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Policy Brief 11/2016

India´s pathway to 100 % renewable power generation - Exploring capacity mix, costs and innovative financing tools

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MOTIVATION AND BACKGROUND

The sustainable development goals (SDGs) and the Paris Agreement represent milestones in the history of international negotiations about recognizing and fighting climate change, as it is the first time that all nations signed environmental conventions consentaneously. India entered into these two epoch-making treaties and approved the target of limiting the global warming to well below 2 degrees. Thus, energy efficiency and a low-carbon power supply development building on renewable energy sources will be unavoidable for India in the long-term.

The following policy brief represents an extract of a detailed study[1] about India's future energy demand until 2050, the potential of renewable energy sources and the feasibility of the innovative infrastructure pension fund instrument to leverage required private capital covering installation costs. Objective of the assessment is to evaluate whether a 100% renewable energy supply until 2050 is feasible in the Indian context and what financial amounts would be required to realize it. A variety of recent published reports and governmental statements until July 2016 were assessed for the scenario development.[2,3,4,5,6,7,8,9]

[1] Röben, Felix (2016) Feasibility of sustainable power supply in India until 2050 supported by an Infrastructure Pension Fund, the greenwerk.
[2] Indian Government. (2015a). INDC. Contribution to COP21: India's Intended Nationally Determined Contribution.
[3] Indian Government. (2015b). Achievements and Initiatives of Ministry of New and Renewable Energy.
[4] Central Electricity Authority. (2016, March 18.). Power Transmission: Existing and approved networks
[5] IDDRI/TERI. (2014). Pathways to Deep Decarbonization 2014 Report. SDSN.
[6] IEA. (2015). India Energy Outlook. Paris, France: World Energy Special Report.
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[8] TERI. (2013). The Energy Report - India 100% Renewable Energy by 2050. New Dehli: WWF India.
[9] World Bank. (2014). More Power to India - The Challenge of Electricity Distribution. Washington.

ARE 100% RENEWABLES BY 2050 A REALISTIC OPTION FOR INDIA?

India will be the most populous country by 2025 and the economy grows with stunning rates. The Government of India tackles the challenge of rural electrification and states e-mobility could be implemented soon. The power demand increases accordingly. Making use of renewable energy sources is certainly the most desirable scenario in order to limit global warming, but it also makes India independent from obsolescent technologies. Furthermore, applying sustainable financial instruments for the implementation hold the potential of benefiting the national welfare system.

Capacity addition

In case of the assessed sustainable scenario based on 100% renewables by 2050, the potential of renewable energy sources in India and the most ambitious plans to make them accessible are considered. Demand Site Management (DSM) and Concentrated Solar Power (CSP) are not fully mature yet, but if applied they reduce the overall costs for power.

Figure 1 shows the development of the electricity generation in the sustainable scenario. The electricity mix becomes slowly more diverse and this development speeds up after 2020. The

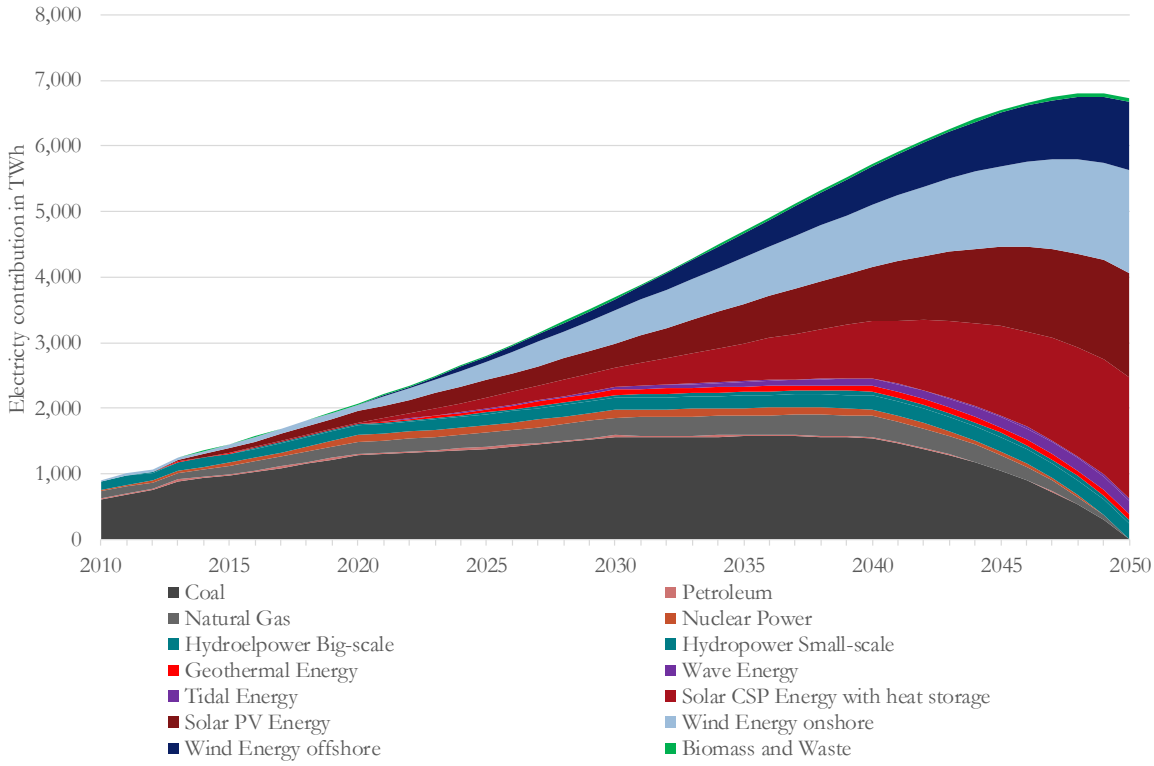

Figure 1: "Sc_100 % RE" development of electricity generation by source, author´s diagram

addition of fossil fuel based power plants and nuclear power plants slows down, the installed capacity remains constant after 2030 and decreases after 2040 until it disappears in the energy mix by 2050.

The assessment of different electricity mix scenarios shows that the current baseline scenario relying heavily on fossil fuels is likely not in accordance with the environmental goals of the Paris Agreement as it generates more than 3.5 $GtCO_2$ per year by 2050. The 100% renewable pathway brings substantial mitigation benefits, however even this scenario leads to significant CO_2 emission from electricity generation that peak with more than 1.5 $GtCO_2$ per year by 2037. Afterwards the broad installation of renewables reduces emissions rapidly until 2050, when about 150 $MtCO_2$ per year are reached.

Besides the mitigation impact, a sustainable development based on 100% renewables is beneficial for the economy from a national perspective. Instead of increasing the dependency on the import of fossil fuels with uncertain availability and fluctuating price development, the capital is invested into sustainable power supply promoting the national development and creating jobs in next generation technologies.

Financial assessment

Satisfying the power demand with renewable energy sources is not only feasible, it would even reduce long-term costs compared to a fossil fuel based development. According to the simulations, solar CSP with heat storage is the most promising power generating technology for India because it has a high geographical potential and can balance the fluctuating energy sources. The levelised cost of electricity (LCOE) of solar CSP is on track to become competitive and according to our findings this technology will play a leading role in the future energy mix. The financial assessment does not take into account adaptation to climate change, future costs for carbon pricing or maintenance of nuclear waste repositories, nor does it consider the decreasing availability of fossil and nuclear fuels. A complete transition to renewable energy sources by 2050 would limit these risks and potential additional costs.

Renewable energy sources require higher investments, but the LCOE can already be competitive in cases of solar PV, wind onshore, hydropower and geothermal energy. Figure 2 shows the sum of all levelised costs in three different cases. The 100% renewables scenario with DSM implies less levelised costs than the baseline scenario due to the domination of cheap fluctuating renewable sources without high storage demand. On the contrary, the most expansive development would be the 100 % RE electricity mix without DSM, due to high costs for storage capacity.

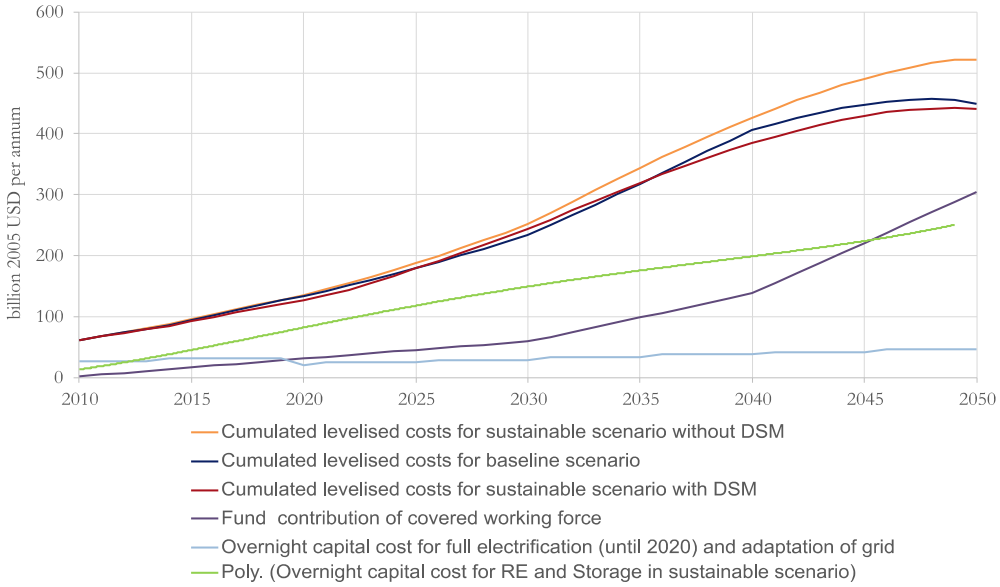

Figure 2: Comparison of financial demand and pension fund potential, author´s diagram

In summary, the sustainable scenario with DSM is financially the most efficient option, even though cost intensive aspects and potential risks of the baseline scenario are not considered in this simulation. Nevertheless, even the most efficient option would require an aggregated total of more than 11 trillion USD to cover the LCOE and storage costs until 2050.

INFRASTRUCTURE PENSION FUND

Such a tremendous volume of investments will require significant amounts of private capital. In order to explore economically sound options, the study reflected the idea of applying a domestic Infrastructure Pension Fund[3] to leverage private capital. This innovative approach strives to achieve environmental, social and economic advancements at once. In its general idea, the population allocates pension payments to a regulated pension fund, which invests domestically in sustainable infrastructure. The investments must meet certain sustainability criteria to balance investments risks for the contributors while guaranteeing environmental sustainability and a decent profit level. In future, revenues from the infrastructure investments are channelled back to the retirees. Constant pension contributions with a long investment horizon are a suitable match to the requirements of infrastructure with long amortization periods and lifetimes such as power grids, storage and potentially capacity.

[3] Currently explored by Michel Köhler in the context of a PhD at the Europe University of Flensburg

The simulation shows a rising potential of the Infrastructure Pension Fund due to GDP growth and increasing salaries. Compared to the predicted overnight capital costs for the renewable scenario as illustrated in Figure 2, the Infrastructure Pension Fund could mobilize up to 30 billion USD per year by 2020 and more than a quarter of the overall required capital until 2050. These assumptions do not consider the returns on investment which could further increase the amount of available capital.

Besides leveraging funds and creating a reliable pension system for large parts of the working population, the approach of creating infrastructure shareholders among broad parts of the population could also address flanking aspects of large-scale infrastructure development such as resistance against constructions or concerns about fair distribution of domestic infrastructure assets.

Conclusion

This study reveals that the currently planned, baseline capacity mix resulting from government targets, predicted developments and expected trends, will likely not be in accordance with the objectives of the Paris Agreement. Our evaluation of the power demand development and alternative capacity addition of renewable energy sources shows that sustainable power supply is feasible in India. The simulations indicate that a complete shift towards a 100% renewable based power supply even holds the potential of being more efficient, if the right technologies are promoted. Thus, India's energy development seems rather to be dependent on political decisions while technical challenges of a 100% renewable energy transformation are expected to be resolvable.

Given the tremendous investment needs in all scenarios, the idea of an Infrastructure Pension Fund was explored and its potential for mobilizing private capital was estimated. Our study demonstrates that its potential to leverage funds matches with the required investments for a 100% renewable power supply in the long-run. Thus, its set-up should be further explored as a suitable financial tool for promoting and financing a transition towards renewable energy sources in India.

About the authors

Felix Röben is an independent energy efficiency consultant and holds the degree Master of Engineering in Renewable Energy Systems. He is associate to the greenwerk since 2015. Michel Köhler is co-founder of the greenwerk and holds a degree in Industrial Engineering with a focus on renewable energy and international climate policy. Michel is doing his PhD exploring innovative mitigation finance mechanisms in the context of a sustainable infrastructure pension fund.

About the greenwerk.

the greenwerk is an advisory network for climate and sustainable energy policy, based in Hamburg, Germany. Based on our background and expertise, we offer a wide range of advisory services to our clients around the globe. Our work focuses on instruments and activities for promoting renewable energy and greenhouse gas mitigation, in both developing and developed countries. With our engagement we support international efforts and climate finance to combat global warming, with technical support on policy frameworks, methodological approaches and instruments. We believe that communication is the key to a global approach for a sustainable use of energy, as well as for tackling anthropogenic climate change – therefore we facilitate knowledge transfer in the field of climate and energy policy, through delegation trips, workshops and conferences as well as trainee programmes.
Furthermore, the greenwerk has closely observed the UNFCCC negotiations over the past years, and has contributed to a global knowledge transfer on climate and energy policy through newsletters, publications, facilitation of capacity building missions and workshops.
the greenwerk also fosters research on innovative financing models for transformational changes in the energy sector and sustainable use of resources in the future. Besides that, we offer a full range of services in the field of mitigation of greenhouse gas emissions, with special emphasis on the design and application of international climate finance instruments such as the Green Climate Fund (GCF) and the development of low carbon policy frameworks in developing countries, in particular Nationally Appropriate Mitigation Action (NAMAs).

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