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

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Abstract

International cooperation in support of a global energy transition is on the rise, and official development assistance (ODA) in the energy sector is increasingly being directed to renewable energy sources. Nevertheless, it is widely acknowledged that investment towards achieving the SDG 7 on clean and affordable energy is insufficient. Moreover, investment in clean energy remains heavily concentrated in a small number of frontrunner countries and overwhelmingly targets grid-connected electricity generation. Worryingly, significant share of international public sector financeing, 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.* OECD and G20 countries should lead the way by discontinuing all public investment support for new coal-based energy infrastructure and establish guidelines for support to other fossil-based investments. (2) *Promote evidence-policy dialogue on the socio-economic dimension of the global energy transition.* International cooperation should play an active role in mobilising socio-economic benefits and address potential risks by supporting evidence-based policy dialogue based on robust assessments at both the country and global levels. (3) *Provide early market support to promote challenge-based energy innovation.* SE4ALL or Mission Innovation should create multi-stakeholder, challenge-based initiatives to promote clean energy innovation in developing and emerging economies and foster early market demand for related products or services.

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Keywords Public policy; climate; energy; innovation; development; international Political Economy

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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 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).

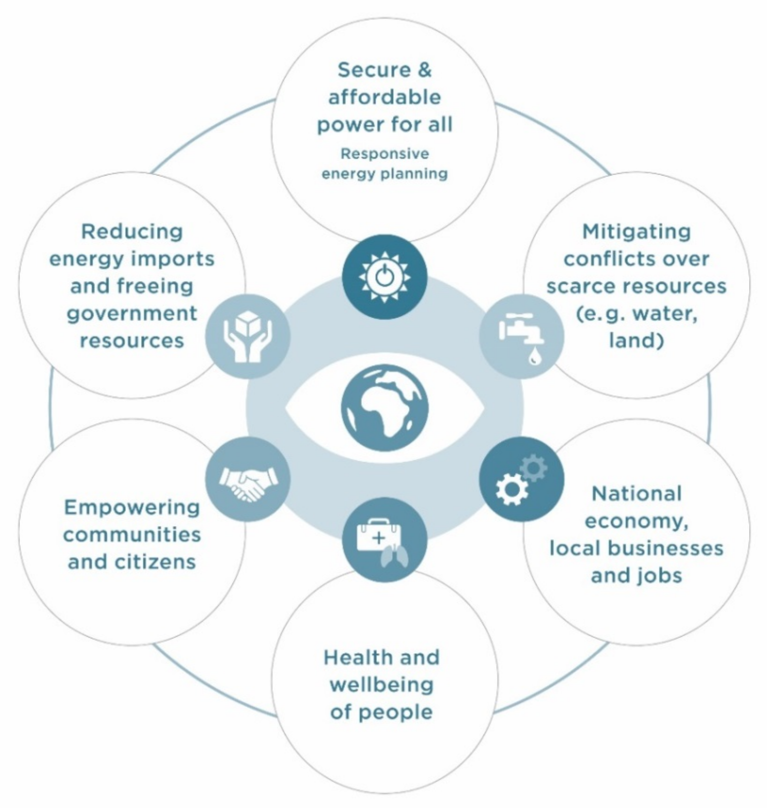
Moreover, the global energy transition promises important social and economic development opportunities (see Figure 1). Worldwide, more than 10 million people are already employed in the renewable energy sector (IRENA, 2018b). In India, clean energy targets are expected to create over 300,000 jobs in 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). 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, 2016a).

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

Mirroring these trends, 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

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 5.3.2019.

Figure 1: Social and economic co-benefits of a global energy transition



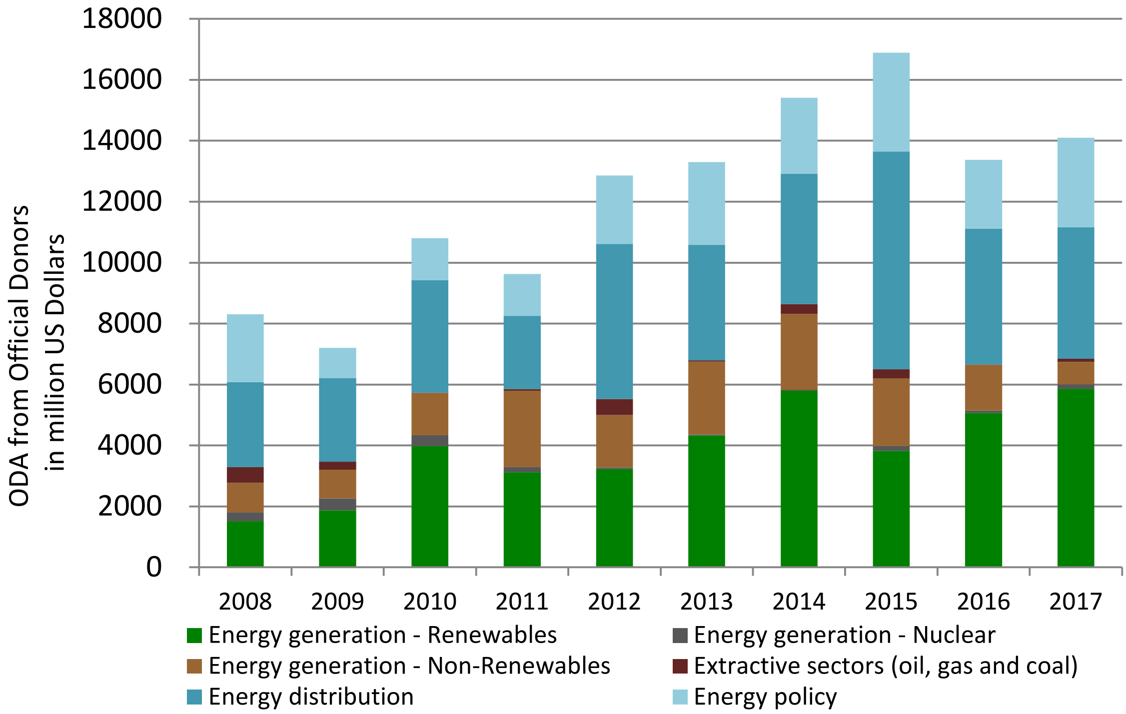
Source: Helgenberger and Jänicke (2017)

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.

Overseas Development Assistance (ODA) in the energy sector is increasingly being directed to renewable energy sources. Data provided by the OECD on ODA reveals that support to renewable energy projects grew substantially over the past decade (see Figure 2 for details). It increased 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, compared to 18 percent in 2008. Starting at similar levels in 2008, the share of fossil-based ODA has remained more stable. Despite a substantial increase in total spending in the period from 2011 to 2015 compared to the period 2008 to 2010, it has lost substantial ground to shares dedicated to renewables. After peaking at a share of 26 percent in 2011, it has seen a downward trend since then, declining to less than USD 1 billion, or 6 percent of total energy-related ODA, in 2017.

Figure 2: Overseas development assistance from official donors in the energy sector



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

2 Gaps and remaining challenges for international energy cooperation

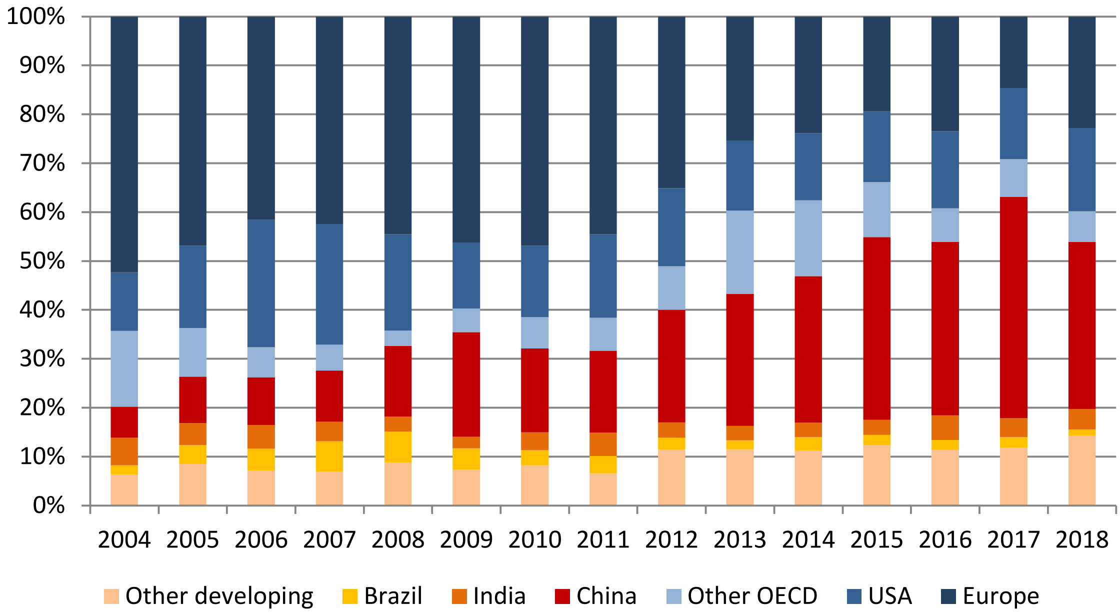
Despite the dynamic and positive development towards more international cooperation for a global energy transition, it is widely acknowledged that investment towards achieving SDG7 on clean and affordable energy is insufficient. A recent report by SE4ALL on 20 high-impact countries estimates their overall 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 in those countries (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 3 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 and BNEF, 2019). Among developing countries, India and Brazil represent the largest recipients, capturing 6 percent of the total.

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 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).

Figure 3: Share of investment in renewable energy by country / group of countries



Source: Authors based on Frankfurt School-UNEP and BNEF (2019).

2.2 Investing in a low-carbon future?

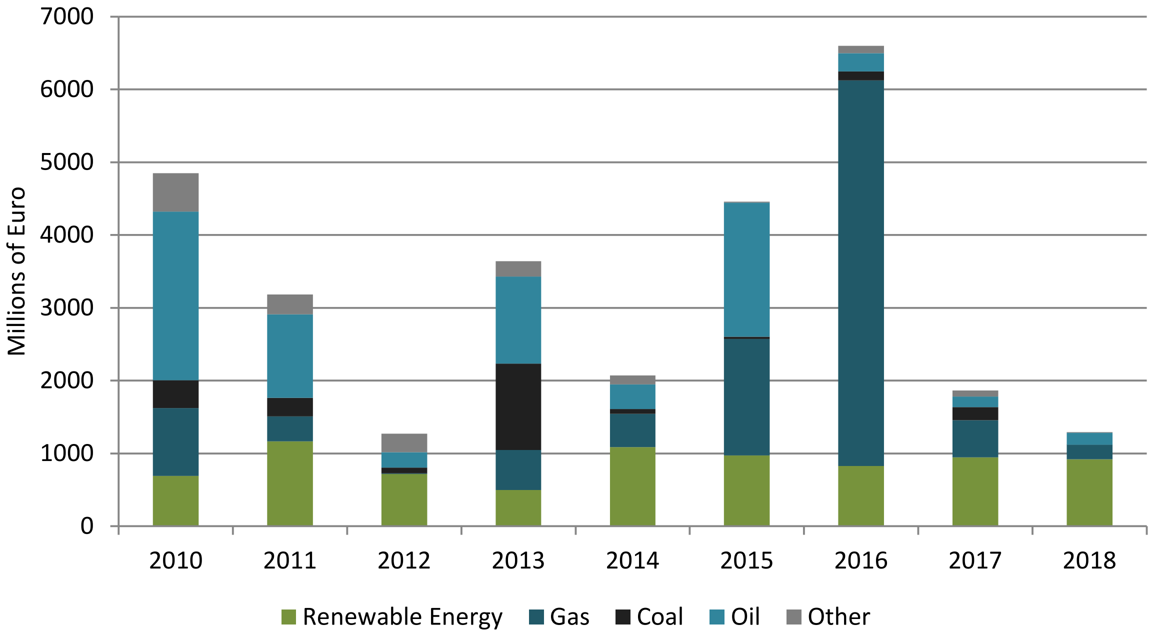
In contrast to some of these frontrunners, in 20 SE4ALL high-impact countries investment in fossil-based infrastructure still dominates (SE4ALL and Climate Policy Initiative, 2018). Official ODA funding for fossil-based infrastructure shows a recent downward trend with commitments in 2017 dropping below 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. In the period from 2013 to 2015, export-credit agencies provided an average of USD 38 billion in export financing for investments in fossil-fuels, including over USD 5 billion for coal-based power plants. 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 4). In 2017, 44 percent of financing went to fossil-based technologies, including 10 percent to coal-based projects. In 2018, fossil-based projects accounted for 28 percent of the total.

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

These investments are supporting the creation 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 these trends continue, this will lead to severe lock-in effects,

Figure 4: 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 21.5.2019.

endangering international climate targets or leading to stranded assets (Pfeiffer et al., 2016). It is estimated that in the absence of additional climate policy measures, Africa's emissions will 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).

2.3 The missed opportunities of low-carbon innovation in developing countries

In addition, existing clean energy investments still primarily target grid-connected electricity generation pioneered in OECD countries. 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; see Box 1 for a discussion on the potential of off-grid and mini-grid technologies for rural electrification). 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. Only in a few instances do the partnerships explicitly target the promotion of innovation and technology development (Quitzow et al., 2019).

Box 1: The potential of off-grid and mini-grid technologies for rural electrification

The population receiving its power supply through off-grid and mini-grid systems has grown rapidly in recent years. It has increased from approximately 20 million in 2011 to 133 million only five years later (IRENA, 2019a). This has been driven not only by declining technology costs, but also by increasing rural connectivity and the related expansion of consumer finance (Dalberg Advisors and Lighting Global, 2018). At the same time, grid-based rural electrification continues to be hampered by a number of problems. In particular in Sub-Saharan Africa, uptake by newly connected households is frequently low, caused by high connection costs and low quality of service. This in turn increases the related financial challenges, eroding the willingness of utilities to increase the slow pace of grid extension in many countries (Bos et al., 2018). Finally, a recent study by the IFC points out the high financial and environmental costs caused by the wide-spread use of diesel-based back-up generators, a response to unreliable grid supply. In Sub-Saharan Africa, they contribute an estimated 9 percent of total power consumption (IFC, 2019). Against this background, off-grid and mini-grid technologies based on renewable energy technologies offer viable alternatives to traditional electrification programs based on grid-extension. Cost-effectiveness depends on the specific local context and needs to be assessed on a case-by-case basis. Emerging planning tools, which draw on the full spectrum of available technology options (i.e. grid extension, mini-grid and stand-alone systems), can support the design of least-cost electrification strategies that incorporate off-grid and mini-grid solutions alongside grid extension (Kemausuor et al., 2014; Mentis et al., 2017; Mutanga et al. 2018).

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.

While the spread of existing clean energy technologies to new markets is crucial to advancing the global energy transition, it risks squandering important potential for low-carbon innovation in developing countries. 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). The failure to address context-specific needs and challenges may significantly slow down the transition to clean energy. For example, the slow and unsustainable transition to cleaner cooking energy solutions and the failed attempts to promote the diffusion of smart meters in Africa have been attributed to a lack of attention to the practical needs and economic challenges of households and the social-cultural dimensions of energy production and consumption practices (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). Yet, 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.

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. They 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 the Commerical Bank of Africa, 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, allowing them to access financial and banking services. 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).

Following this trend, market-creating innovations in the energy sector are beginning 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. Global investment in the sector reached close to USD 1 billion in 2017. 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). Moreover, a series of studies implemented by GOGLA, the global association for the off-grid solar energy industry, have shown that the off-grid solar energy market is beginning to generate significant new employment opportunities. In 2018, markets for off-solar home systems in East Africa and South Asia had estimated sales of 7.8 million and 21.9 million devices and generated an estimated 75,000 and 260,000 jobs, respectively (GOGLA, 2019).

The ongoing revolution in information and communication technologies can represent a critical enabler for further innovation and value creation in general and in the energy sector specifically (Beliz et al., 2019). 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. Like traditional, grid-connected rural electrification schemes, such energy solutions may not be economically viable in the absence of public financial support. Due to their positive externalities for local value creation and employment, they warrant greater attention from international donors.

2.4 Missing socio-economic data for enabling a just transition

Finally, numerous studies point out the multiple benefits of renewable energy and energy efficiency (Helgenberger et al., 2019; Internationational Energy Agency, 2014; IRENA, 2016b). However, this does not necessarily mean that support schemes are designed to maximize local benefits and promote socio-economic progress, needed for just transitions. Moreover, in the short to medium-term, transition processes may come with adverse and unequally distributed socio-economic impacts. Understanding these socio-economic opportunities and challenges processes is critical for building the support of populations as well as decision-makers in affected countries (Rosemberg, 2017). Reform efforts across various policy fields have shown that robust analysis of socio-economic implications can play an important role in enabling policy action (World Bank, 2008, 2006, 2003). Conversely, without credible data on the expected socio-economic impacts of policy reforms, policy action in support of energy transition processes is likely to be cautious at best.

Regrettably, empirical data on the socio-economic impacts of the deployment of renewable energy and other clean energy solutions in developing and emerging economies remains relatively scarce (Jacob et al., 2015; Pahle et al., 2016). While IRENA has developed sophisticated methods for estimating the socio-economic impacts of renewable energy, their application in developing and emerging countries remains fairly limited (IRENA, 2016b). The Global

Tracking Framework for tracking progress towards SDG 7 on affordable and clean energy has made important advances in measuring different levels of energy access (IEA et al., 2019). Yet, it does not engage with the broader socio-economic implications of a transition to clean energy. Moreover, there is little empirical data on the development of global clean energy industries and their geographic distribution. This would be needed to help assess regional opportunities for value creation within these emerging industries (IRENA, 2019b).

Regarding potential transition risks, the evolving debate on a Just Transition has spurred efforts to identify and conceptualize the socio-economic costs, benefits and trade-offs of policies aimed at decarbonizing the energy sector (Climate Strategies, 2018; Gambhir et al., 2018; Jakob and Steckel, 2014; Marcu and Vangenechten, 2018; Newell and Mulvaney, 2013). However, little systematic evidence has been collected on the socio-economic impacts at the country-level in the Global South. One important exception is the work of the World Bank's Energy Sector Management Program (ESMAP) on the phasing-out of fossil fuel subsidies in a series of developing and emerging economies. ESMAP's Energy Subsidy Reform Technical Assistance Facility[2] has supported the multi-dimension assessment of subsidy reform, covering impacts on public finances, households, firms, the environment as well as the political economy of reform. Its integrated approach to country-level assessment and reform development might offer an important reference point for closing this important knowledge gap.

3 Advancing a global energy transition through more effective international cooperation

The challenges and gaps outlined above provide the starting-point for the following recommendations aimed at strengthening international cooperation in support of a global transition to clean energy.

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

International cooperation should focus on creating a conducive and enabling 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.

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[2] See https://www.esmap.org/energy_subsidy_reform for details on the program.

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 their 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; Bak 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.

3.2 Promote evidence-based policy dialogue on the socio-economic dimension of the global energy transition

As argued in Section 2.4 above, ambitious policy action in support of energy transition processes will depend on credible strategies for the mobilization of socio-economic opportunities. Equally important are effective measures for the mitigation of potentially adverse impacts on local populations and stakeholders. International cooperation should play an active role in developing such strategies and measures 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 around the world and should be expanded. In a first step, this might be done for the high-impact countries within SE4ALL.

Crucially, assessments should be developed in close cooperation with governments in the affected countries. This way the ownership of the results can be enhanced, increasing the likelihood that governments will take corresponding action. Moreover, such studies can provide the basis for cross-country assessments of best practice and processes of mutual learning. Formats for bi- or multilateral South-South policy dialogue, such as the International Solar Alliance, also offer important venues for dialogue. 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 its recent report on measuring the socio-economic footprint of the energy transition (IRENA, 2019b), offer an important starting point. In particular, efforts should be made to conduct systematic data collection on clean energy supply chains. 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.

It is equally important to consider the potentially adverse effects that might accompany a global energy transition both at the global and the country-level. 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, in particular in the Global South. Developing an evidence-base on these questions is crucial for the development of appropriate mitigation strategies. This should include policy-based analysis along the lines of the assessments conducted within the World Bank's Energy Subsidy Reform Technical Assistance Facility (see Section 2.4 above). Similar efforts should be made for a broader spectrum of policies.

3.3 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 solutions offer examples of such approaches. These include support for the development of quality assurance infrastructure, consumer awareness and support programs, financial 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, involving not only the private sector but also civil society in the targeted countries or regions. 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. To do so effectively will also require strengthening the capacity of civil society organizations to engage effectively in such processes. It has been found that the involvement of civil society organizations in energy-related cooperation is very limited (Quitzow et al., 2016). If equipped with the needed expertise, civil society can play an important role in identifying and advocating for innovation in areas that address the needs of local populations.

4 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 promote 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 path and unjust transitions.

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