Economics
The Open-Access, Open-Assessment E-Journal

Discussion Paper
No. 2019-37 | June 03, 2019 | http://www.economics-ejournal.org/economics/discussionpapers/2019-37

Advancing a global transition to clean energy – the role of international cooperation

Rainer Quitzow, Sonja Thielges, Andreas Goldthau, Sebastian Helgenberger, and Grace Mbungu

Abstract
International cooperation in support of a global energy transition is on the rise. Initiatives and venues for multilateral cooperation are complemented by growing bilateral engagement to foster international lesson-drawing and exchange. Official development assistance (ODA) in the energy sector is increasingly being directed to renewable energy sources. Despite these promising developments, it is widely acknowledged that investment towards achieving the Sustainable Development Goal (SDG) 7 on clean and affordable energy is insufficient. A recent report by SE4ALL estimates annual investments in support of SDG7 at USD 30 billion. This is well below the USD 52 billion that would be needed (SE4ALL and Climate Policy Initiative, *Energizing finance: Understanding the landscape 2018*, 2018). Moreover, investment in clean energy remains heavily concentrated in a small number of frontrunner countries. In terms of technologies, investments in clean energy still overwhelmingly target grid-connected electricity generation. Despite their proven ability to provide rapid and affordable access to clean energy in many country contexts, off-grid technologies account for only 1.3 percent of investments (SE4ALL and Climate Policy Initiative, 2018). Worryingly, a significant share of international public sector financing, most notably by export-credit agencies, is still allocated to coal and other fossil-based technologies. Against this background, this paper makes three recommendations for strengthening international cooperation in support of a global energy transition: 1) Promote investment in clean energy and end support for coal-based energy infrastructure. 2) Tackle the socio-economic dimension of the global energy transition.3) Provide early market support to promote challenge-based energy innovation.

(Submitted as Global Solutions Paper)

JEL F5 O3 O38 Q01 Q4 Q48
Keywords Public policy; climate; energy; innovation; development; international political economy

Authors
Rainer Quitzow, Institute for Advanced Sustainability Studies, Potsdam, Germany, rainer.quitzow@iass-potsdam.de
Sonja Thielges, Institute for Advanced Sustainability Studies, Potsdam, Germany
Andreas Goldthau, Institute for Advanced Sustainability Studies, Potsdam, Germany
Sebastian Helgenberger, Institute for Advanced Sustainability Studies, Potsdam, Germany
Grace Mbungu, Institute for Advanced Sustainability Studies, Potsdam, Germany

Citation Rainer Quitzow, Sonja Thielges, Andreas Goldthau, Sebastian Helgenberger,and Grace Mbungu (2019). Advancing a global transition to clean energy – the role of international cooperation. Economics Discussion Papers, No 2019-37, Kiel Institute for the World Economy. http://www.economics-ejournal.org/economics/discussionpapers/2019-37

Received May 10, 2019 **Accepted as Economics Discussion Paper** May 17, 2019 **Published** June 3, 2019

1 Introduction

1.1 The transition to clean energy is accelerating

The global transition to clean energy has accelerated markedly over the past decade. Renewable energy capacities have more than doubled over the past ten years and represented 70 percent of net capacity additions in the power sector in 2017 (REN21, 2018). Renewables now represent an estimated 26.5 percent of power generation globally. Correspondingly, renewables now dominate expenditures in the electricity sector. In 2017, investment in renewable power generation stood at USD 298 billion, representing two thirds of investments in power generation (OECD/IEA, 2018).

This acceleration of deployment has come hand in hand with rapid reductions in the cost of renewable energy technologies. According to the IEA, recent auctions have generated bids for onshore wind and solar photovoltaics projects with prices between USD 20 and USD 50 per megawatt hour (MWh).[1] Further price reductions are expected for wind, solar photovoltaics as well as other technologies, like concentrated solar power, offshore wind and geothermal power. In many regional contexts, this will bring prices for renewable electricity consistently below those for fossil-based power (IRENA, 2018a).

1.2 The role of international cooperation to promote a global energy transition

Mirroring these developments, international cooperation to support a global energy transition is on the rise. The international institutional architecture has developed significantly over the past decade. The International Renewable Energy Agency (IRENA), founded in 2009, provides an institutionalised and internationally recognised forum for global knowledge development and exchange on renewable energy. In 2011, UN General Secretary Ban Ki-moon launched the UN Initiative Sustainable Energy for All (SE4ALL). It provides a framework for activities in support of implementing the Sustainable Development Goal 7 for affordable and clean energy. The International Energy Agency (IEA) now also engages actively to support a transition to clean energy with initiatives like its Clean Energy Transitions Programme. Other important initiatives include the Clean Energy Ministerial, the G20 Energy Transitions Working Group, the International Partnership for Energy Efficiency and the Berlin Energy Transition Dialogue.

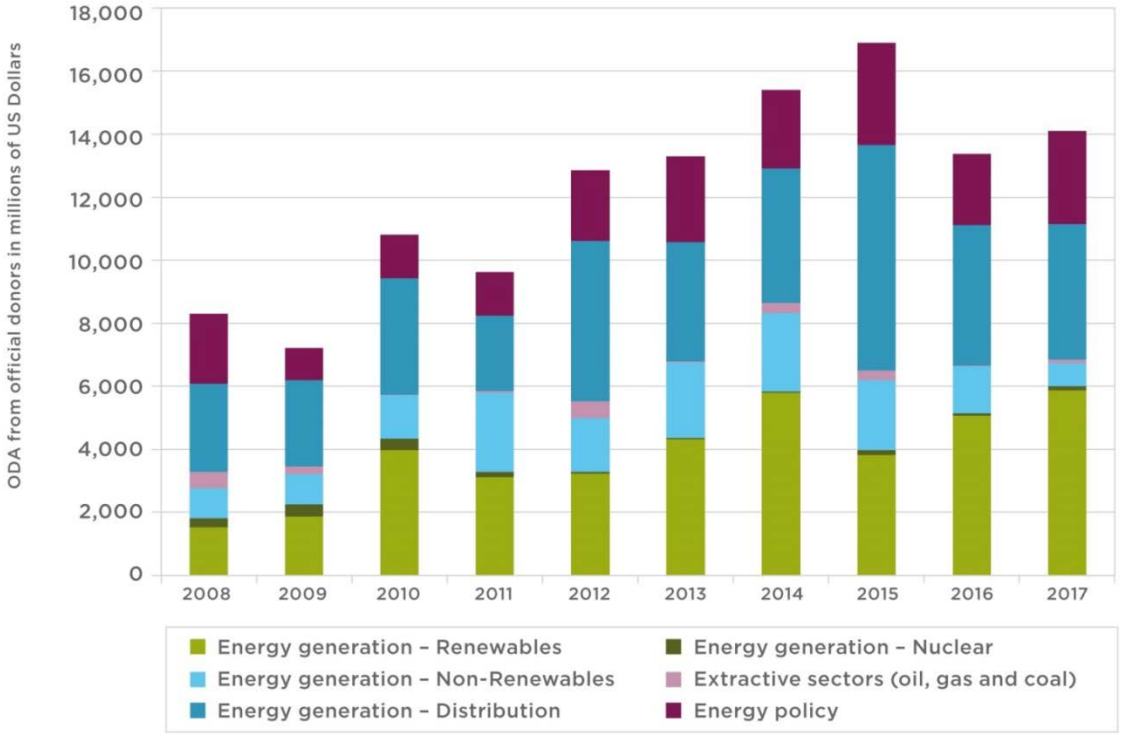
Initiatives and venues for multilateral cooperation are complemented by growing bilateral engagement to foster international lesson-drawing and exchange. Germany, for instance, has forged energy partnerships and dialogues with over 20 countries with the aim of promoting renewables and energy efficiency (Quitzow et al. 2019). The EU and a number of its member countries, such as Denmark, also hold clean energy dialogues with a range of countries. China and the US collaborate in the context of the US-China Clean Energy Research Center.

---

[1] See https://www.iea.org/newsroom/news/2019/february/have-the-prices-from-competitive-auctions-become-the-new-normal-prices-for-.html, accessed on 5 March 2019.

ODA in the energy sector is also increasingly being directed to renewable energy sources. Data provided by the OECD on ODA reveals that support to renewable energy projects has increased substantially over the past decade (see Figure 1 for details). It grew from slightly over USD 1.5 billion in 2008 to close to USD 6 billion in 2017. In 2017, support for renewables made up 41 percent of total energy ODA. Up to 2016, funding for fossil-based energy supply remained relatively stable with commitments ranging from USD 1.2 billion in 2009 to USD 2.8 billion in 2014. In 2017, commitments decreased significantly to less than USD 1 billion.

Figure 1: Overseas development assistance from official donors in the energy sector



Source: Authors based on data available from the OECD's Creditor Reporting System.

2 Gaps and remaining challenges for international energy cooperation

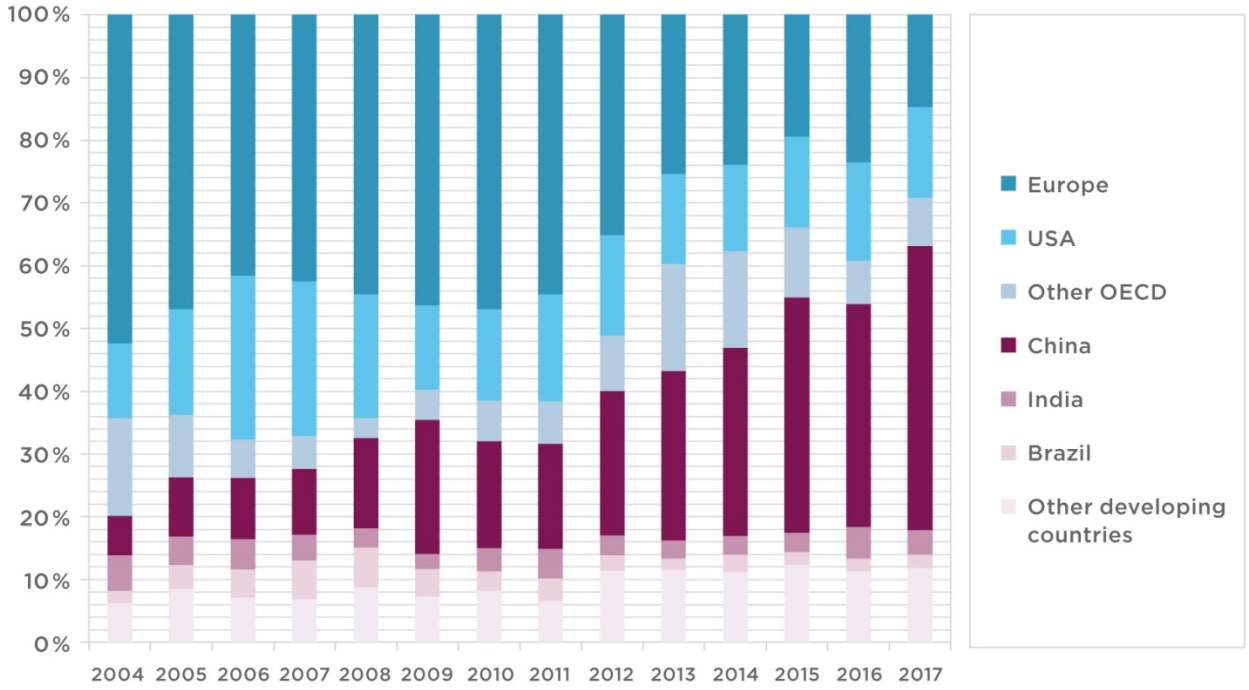
Despite the dynamic and positive development towards more international cooperation for a global energy transition, it is widely acknowledged that investment towards achieving SDG7 on clean and affordable energy is insufficient. A recent report by SE4ALL estimates the overall annual investments (from private and public sources) in support of SDG7 at USD 30 billion. This is well below the USD 52 billion that would be needed (SE4ALL and Climate Policy Initiative, 2018).

2.1 Investment and employment concentrated in frontrunner countries

Moreover, investment in clean energy remains heavily concentrated in a small number of frontrunner countries. China, the US and Europe accounted for three quarters of total global investment in renewable energy in 2017 (see Figure 2 below). Among developing countries, India and Brazil represent the largest recipients, capturing 6 percent of the total. A mere USD 33 billion, representing 11 percent of the total, found their way into the remaining developing countries (Frankfurt School-UNEP (FS-UNEP); BNEF, 2018). Among developing countries, India and Brazil represent the largest recipients, capturing 6 percent of the total. A mere USD 33 billion, representing 11 percent of the total found their way into the remaining developing countries (Frankfurt School-UNEP Centre/Bloomberg New Energy Finance 2018).

Manufacturing and employment creation in the clean energy sector, including renewable energy generation and storage technologies, shows a similar picture. Globally, clean energy manufacturing is dominated by China, Japan, Germany and the US. Brazil and India represent important regional hubs in the wind energy sector, while Japan, Taiwan and South Korea represent important players in various segments of the solar photovoltaics supply chain (CEMAC, 2017). This is also reflected in the global distribution of jobs in the renewable energy sector. China is the clear leader, accounting for 44 percent of employment. It is followed by the

Figure 2: Share of investment in renewable energy by country / group of countries



Source: Authors based on Frankfurt School-UNEP; BNEF (2018).

European Union, which accounts for fourteen percent of global employment. Of this, about a quarter is located in Germany. Brazil and the US each represent approximately ten percent of the total number of jobs (IRENA, 2018b).

2.2 Focus on existing solutions

In terms of technologies, investments still primarily target grid-connected electricity generation. Despite their proven ability to provide rapid and affordable access to clean energy in many country contexts, off-grid technologies account for only 1.3 percent of investments. Worryingly, a large share of investments is still allocated to fossil-based technologies. In 20 high-impact countries covered by SE4All's investment tracking, about half of the investment in electricity generation still goes to fossil-based infrastructure (SE4ALL and Climate Policy Initiative, 2018).

These investment trends are largely mirrored in the current landscape of international cooperation. Overall, international cooperation is strongly focused on the promotion of existing technologies and solutions. A recent review of Germany's energy partnerships conducted by the IASS shows that its bilateral cooperation primarily focuses on disseminating the lessons and technical know-how from Germany's energy transition to its partner countries. Accordingly, a major focus is on the deployment of grid-connected renewable energy technologies and related regulatory issues and challenges of system integration. Only in a few instances do the partnerships explicitly target the promotion of innovation and technology development (Quitzow et al., 2019).

International initiatives that do target innovation and technology development primarily focus on cooperation among energy transition leaders. Initiatives like the US-China Clean Energy Research Center (CERC) and Mission Innovation explicitly target international cooperation for technology development and innovation in clean energy. With a budget of 400 million US Dollars over ten years, CERC, a public-private partnership, has provided funding for collaborative R&D on advanced clean energy technologies involving Chinese and US researchers. Mission Innovation represents a multilateral initiative, which seeks to engage the public and private sector to increase investment in clean energy innovation. It supports cross-border partnerships to confront specified innovation challenges. Like CERC, it engages primarily existing frontrunners, like China, the US, Japan, members of the European Union, India and Brazil. Little attention is paid to the development of innovation partnerships, aimed at developing new solutions or technological innovations aimed at less developed markets.

2.3 The potential for energy innovation in developing countries

Support for the spread of clean energy technologies in new markets is crucial to advancing the global energy transition. These efforts should not be limited to existing clean energy solutions however. Depending on existing infrastructure or the particular climatic or societal context, existing technologies may not always be the most appropriate. Energy efficient building designs, for instance, must take into account both local climatic conditions and social practices (Pocock et al., 2016). Similarly, the slow pace of diffusion of clean cook stoves and failed

attempts to promote the diffusion of smart meters in Africa and Asia have been attributed to a lack of attention to the practical needs of households and the broader socio-cultural context (de Bercegol and Monstadt, 2018; Fadaeenejad et al., 2014; Groves et al., 2017; Shove and Walker, 2014; Sovacool and Dworkin, 2015; van der Kroon et al., 2013)

Moreover, innovation aimed at the needs of emerging and developing markets offers important opportunities for value creation. Estimates show that approximately two-thirds of middle-class consumption is likely to be located in emerging and developing economies by 2030 (Kharas, 2017). Accordingly, these markets represent important growth markets for energy-related infrastructure and services, with important opportunities for value creation. So-called "market-creating" innovations (Mezue et al. 2015) provide a particularly promising opportunity for technology leapfrogging and value creation. Market-creating innovations build on and combine existing technologies to transform previously inaccessible offerings into products or services that are widely accessible to users. In the energy sector, for example, the pay-as-you-go market in solar devices leverages digital platforms and low-cost solar technologies to deliver affordable solar appliance (see box 1 on the following page for further details).

Finally, in the absence of clean energy solutions tailored to these growth markets, there is a high risk of new, high carbon infrastructure lock-ins in these countries. Many developing countries face massive investment needs in power generation capacity in the near future. If a significant share of this demand is met with fossil fuels, such as coal, this will lead to severe lock-in effects that can endanger ambitious international climate targets or run the risk of being stranded

Box 1: The potential of market-creating innovations for value creation in the energy sector

Market creating innovations offer new trajectories for economic growth in developing countries with opportunities for new economic actors. The mobile payment platform M-Pesa represents such an example. Developed by Safaricom, a Kenyan mobile network operator, and Commerical Bank of Africa, a commercial bank headquartered in Kenya, M-Pesa spurred a revolution in financial inclusion. It enabled consumers to store value on the SIM cards of their mobile phones, thus allowing them to access financial services in this way. While the platform started as a vehicle for making local payments, it now offers a host of additional financial services and has provided a platform for a broad range of innovations that help link Kenyan consumers to the financial system. Deposit accounts, for instance, have increased from 2,55million in 2005 (before the launch of M-Pesa in 2007) to 34 million in 2015. This was primarily driven by M-Pesa enabled micro-accounts (Ndung'u, 2018).

Market-creating innovations in the energy sector are likely to leverage and combine advances in the sector with other areas of innovation. For example, the so-called pay-as-you-go (PAYGO) market in solar home systems and solar-powered appliances combines mobile payment technology with low-cost solar photovoltaics technologies to deliver low-cost products to new customer groups. The market has grown from approximately 1 million devices sold in 2010 to 25 million in 2017. There are now more than 300 companies active in over 100 countries globally. More than 80 percent of the related investment was concentrated in Africa, while headquarters are located predominantly in China (66 percent), Europe (12 percent) and Africa (9 percent) (Dalberg Advisors and Lighting Global, 2018). The ongoing revolution in information and communication technologies can represent a critical enabler for further innovation in the energy sector. When combined with innovation in end-use sectors, like health care, transport, or productive sectors, they provide opportunities for the creation of new platforms for low-carbon development.

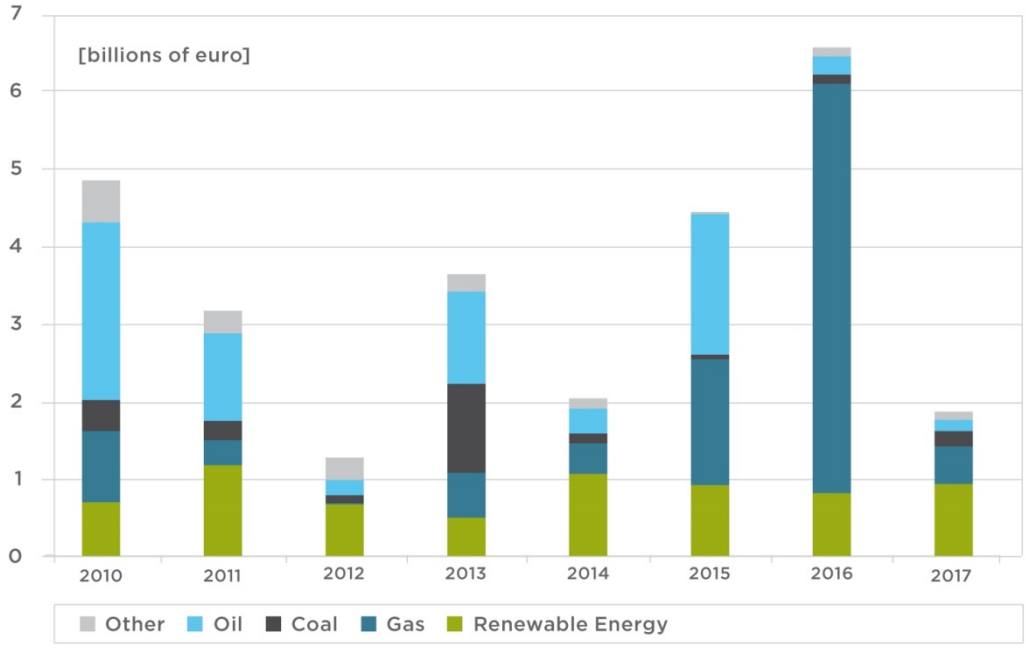
(Pfeiffer et al., 2016). For instance, it is estimated that in the absence of additional climate policy measures, Africa's emissions are expected to increase seven to fifteen times by 2100, accounting for 3-23% of global emissions by that time (Calvin et al., 2016; Lucas et al., 2015).

2.4 Investing in a low-carbon future?

Official ODA funding for fossil-based infrastructure shows a downward trend with commitments in 2017 dropping below USD 1 billion. However, funding from public export-credit agencies remains strongly oriented towards fossil-based energy supply, including coal. Despite an agreement among OECD countries to reduce coal-related financing, a number of banks continue to pursue investments in the coal sector. The Japanese Bank for International Cooperation and the Export-Import Bank for Korea have been found to be particularly active in launching new coal-based projects (DeAngelis, 2018). But Germany's export-credit agency, Euler Hermes, also continues to provide guarantees to fossil-based projects on a significant scale (see Figure 3). In 2017, 44 percent of financing went to fossil-based technologies, including 10 percent to coal-based projects.

In addition, China Development Bank and China Export-Import Bank have become major sources of funding sources of coal- and other fossil-based energy supply around the world.

Figure 3: German Euler Hermes export credit guarantees for energy projects by energy source



Source: Authors, based on data available at https://www.agaportal.de/exportkreditgarantien/grundlagen/energiesektor, accessed on 21 May 2019.

Between 2005 and 2017, the two Chinese policy banks dedicated over 40 percent of their power sector funding to coal-based energy supply. This is particularly significant given the increasing

volumes of finance that these Chinese banks provide. Their energy sector financing amounted to close to USD 200 billion in the period from 2007 to 2016, almost twice as much as the World Bank provides to projects in the energy sector (Gallagher et al. 2018).

Against the background of the challenges clean energy still faces, this policy brief makes three recommendations to further strengthen international cooperation.

3 Promote investment in clean energy and end support for coal-based energy infrastructure

International cooperation should focus on creating a conducive environment for investment in renewable energy, while discouraging investment in fossil fuels. To this end, donor countries from the OECD and G20 should lead the way by discontinuing all public financial support for new coal-based energy infrastructure and by adopting guidelines for investment in other fossil-based energy infrastructure. Coal-fired power plants are not only a threat to globally agreed climate targets; by creating new lock-ins in high carbon infrastructure, they also increase the economic and financial risk of stranded assets. Moreover, cost competitive clean energy alternatives make the economic case for investments in coal-fired power plants obsolete.

The OECD *Sector Understanding on Export Credits for Coal-fired Electricity Generation Projects* offers an important starting point for developing an agreement among all donor countries to discontinue all public financial support for coal-based energy infrastructure. It includes, for instance, provisions to ensure that eligible projects are in line with the host country's climate mitigation strategy and that less carbon-intensive alternatives are not viable (OECD, 2015). The G20 energy work stream would offer an appropriate forum for not only extending the agreement to all G20 donor countries, but to extend its scope to all new coal-fired power plants. In its 2016 Voluntary Action Plan on Renewable Energy, the G20 agreed in principle on the need to reduce coal consumption. What is missing, however, is a clear commitment of the G20 members to cease public financing for new coal-fired power plants overseas.

Moreover, the G20 should call on all multilateral development banks (MDBs) to adopt policies banning investments in coal-based energy supply. While the World Bank and a number of other MDBs have done so, this should be extended to include the remaining MDBs. In order to track the implementation of such commitments, a process for the development and communication of corresponding policies should be established. The discontinuation of financial support for coal-based power plants would not only ensure that MDBs avoid the creation of new lock-ins in high carbon infrastructure, but would also set an important precedent and framework for national development finance institutions (DFIs) to follow.

In parallel, the G20 energy and climate work streams should develop more general guidelines for the provision of public financial support to investments in other fossil-based infrastructure. This should be based on a life-cycle assessment of climate impacts and climate asset risks. Such a framework should build on experiences with shadow carbon pricing as a method for assessing carbon asset risk, as introduced by a number of MDBs (Larsen et al., 2018). Again, the

development of such a framework for use by G20 donor countries and MDBs is not only important in its own right. It can provide guidance and the political motivation for other DFIs to adopt corresponding approaches.

4 Tackle the socio-economic dimension of the global energy transition

This global energy transition presents important social and economic development opportunities (see Figure 4). Worldwide, more than 10 million people are already employed in the renewable energy sector (IRENA, 2018b). In India, clean energy targets are expected to create over 300,000 jobs in the next five years (CEEW and NRDC, 2017). A recent report on South Africa shows that by pursuing ambitious renewable energy scenarios, gross employment in the power sector could be more than doubled by 2030 (IASS and CSIR, 2019). Germany's *Energiewende* is fostering societal ownership in the energy system, with more than 1,700 citizen-led energy cooperatives across the country generating direct revenue for citizens and local communities (Helgenberger et al., 2019). Studies also point out the significant health benefits related to renewable energy. Doubling the share of renewables in the global energy mix could save up to 4 million lives annually by reducing outdoor air pollution (IRENA, 2018b, 2016).

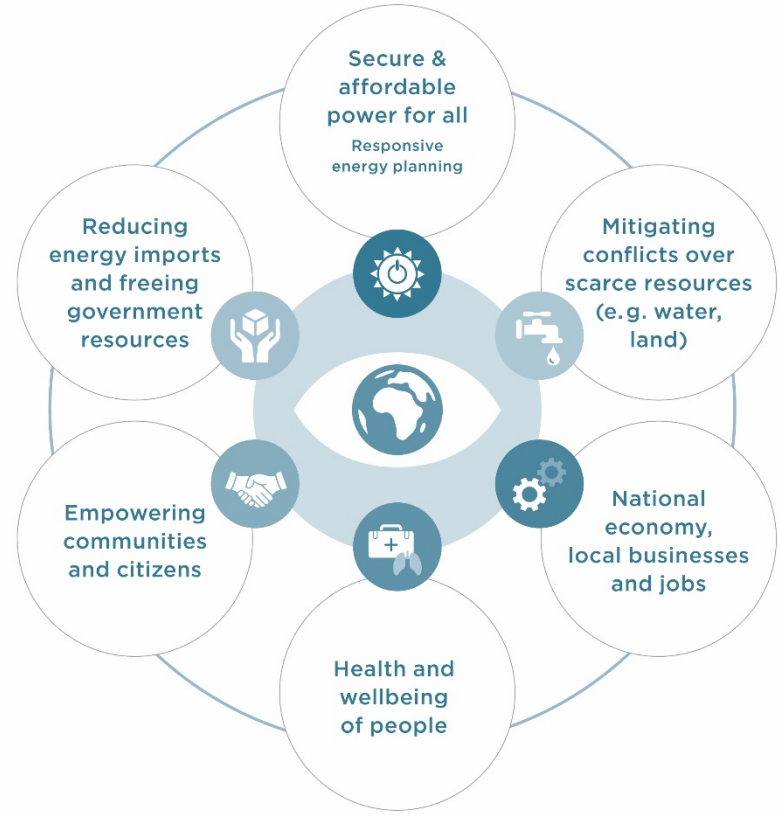
In order to accelerate and expand the geographic scope of the global energy transition, international cooperation should play an active role in mobilizing the socio-economic benefits of a global energy transition at the national-level by supporting policy dialogue and robust analysis of socio-economic benefits at both the country and global levels. At the country-level, the COBENEFITS project, led by IASS in the framework of Germany's International Climate Initiative (IKI), offers in-depth assessments in a number of countries. Similar country-level analyses are needed to underpin investment strategies in developing and emerging countries and should be expanded. In a first step, this might be done for the high-impact countries within SE4ALL. Such analysis can provide the basis for cross-country assessments of best practice and processes of mutual learning on the national-level benefits of renewables. Formats for bi- or multilateral South-South policy dialogue, such as the International Solar Alliance, will also be vitally important. China, but also India and Brazil, are the key players in low carbon development outside the OECD and should be encouraged to take the lead in creating such exchanges.

At the global level, socio-economic analyses conducted by IRENA, such as the annual reviews of employment in the renewable energy sector, offer an important starting point. In addition, efforts should be made to systematically cover developments in clean energy manufacturing. The Clean Energy Manufacturing Center, launched by the US Department of Energy, represents an important effort to generate data on clean energy manufacturing for stakeholders in the US. These data are required for a robust assessment of the factors, including international and national policies, regulations and standards, which are shaping the localisation of industrial production within the emerging clean energy sector. Such analysis is urgently needed to address the needs of developing and emerging economies. The OECD's Policy Dialogue on Global

Value Chains, Production Transformation and Development could offer a forum for developing such a data collection initiative.

Finally, it is equally important to consider the potentially adverse effects that might accompany a global energy transition. This includes but is not limited to the financial risks related to existing and new investments in fossil-based power generation (carbon risk). To date, there is little systematic analysis of the broader socio-economic risks of a global energy transition and the related exposure of individual countries and stakeholder groups. Developing an evidence-base on these questions is crucial for the development of appropriate mitigation strategies. This in turn is key to garnering the support of affected stakeholders and countries and should accompany policy dialogue and analysis on the socio-economic benefits of a transition to clean energy.

Figure 4: Social and economic co-benefits driving the global energy transition



Source: Helgenberger and Jänicke (2017)

5 Provide early market support to promote challenge-based energy innovation

As outlined above, there is an important need for energy innovation that targets the particular needs of users in developing and emerging countries. At the same time, developing and emerging economies frequently lack the institutional infrastructure necessary to support clean energy innovation. This requires innovation eco-systems that span infrastructure and human resources for research and development, financing for innovation and entrepreneurship as well as networks of innovative firms. In addition to this, clean energy innovation typically requires some form of support for early market demand for innovative products or services.

While the international community cannot provide a shortcut to the development of such institutions, it could support international multi-stakeholder initiatives to jointly tackle selected energy innovation challenges. Under the umbrella of SE4All or Mission Innovation, this could provide a forum for bringing together cutting-edge international expertise with domestic knowledge and capacities to meet selected innovation challenges. The aim should be to concentrate a critical mass of resources on a clearly defined innovation challenge, in order to catalyse progress towards the chosen goal.

Within this context, efforts to foster early market demand for the resulting products or services should play a central role. While feed-in tariffs or reverse auctions play this role in stimulating markets for traditional, grid-connected renewable energy technologies, additional instruments are needed to stimulate and aggregate demand in other areas of application. Market support programmes for off-grid solar energy technologies and clean cooking devices offer examples of such approaches. These include support for the development of quality assurance infrastructure, consumer awareness programs and business support services. Challenge-based innovation initiatives should prepare the ground for the roll-out of additional market support programmes for innovative applications in new end-user markets.

Innovation-oriented procurement by the public sector offers an important entry-point for stimulating such early market demand. This practice has successfully stimulated technologies such as the Global Positioning System in the US or fuel cell electric buses in Japan. In developing countries, there are examples in the health sector. So-called advanced market commitments have been used to stimulate the development of vaccines in high-impact areas. These legally-binding agreements provide funding to subsidise the purchase, at a pre-determined maximum price, of an as yet unavailable vaccine, accelerating its development and availability.

Finally, the focus of innovation challenges should be developed in participatory processes. This would create opportunities to raise awareness and generate debate on energy innovation within the respective countries, while identifying challenges that reflect domestic priorities and needs.

6 Conclusion

Rapid declines in the costs for renewable energy technologies have unleashed an irreversible process of transformation in the energy sector. Even the most conservative forecasts now project a rapid expansion of renewable energy around the world. In order to meet climate and sustainable development targets, however, there needs to be a parallel, rapid phase-out of fossil fuels. Policy decisions thus remain crucial for determining the speed and success of a global transition to clean energy. Cooperation among leading countries can play a key role in setting the pace and a conducive framework in this regard. However, international energy cooperation needs to go beyond the solutions and strategies being pioneered in these countries. It will be equally important to address the unique challenges of developing and emerging countries or run the risk of new lock-ins in high carbon growth paths.

References

Calvin, K., Pachauri, S., De Cian, E., Mouratiadou, I., 2016. The effect of African growth on future global energy, emissions, and regional development. *Climatic Change* 136, 109–125. doi:10.1007/s10584-013-0964-4

CEEW, NRDC, 2017. Greening India's workforce. Gearing up for expansion of solar and wind power in India, Issue Paper, June 2017. Council for Energy Environment and Water (CEEW); Natural Resources Defense Council (NRDC), New Delhi.

CEMAC, 2017. Benchmarks of global clean energy manufacturing. Clean Energy Manufacturing Analysis Center (CEMAC), Golden, Colorado.

Dalberg Advisors, Lighting Global, 2018. Off-grid solar market trends Report 2018. International Finance Corporation, Washington D.C.

de Bercegol, R., Monstadt, J., 2018. The Kenya Slum Electrification Program. Local politics of electricity networks in Kibera. *Energy Research & Social Science* 41, 249–258. doi:10.1016/j.erss.2018.04.007

DeAngelis, K., 2018. ECA Support for Coal in the Face of OECD Financing Restrictions. Friends of the Earth US, Washington, DC.

Fadaeenejad, M., Saberian, A.M., Fadaee, M., Radzi, M.A.M., Hizam, H., AbKadir, M.Z.A., 2014. The present and future of smart power grid in developing countries. Renewable and *Sustainable Energy Reviews* 29, 828–834. doi:10.1016/j.rser.2013.08.072

Frankfurt School-UNEP (FS-UNEP); BNEF, 2018. Global trends in renewable energy investment 2018. Frankfurt School of Finance & Management, Frankfurt.

Groves, C., Henwood, K., Shirani, F., Thomas, G., Pidgeon, N., 2017. Why mundane energy use matters: Energy biographies, attachment and identity. *Energy Research & Social Science* 30, 71–81. doi:10.1016/j.erss.2017.06.016

Helgenberger, S., Jänicke, M., 2017. Mobilizing the co-benefits of climate change mitigation connecting opportunities with interests in the new energy world of renewables, IASS Working Paper, June 2017. Institute for Advanced Sustainability Studies, Potsdam.

Helgenberger, S., Jänicke, M., Gürtler, K., 2019. Co-benefits of climate change mitigation, in: Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T. (Eds.), Climate action: encyclopedia of the UN Sustainable Development Goals. Springer International, Cham, pp. 1–13. doi:10.1007/978-3-319-71063-1_93-1

IASS, CSIR, 2019. Future skills and job creation through renewable energy in South Africa. Assessing the co-benefits of decarbonising the power sector. Institute for Advanced Sustainability Studies (IASS) and Council for Scientific and Industrial Research (CSIR), Potsdam.

IRENA, 2016. The true costs of fossil fuels: saving in the externalities of air pollution and climate change. IRENA, Abu Dhabi.

IRENA, 2018a. Renewable power generation costs in 2017. IRENA, Abu Dhabi.

IRENA, 2018b. Renewable energy and jobs - Annual review 2018. IRENA, Abu Dhabi.

Kharas, H., 2017. Global Middle Class. An Update., Global economy and development Working Paper 100. Brookings Institution, Washington, DC.

Larsen, G., Smith, C., Krishnan, N., Bartosch, S., Fekete, H., 2018. Toward Paris alignment: How the multilateral development banks can better support the Paris Agreement. World Resources Institute, Washington D.C.

Lucas, P.L., Nielsen, J., Calvin, K., L. McCollum, D., Marangoni, G., Strefler, J., van der Zwaan, B.C.C., van Vuuren, D.P., 2015. Future energy system challenges for Africa: Insights from Integrated Assessment Models. *Energy Policy* 86, 705–717. doi:10.1016/j.enpol.2015.08.017

Ndung'u, N., 2018. The M-Pesa technological revolution for financial services in Kenya: A platform for financial inclusion, in: *Handbook of Blockchain*, Digital finance, and inclusion, Volume 1. Elsevier, pp. 37–56. doi:10.1016/B978-0-12-810441-5.00003-8

OECD/IEA, 2018. World energy investment 2018. International Energy Agency (IEA), Paris. doi:10.1787/9789264301351-en

Pfeiffer, A., Miller, R., Hepburn, C., Beinhocker, E., 2016. The "2°Capital Stock" for electricity generation: Committed cumulative carbon emissions from the electricity generation sector and the transition to a green economy. *Applied Energy* 179, 1395–1408.

Pocock, J., Steckler, C., Hanzalova, B., 2016. Improving socially sustainable design and construction in developing countries. Procedia Engineering 288 – 295.

Quitzow, R., Thielges, S., Helgenberger, S., 2019. Deutschlands Energiepartnerschaften in der internationalen Energiewendepolitik, IASS Diskussionspapier, März 2019. Instutute for Advanced Sustainability Studies, Potsdam.

REN21, 2018. Renewables 2018 Global status report. REN21 Global Secretariat, Paris.

SE4ALL, Climate Policy Initiative, 2018. Energizing finance: Understanding the landscape 2018. Sustainable Energy for All, Vienna.

Shove, E., Walker, G., 2014. What is energy for? Social practice and energy demand. *Theory, Culture & Society* 31, 41–58. doi:10.1177/0263276414536746

Sovacool, B.K., Dworkin, M.H., 2015. Energy justice: Conceptual insights and practical applications. *Applied Energy* 142, 435–444. doi:10.1016/j.apenergy.2015.01.002

van der Kroon, B., Brouwer, R., van Beukering, P.J.H., 2013. The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and Sustainable Energy Reviews* 20, 504–513. doi:10.1016/j.rser.2012.11.045