brazil and Russia have not shown any significant developments in solar PV deployment. The effectiveness in the solar PV sector is very limited, which also can be explained with the low maturity level of solar PV. Photovoltaic technology (crystalline and thin film) is currently in the take-off phase while third-generation PV is still in demonstration phase (6). On-shore wind power for example has already begun to reach market consolidation while offshore wind power currently is in its inception phase. China shows a higher effectiveness with solar PV policies than India. Some of the challenges for solar PV in India are the strong competition from China and Taiwan and also deficits in technical knowledge in certain segments (38).

Biomass with its double-use as fuel for electricity generation as well as fuel in the transportation sector is more volatile. In particular in Brazil, the prices for sugar-cane can vary significantly due to the dependence on weather, market prices and biomass demand which also have an effect on the biomass electricity generation. China has deployed biomass power plants recently, which was driven by the increased feed-in tariff in 2010.

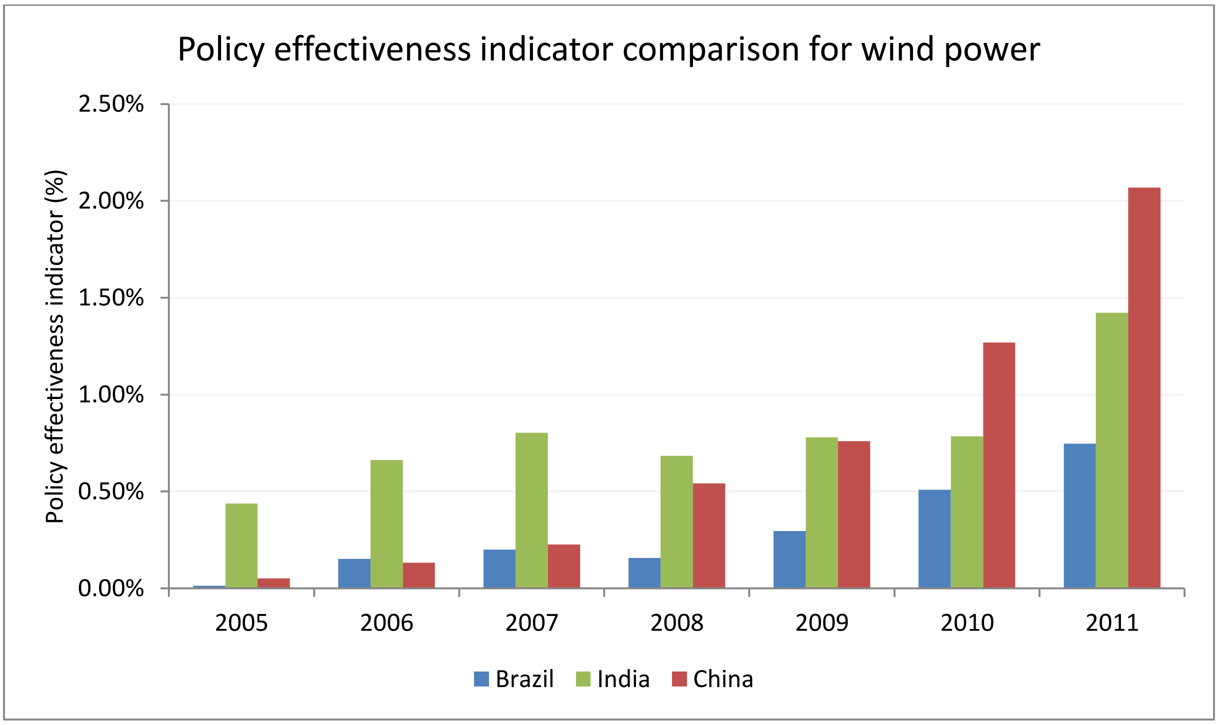

Figure 37: Policy effectiveness indicator comparison for wind power (Source: own calculations)

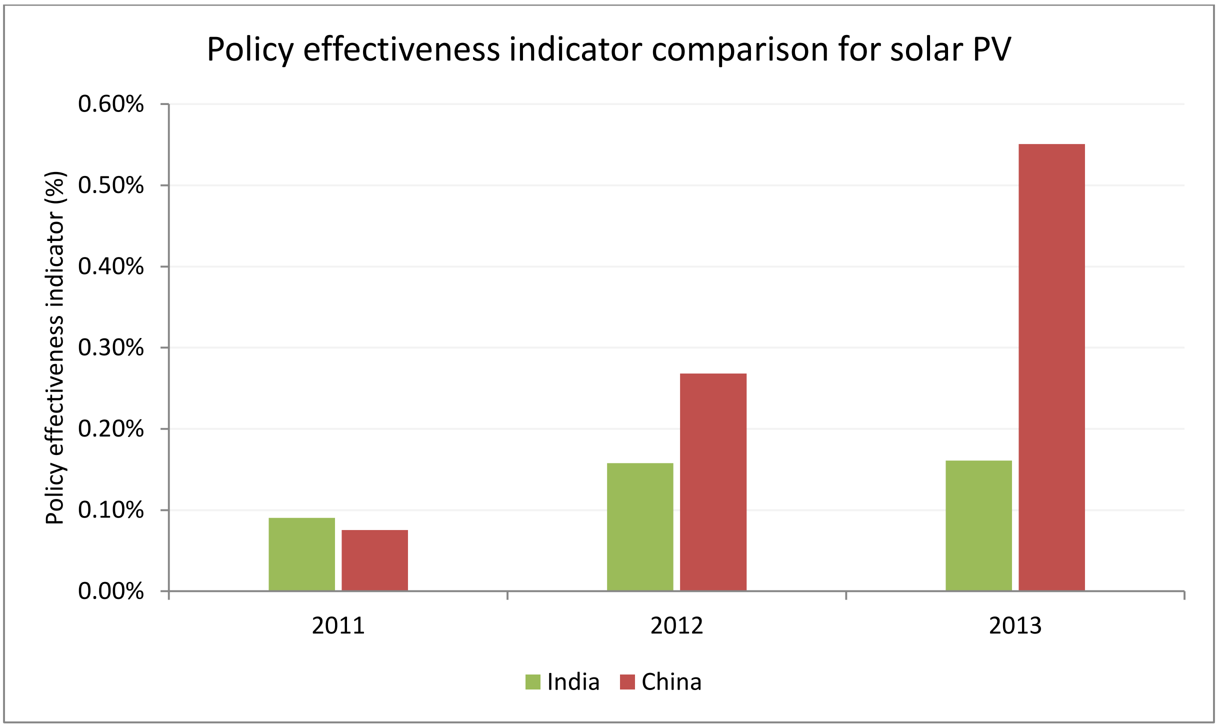

Figure 38: Policy effectiveness indicator comparison for solar power (Source: own calculations)

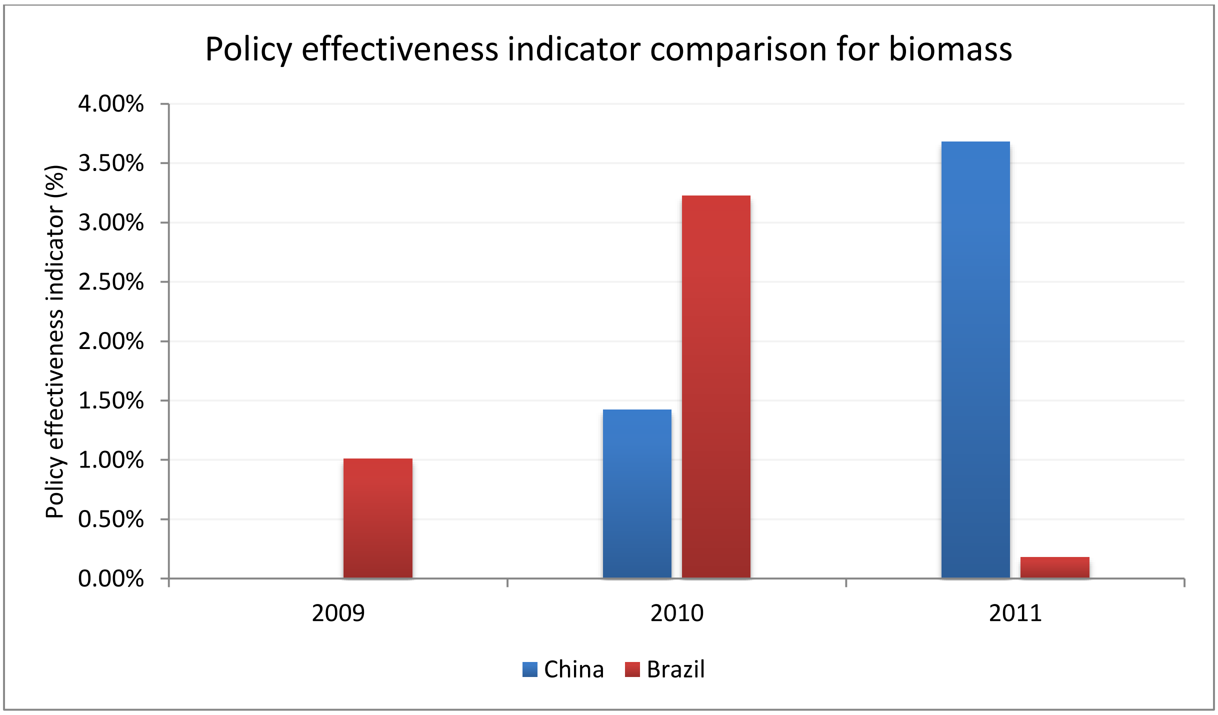

Figure 39: Policy effectiveness indicator comparison for biomass (Source: own calculations)

4.3 Policy efficiency

Government expenditures are one key issue for the policy framework for renewable energy, since with large-scale deployment also the expenditures for support mechanisms increase significantly. Figure 40 shows the calculated total cost indicators for the BRICs (except Russia) for wind power technology. The TCI shown in this figure considers only feed-in tariffs or power purchase agreement prices. Other benefits such as tax reductions etc. were not included in these calculations due to very limited data on actual expenses in these fields. What can be obtained from the comparison is the most recent improvement of the correlation between expenditures and gains in generation in China and India. The overall trend however is quite linear, 0.1% of additional wind electricity generation share (compared to the total electricity generation) required approximately 0.1% more premium expenditures (compared to the total wholesale electricity value). As with higher technology maturity and decreasing costs, it can be expected that this relation will change and an increase in renewable electricity generation will not rely on higher government expenditures (as already can be seen with hydropower).

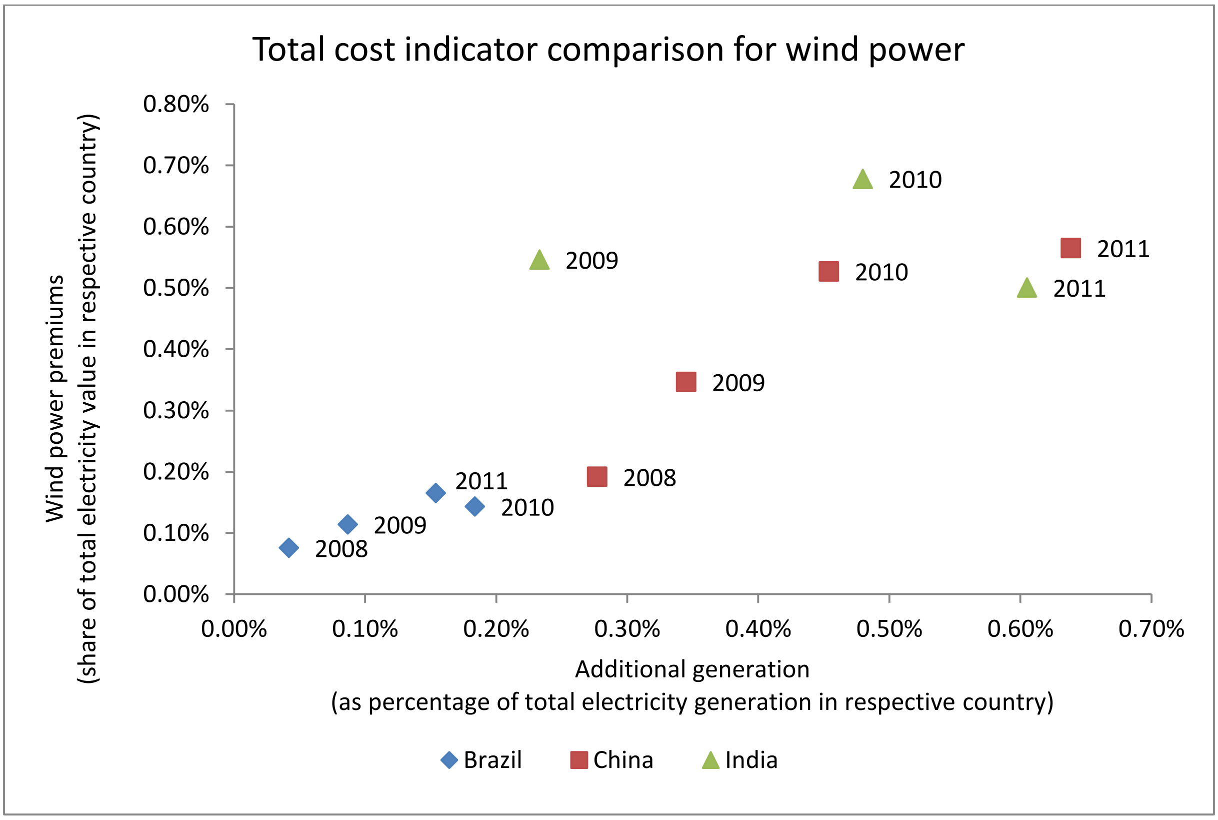

Figure 40: Total cost indicator comparison for wind power (Source: own calculations)

4.4 Investment comparison

Government policies have a direct impact on the attractiveness for investments in the renewable sector, especially for non-competitive technologies in the inception and take-off phase. In this term, China has managed to create a highly attractive environment for investments since it has surpassed Europe and now ranks first worldwide in total new renewable investments (50). Also among the BRICs only China could record a consecutive increase in investments from 2004 until 2012. Brazilian investments declined recently and now have reached the level of 2005; a similar development can also be seen in India. The recent decline has different reasons, both technological and economical. The decline in solar power investments as could be seen in China and India (Figure 29 and Figure 35) also reflect the falling costs for solar PV, while wind power investment declines in China occurred due to grid connection issues and cash shortages whereas Brazilian wind power investments suffered from delays between auctions and the resulting debt and equity financing (50).

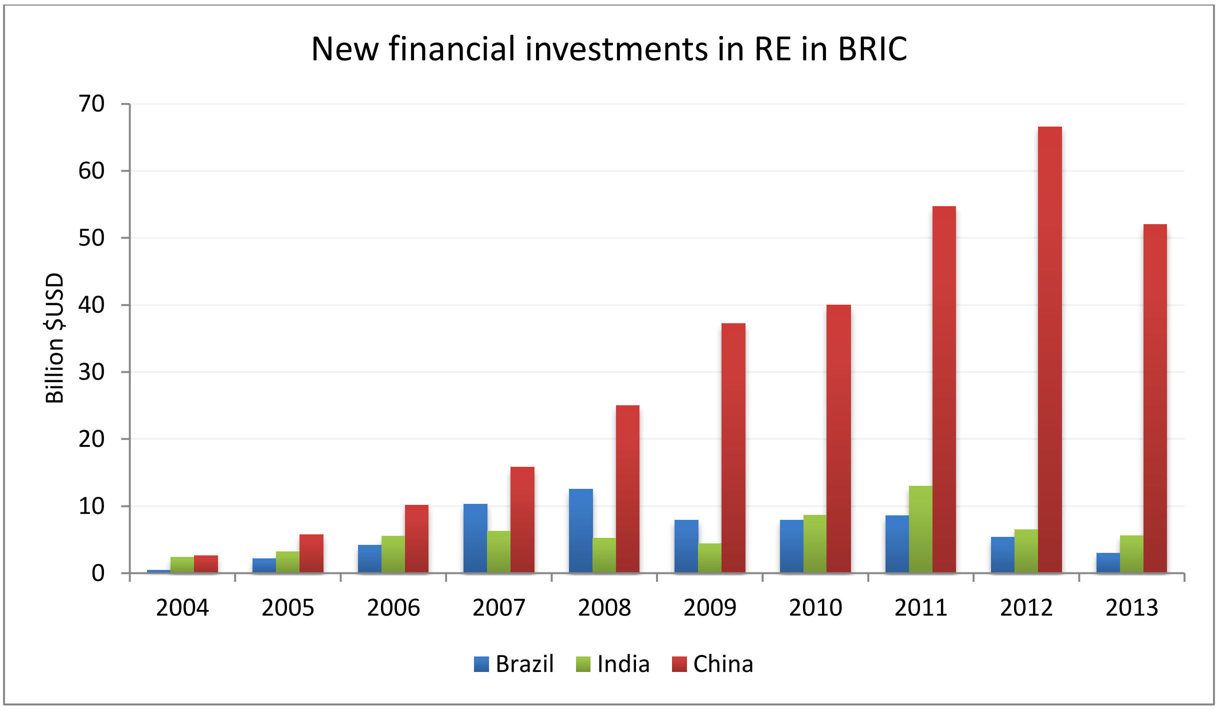

Figure 41: New financial investments in renewable energy
(Source: own compilation on base of (57), (58), (59), (60), (56), (50))

4.5 General conclusions

Large efforts have been achieved in the renewable electricity sector by the BRICs (except in Russia, which just recently has implemented a renewable electricity policy), however the growth of fossil fuel consumption for electricity generation still exceeds the renewable electricity generation growth rate (except in Brazil). Nonetheless, technological improvements have significantly lowered the costs for renewable energy and enabled those technologies to become market-competitive. Besides a higher energy security thanks to diversified power sources and CO_2 emission reductions also the positive economic impact of renewable power technologies is large. For example, the REN21 global status report estimated almost 3 million jobs created in the field of renewable energy (1). Also exports are a key factor regarding economic benefits. The domestic installation of new solar PV capacity in China was around 500 MW in 2010, but in the same year China exported 7.5 GW of solar PV, thus fifteen times the domestic annual installation. In the wind power sector the share of Chinese suppliers for new domestic wind power capacities jumped up from around 30% in 2005 to almost 90% in 2009 (however the exports were low for wind turbines) (75). Also in Brazil several wind manufacturers could be attracted and brought new jobs. However there are also several barriers which hinder renewable energy developments. One serious technological barrier is grid-connectivity, in particular for China with temporarily almost 30% of installed wind power capacity lacking grid connection, but also for Brazil and India. Another significant barrier is insufficient research & development. Particularly in India, R&D for solar PV is necessary to lower upfront costs, but also in Brazil at the PROINFA period, sufficient local suppliers for wind turbine manufacturing were missing. Also delays in construction occurred several times for example at PROINFA in Brazil. From the government perspective, the most urgent issues are coordination problems within ministries and stakeholders involved in the RE development process and policy uncertainties due to policy changes which could be identified in all BRIC countries. Financial barriers are on the one hand high upfront costs, particularly for solar PV but also the high dependency on debt financing as can be seen in China with 80% of wind power project funds relying on debts (76). Regarding a proper policy design with both high effectiveness and efficiency it must be noted first, that there is no one-size-fits-all policy for renewable energy. Suitable policies are dependent on the local situation and current development position. Nonetheless after analyzing the most important government support schemes some conclusions could be derived. First, feed-in tariffs are an appropriate tool to lower investment risks by assuring a predictable long-term remuneration for electricity generators. From the observations, FITs are rather applicable for technologies entering the take-off phase. FITs for technologies in inception phase are difficult to apply, since finding the proper tariff with many unpredictable factors is a complex procedure and could either lead to windfall profits when the tariff is too high or to no developments at all, when it is not sufficient to attract project stakeholders. One possibility to avoid these problems or at least limit consequences in case of failure are limited FITs up to a certain capacity or generation rate as already applied in all BRIC countries. For inception technologies, local subsidies and incentives for testing purposes are more suitable and also have been implemented. Tax reductions and accelerated depreciation were also used in order to start developments and are along with FITs key drivers for growth. Auctions and tenders with power purchase agreements were also applied and Brazil has switched completely to this system. Auctions are suitable to lower prices significantly as could be observed in Brazil, however strong competition is necessary for auctions to work. Also the risk of bidding too low has to be considered, which resulted in several project delays or even abortions due to insufficient return on investment. RPS were applied in China and India with mixed results due to some issues regarding the implementation, however the impact on RET deployment is difficult to measure. REC trading in India has shown modest success and investors were observed to hesitate to enter the certificate market since the uncertainties are yet high. To summarize, a mixture of support policies (but primarily including predictable tariffs) is useful and a suitable approach for deploying new RE capacities, however technological, governmental and financial barriers have to be addressed simultaneously in order to unleash the whole potential of those policies.

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Appendix

Electricity generation data

Brazil

All data except solar PV obtained from EIA International energy statistics (7); solar PV data obtained from IEA statistics (77)

Units in TWh	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar PV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	1.92	2.04	2.36	3.17	3.12	3.13	3.20	3.63	3.43	3.32
Hydro	128.44	129.40	139.65	149.89	164.85	176.51	180.70	183.74	197.10	202.64
Nuclear	0.00	0.00	0.05	0.17	2.73	2.92	0.12	0.92	0.31	1.51
Fossil	7.94	8.72	7.97	7.22	7.40	8.11	15.22	12.16	10.94	10.82

Appendix Table 1: Electricity generation in Brazil by technology and year (1980-1989)

Units in TWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Solar PV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	3.86	4.00	4.90	4.95	5.39	5.59	6.75	7.38	7.51	8.37
Hydro	204.64	215.60	221.11	232.71	240.28	251.37	263.11	276.18	288.55	290.07
Nuclear	1.94	1.37	1.66	0.42	0.05	2.39	2.31	3.01	3.14	3.78
Fossil	9.52	10.47	11.17	11.16	11.18	12.84	15.48	17.70	18.62	27.47

Appendix Table 2: Electricity generation in Brazil by technology and year (1990-1999)

Units in TWh	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind	0.00	0.04	0.06	0.06	0.06	0.09	0.24	0.65	0.84	1.24
Solar PV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	7.84	8.98	10.22	11.89	12.48	13.59	14.72	18.03	19.61	22.51
Hydro	301.36	265.20	283.23	305.62	320.80	337.46	348.81	374.02	369.57	390.99
Nuclear	4.94	14.27	13.84	13.40	11.60	9.90	13.75	12.31	13.97	12.31
Fossil	28.43	34.69	32.95	30.98	39.46	38.76	38.66	36.59	54.95	35.52

Appendix Table 3: Electricity generation in Brazil by technology and year (2000-2009)

Units in TWh	2010	2011	2012
Wind	2.18	3.00	5.05
Solar PV	0.00	0.00	
Geothermal	0.00	0.00	
B & W	31.50	32.00	27.10
Hydro	403.29	428.33	415.34
Nuclear	13.80	14.88	
Fossil	60.13	56.55	

Appendix Table 4: Electricity generation in Brazil by technology and year (2010-2012)

China

All data except solar PV obtained from EIA International energy statistics (7); solar PV data obtained from IEA statistics (77). Data for 2012 and 2013 was estimated based on the calculated average full load hours (considered time period: solar: 2005-2011, wind: 2009-2011) and the given data for installed capacities.

Units in TWh	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar PV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	57.62	64.85	73.66	85.54	85.93	91.48	93.56	99.20	108.01	117.22
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fossil	227.86	229.17	238.10	249.10	272.79	299.20	333.79	373.27	409.84	438.32

Appendix Table 5: Electricity generation in China by technology and year (1980-1989)

Units in TWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Wind	0.00	0.01	0.01	0.02	0.04	0.06	0.10	0.21	0.37	0.49
Solar PV	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	0.00	0.00	0.00	0.00	0.34	2.90	1.42	2.61	2.36	2.40
Hydro	125.14	123.85	130.19	149.19	165.35	184.90	185.05	192.62	202.26	210.80
Nuclear	0.00	0.00	0.50	2.47	13.50	12.38	13.62	11.35	13.46	14.09
Fossil	465.21	519.26	585.34	644.04	701.17	756.06	805.30	863.43	885.23	944.46

Appendix Table 6: Electricity generation in China by technology and year (1990-1999)

Units in TWh	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind	0.62	0.75	0.87	1.04	1.33	2.03	3.87	5.71	14.80	26.90
Solar PV	0.02	0.02	0.04	0.06	0.07	0.07	0.08	0.11	0.15	0.39
Geothermal	0.00	0.00	0.00	0.00	0.00	0.12	0.13	0.12	0.14	0.15
B & W	2.42	2.44	2.43	2.42	2.41	2.41	2.40	2.39	2.35	2.35
Hydro	220.19	274.66	285.09	280.84	350.01	393.05	431.43	480.41	579.34	609.48
Nuclear	15.90	16.60	25.17	41.66	47.95	50.33	54.85	62.60	65.33	66.60
Fossil	1041.46	1132.21	1271.07	1484.23	1701.76	1922.15	2225.06	2539.22	2618.56	2802.52

Appendix Table 7: Electricity generation in China by technology and year (2000-2009)

Units in TWh	2010	2011	2012	2013
Wind	44.62	73.20	112.42	136.45
Solar PV	0.94	3.00	8.68	21.23
Geothermal	0.16	0.16		
B & W	11.41	34.00		
Hydro	713.79	687.06		
Nuclear	70.21	83.03		
Fossil	3063.00	3595.50		

Appendix Table 8: Electricity generation in China by technology and year (2010-2013)

India

All data except solar PV obtained from EIA International energy statistics (7); solar PV data obtained from IEA statistics (77). Data for 2012 and 2013 was estimated based on the calculated average full load hours (considered time period: solar: 2009-2011) and the given data for installed capacities.

Units in TWh	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Wind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Solar PV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	46.54	49.56	48.31	49.87	53.41	50.51	53.31	46.99	57.29	61.51
Nuclear	3.00	3.02	2.02	3.49	3.84	4.70	4.73	4.75	5.19	3.80
Fossil	69.72	78.54	89.08	91.63	104.49	119.73	133.85	156.49	166.95	189.79

Appendix Table 9: Electricity generation in India by technology and year (1980-1989)

Units in TWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Wind	0.03	0.04	0.09	0.10	0.20	0.53	0.92	1.04	1.13	1.51
Solar PV	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97
Hydro	70.94	72.05	69.19	69.77	81.90	71.87	68.24	73.91	82.17	79.90
Nuclear	5.61	5.17	6.01	5.90	4.72	6.46	7.42	10.45	10.64	11.45
Fossil	198.91	223.06	240.69	263.58	279.30	317.21	336.09	355.76	376.82	410.70

Appendix Table 10: Electricity generation in India by technology and year (1990-1999)

Units in TWh	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind	1.68	2.24	2.69	3.59	4.49	6.60	8.69	11.80	13.70	17.80
Solar PV	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Geothermal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B & W	1.35	1.82	1.84	1.86	1.89	1.92	1.95	1.98	2.00	2.03
Hydro	73.72	72.96	63.46	74.59	83.88	100.71	112.58	119.38	109.14	103.17
Nuclear	14.06	18.23	17.76	16.37	15.04	15.73	15.59	15.91	13.17	14.01
Fossil	438.84	453.66	478.70	503.32	525.00	536.41	573.47	622.82	658.77	718.27

Appendix Table 11: Electricity generation in India by technology and year (2000-2009)

Units in TWh	2010	2011	2012	2013
Wind	19.91	26.00		
Solar PV	0.02	1.00	2.71	5.19
Geothermal	0.00	0.00		
B & W	2.06	4.00		
Hydro	113.28	131.00		
Nuclear	19.46	28.95		
Fossil	749.40	794.50		

Appendix Table 12: Electricity generation in India by technology and year (2010-2013)

Russia

All data except solar PV obtained from EIA International energy statistics (7); solar PV data obtained from IEA statistics (77).

Units in TWh	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Wind	--	--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar	--	--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	--	--	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
B & W	--	--	1.85	1.76	1.61	1.58	1.56	1.53	1.52	2.08
Hydro	--	--	170.13	171.67	173.23	173.66	151.80	155.02	156.91	158.89
Nuclear	--	--	113.62	113.24	92.91	94.34	103.32	104.50	98.33	110.91
Fossil	--	--	679.62	627.92	540.36	545.96	547.84	533.18	530.09	527.22

Appendix Table 13: Electricity generation in Russia by technology and year (1992-1999)

Units in TWh	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Wind	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Solar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal	0.06	0.09	0.16	0.32	0.40	0.41	0.46	0.49	0.47	0.46
B & W	2.54	2.87	2.80	1.81	1.81	2.64	2.74	2.00	2.54	2.64
Hydro	162.44	172.16	160.60	154.20	174.07	170.95	171.62	175.28	163.12	172.44
Nuclear	122.46	125.36	134.14	141.17	137.47	140.22	144.30	151.81	154.18	154.95
Fossil	544.33	541.01	547.55	569.72	570.73	588.42	621.22	633.39	665.12	610.22

Appendix Table 14: Electricity generation in Russia by technology and year (2000-2009)

Units in TWh	2010	2011
Wind	0.00	0.00
Solar	0.00	0.00
Geothermal	0.51	0.51
B & W	2.77	2.80
Hydro	164.82	163.28
Nuclear	162.17	161.71
Fossil	654.33	668.72

Appendix Table 15: Electricity generation in Russia by technology and year (2010-2011)

Installed capacity data

Brazil

All data obtained from EIA International energy statistics (7) except data for solar capacity in 2011. Data for solar PV capacity in 2011 and 2012 was obtained from the EPIA Global Market Outlook for PV 2013-2017 (53), data for wind power capacity in 2012 was obtained from the GWEC Global Wind Report Annual Market Update 2012 (48). The projections for the period 2013-2022 are obtained from the MME's and EPE's Plano Decenal de Expansão de Energia (20).

Units in GW	2005	2006	2007	2008	2009	2010	2011	2012
Wind	0.029	0.237	0.247	0.414	0.6	0.927	1.402	2.508
Solar	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.005	0.017
B & W	6.0792	6.2871	6.3972	6.9756	6.103	7.826	7.826	8.618
Hydro	70.858	73.434	76.871	77.87	79.291	80.703	82.14	84

Appendix Table 16: Installed capacity of RETs in Brazil (2005-2012)

Units in GW	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Wind	3.898	6.561	9.097	10.78	12.063	13.063	14.063	15.063	16.263	17.463
B & W	9.473	9.572	9.572	9.572	9.672	10.419	11.279	12.089	13.069	13.769
Hydro	94.026	96.079	100.261	103.296	107.847	112.895	114.68	117.535	120.35	125.918

Appendix Table 17: Projections for installed capacity of RETs in Brazil (2013-2022)

China

All data obtained from EIA International energy statistics(7) except data for 2011 and 2012. Data for solar PV capacity in 2011 and 2012 was obtained from the EPIA Global Market Outlook for PV 2013-2017 (53), for solar PV in 2013 from Bloomberg (64). Data for wind power capacity in 2012 and 2013 was obtained from the GWEC Global Wind Statistics 2013 (63). Data for biomass in 2012 was obtained from Renewable Facts (72). Hydropower data for 2011 and 2012 was obtained from the REN21 Global Status Report 2013 (1).

Units in GW	2005	2006	2007	2008	2009	2010	2011	2012	2013
Wind	1.27	2.67	6.03	12.17	17.67	31.31	47.84	75.32	91.42
Solar	0.07	0.08	0.1	0.15	0.3	0.89	3.3	8.3	20.3
B & W	1.9	1.9	2.2	2.6	3	4.4	5.3	7.8	
Hydro	111.79	122.37	136.32	161.3	183.1	203.75	213.5	229	

Appendix Table 18: Installed capacity of RETs in China (2005-2012)

India

All data obtained from EIA International energy statistics (7) except data for wind power and data for 2012 and 2013. Wind power data was obtained from the annual GWEC Global Wind Reports and the GWEC Global Wind Statistics 2013 (63). Data for biomass and waste capacities was obtained from the Indian Ministry of new and renewable energy (MNRE) (71). Hydro energy data for 2012 is obtained from Renewable Facts (78). Data for solar PV 2012 is obtained from (53), for 2013 from (79).

Units in GW	2005	2006	2007	2008	2009	2010	2011	2012	2013
Wind	4.43	6.27	7.845	9.655	10.926	13.065	16.084	18.421	20.149
Solar	0.0028	0.00274	0.00212	0.00212	0.01	0.01	1	1.2	1.969
B & W	0.989	1.1851	1.4613	1.8	2.2	2.6	3.48	3.63	3.9
Hydro	34.152	36.63	38.089	39.308	39.598	40.61	40.61	40.63	

Appendix Table 19: Installed capacity of RETs in India (2005-2013)

Russia

All data obtained from EIA International energy statistics (7) except data for wind power and hydropower data in 2012. Wind power data was obtained from the World Wind Energy Association Annual Report 2012 (62). Hydropower data was obtained from (56).

Units in GW	2005	2006	2007	2008	2009	2010	2011	2012	2013
Wind	0.014	0.0165	0.0165	0.0165	0.014	0.0154	0.0154	0.0168	0.0168
Geothermal	0.079	0.079	0.0819	0.0819	0.0819	0.0819			
Hydro	44.635	44.862	45.604	45.604	45.673	45.673	45.673		

Appendix Table 20: Installed capacity of RETs in Russia (2005-2013)

2020 potentials

All data obtained from IEA Deploying Renewables Report (6).

Units in TWh	Russia	China	India	Brazil
Bioenergy	1162.92435	648.328833	357.284481	309.909722
Hydropower	996.629842	2078.37908	613.012213	738.661372
Solar PV	142.76111	1561.49856	456.35977	174.426099
Wind (onshore)	130.622425	1419.77504	364.366697	146.706023

Appendix Table 21: Renewable electricity generation potentials 2020

Investment data

All data obtained from the annual "Global Trends in Renewable Energy Investment" reports by Frankfurt School of Finance & Management in collaboration with UNEP and Bloomberg New Energy Finance (50).

New investments in RETs by country(billion US$)	2004	2005	2006	2007	2008	2009	2010	2011	2012
Brazil	0.5	2.2	4.2	10.3	12.5	7.9	7.9	8.6	5.4
China	2.6	5.8	10.2	15.8	25	37.2	40	54.7	66.6
India	2.4	3.2	5.5	6.3	5.2	4.4	8.7	13	6.5

Appendix Table 22: New investments in RETs by country

Investments in RETs in Brazil (billion US$)	2009	2010	2011	2012
Wind	2.2	2.4	5	3.4
Small Hydro	1.7	1.2	0.9	0.7
Biomass	0.6	0.9	0.5	0.5
Solar	--	--	0.03	0.1

Appendix Table 23: Investments in RETs in Brazil by technology

Investments in RETs in China (billion US$)	2009	2010	2011	2012
Wind	27.2	41.4	31.4	28.1
Small Hydro	--	--	2.9	2.7
Biomass	3	3.7	2.1	2.5
Solar	3.3	3.8	13.3	25.7

Appendix Table 24: Investments in RETs in China by technology

Investments in RETs in India (billion US$)	2009	2010	2011	2012
Wind	1.6	2.6	5.9	3.1
Small Hydro	0.2	--	0.5	0.6
Biomass	0.6	0.6	0.9	0.6
Solar	0.1	0.5	4.7	1.8

Appendix Table 25: Investments in RETs in India by technology

Currency exchange rates

All data are annual averages obtained from the OECD StatExtracts (80). CNY (Yuan) is the official ISO-4217 code for Chinese currency, however it is also often referred to as RMB (Renminbi).

Currency exchange	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Brazil (R$ per 1US$)	1.829	2.35	2.92	3.077	2.925	2.434	2.175	1.947	1.834	1.999	1.759	1.673	1.953	2.157
China (RMB per 1 US$)	8.279	8.277	8.277	8.277	8.277	8.194	7.973	7.608	6.949	6.831	6.77	6.461	6.312	6.196
Russia (Ruble per 1 US$)	28.129	29.169	31.348	30.692	28.814	28.284	27.191	25.581	24.853	31.74	30.368	29.382	30.84	31.837
India (Rs. Per 1 US$)	44.942	47.186	48.61	46.583	45.316	44.1	45.307	41.349	43.505	48.405	45.726	46.67	53.437	58.598

Appendix Table 26: Currency exchanges rates

Reference prices for TCI calculation

The reference price for Brazil was estimated based on data for hydropower LCOE from the 2010 report “Projected Costs of Generating Electricity” by the IEA and OECD (81). Data for China thermal wholesale electricity prices was obtained from the Appendix E of the “Carbon Emission Policies in Key Economies” report issued by the Australian Government Productivity Commission (82); the 2011 data for China was calculated based on an article by Bloomberg Businessweek (83). Price data for India was obtained from the “Restructuring Debts of Discoms' for Sustainable Power Growth” report from 2013 issued by PHD Chamber and Arthur D. Little (84).

Reference prices for TCI (US$ per kWh)	2005	2006	2007	2008	2009	2010	2011	2012	2013
Brazil				0.35	0.35	0.35	0.35		
China	0.040	0.044	0.047	0.055	0.056	0.056	0.063		
India					0.069	0.078	0.081	0.082	0.084

Appendix Table 27: Reference prices for TCI calculation

Feed-in tariffs

Brazil

Feed-in tariff prices for PROINFA were obtained from (12), auction prices were obtained from (9).

Feed-in tariffs (US$ per MWh)	PROINFA	Auction 2009	Auction 2010	Auction 2011
Wind power (onshore)	157.5	76.5	65	56.25
Small hydro	96			
Biomass	70			

Appendix Table 28: Feed-in tariffs in Brazil

China

Feed-in tariff prices for wind power in China were obtained from (33), tariffs for solar PV were obtained from (31), (32) and (36). Data for renewable energy surcharge was obtained from (31).

Feed-in tariff	Category	Tariff (RMB/kWh)	Tariff (US$/MWh)
Wind power (onshore)	I	0.51	74.66
	II	0.54	79.05
	III	0.58	84.91
	IV	0.61	89.3

Appendix Table 29: Wind power feed-in tariffs in China

Feed-in tariff	Category	Tariff (RMB/kWh)	Tariff (US$/MWh)
Solar PV	Before 31st Dec 2011	1.15	178.0
	After 31st Dec 2011	1	154.77
	Revision 2013 Type I area	0.90	139.3
	Revision 2013 Type II area	0.95	147.04
	Revision 2013 Type III area	1	154.77

Appendix Table 30: Solar PV feed-in tariffs in China

Feed-in tariff	Category	Tariff (RMB/kWh)	Tariff (US$/MWh)
Biomass	2006-2010	0.25	31.36
	2010-present	0.75	94.07

Appendix Table 31: Biomass feed-in tariffs in China

Renewable energy surcharge	2006	2007	2008	2009	2010	2011	2012	2013
Surcharge (RMB/kWh)	0.001	0.001	0.001	0.004	0.004	0.008	0.008	0.015
Surcharge (US$/MWh)	0.13	0.13	0.14	0.59	0.59	1.24	1.27	2.42

Appendix Table 32: Renewable energy surcharge China

India

Data for generation based incentives was obtained from (38) and (41). Wind power GBI is limited to 10.000.000 Rs. per MW within ten years, the GBI for wind power was in force from 2009-2012 and has been reinstated in 2013. State-wise FIT data was obtained from (41).

Generation based incentives	Tariff (Rs./kWh)	Tariff (US$/MWh)
Wind power (onshore)	0.5	10.33
Solar PV	12.41	256.38

Appendix Table 33: Generation based incentives for wind power and solar PV in India

Feed-in tariff	State	Tariff (Rs./kWh)	Tariff (US$/MWh)
Wind power	Andhra Pradesh	4.70	87.95
	Gujarat	4.23	79.16
	Haryana Zone 1	6.14	114.90
	Haryana Zone 2	4.91	91.88
	Haryana Zone 3	4.09	76.54
	Haryana Zone 4	3.84	71.86
	Karnataka	3.70	69.24
	Kerala	3.64	68.12
	Madhya Pradesh	4.35	81.40
	Maharashtra Zone 1	5.67	106.11
	Maharashtra Zone 2	4.93	92.26
	Maharashtra Zone 3	4.20	78.60
	Maharashtra Zone 4	3.78	70.74
	Orissa	5.31	99.37
	Punjab	5.07	94.88
	Rajasthan Zone 1	4.46	83.46
	Rajasthan Zone 2	4.69	87.77
	Tamil Nadu	3.51	65.68
	Uttarakhand Zone 1	5.15	96.38
	Uttarakhand Zone 2	4.35	81.40
	Uttarakhand Zone 3	3.65	68.30
	Uttarakhand Zone 4	3.20	59.88
	West Bengal	4.87	91.14

Appendix Table 34: Wind power feed-in tariffs in India by state