Foundations Platform F20: A report to the G20 summit 2017

Renewable Energy, Climate Action and Resilient Societies:

Accelerating the Global and Local Paradigm Shift

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Renewable Energy, Climate Action and Resilient Societies:

Accelerating the Global and Local Paradigm Shift

A report by the Foundations Platform

F20

Imprint

Authors: Thomas Spencer, David Levai, Xin Wang

Institut du développement durable et des relations internationales | Institute for Sustainable Development and International Relations

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Notification

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Foreword

"Climate change represents one of the largest risks to sustainable development, inclusiveness, equitable economic growth and financial stability. To curtail climate change, we need fast, fundamental, and foremost global action." These are the first two sentences of a joint declaration signed by several G20 Engagement Groups and by the Foundations 20 (F20) platform. These groups represent a broad range of key actors from the private sector, trade unions, environmental organizations and foundations, science, think tanks, youth organizations and women's organizations.

In this statement that was launched right after the announcement of the US administration to withdraw from the Paris Agreement, the signatories urge the remaining nineteen G20 countries to continue the implementation of the Paris Agreement and to increase the pace of the global transformation towards a climate friendly society. With this publication, the F20-Platform summarizes compelling evidence that the expansion of renewable energy systems and the decarbonization of the economy is happening at unprecedented speed globally. This development is driven by a combination of policy interventions, very rapid innovation, a drop of renewable electricity costs and changing societal priorities in many places around the world. These changing priorities result in higher political attention and investments, such as clean air, green industrial development and local communities. Governments must now build on this and further enhance the pace of this transformation by setting ambitious goals and by implementing the necessary policies.

This transformation also creates tremendous opportunities for countries and companies in terms of new opportunities in job creation and economic development. Hence, countries neglecting this trend will risk being left behind. The economic shift at the scale and speed required to mitigate climate change, however, can only be implemented with the buy-in and participation of civil society.

Increasing inequality and the fragmentation of the public discourse make obtaining this social buy-in all the more difficult. Civil society must thus be seen as an essential partner for politics to drive the transformation forward and shift towards the new paradigm of sustainable economic development while maintaining jobs and mitigate climate change.

Transforming our economy and getting our societies engaged in the spirit of the 2030 Agenda and the Paris Climate Agreement is possible. Existing decarbonization success stories, such as presented in this publication, serve as good examples for sustainable development in the field of climate protection and should motivate more ambitious action worldwide.

Foundations have a crucial role to play as drivers of change and as a bridge between public sector, private sector, and civil society on climate change. This report represents the commitment of the participating foundations to do their part in this transformation – a commitment that is well illustrated by the multi-colored fingerprint logo of the F20-Platform. It will be at the core of our philanthropic work going forward.

Dr. Heinrich Bottermann
Secretary General Deutsche Bundesstiftung Umwelt (DBU)

Caio Koch-Weser
Chairman of the Board of the European Climate Foundation

Dr. Lars Grotewold
Director Centre for Climate Change Stiftung Mercator

Klaus Milke
Chairman of Stiftung Zukunftsfähigkeit

Gabriel Baracatt
Chief Executive Director, Fundación Avina

Dr. Johannes Merck
Chairman of the Michael Otto Foundation for Environment Protection

Jakob von Uexkull
Founder, World Future Council

Eberhard Brandes
CEO, WWF Germany

Michael Northrop
Program Director Sustainable Development Rockefeller Brothers Fund

Sabine Nallinger
Managing Director Foundation 2° - German CEOs for Climate Protection

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Key Messages

1. The global transition to renewable energy systems is underway and accelerating, driven by a combination of policy interventions, very rapid innovation, particularly the fall in renewable electricity costs, and changing societal priorities in many areas, such as the importance being placed on clean air, green industrial development, and investments in local communities.
2. This transition creates tremendous opportunities for countries and companies to ramp-up a new kind of job creation and economic development based on renewable, efficient energy systems. At the same time, countries and actors, who do not anticipate the shift, could be left behind and lose out economically. The good news is that the necessary tools are there. The main question is whether the social and political will for change can be developed and harnessed at the speed and scope required.
3. An economic shift on the scale and speed required to mitigate climate change cannot be achieved solely from the 'top-down'; it can only be implemented with the buy-in and participation of civil society. Worrying trends of inequality, economic disruption, and the fragmentation and fractiousness of public discourse make obtaining this social buy-in all the more difficult. Civil society must thus be seen as an essential partner of policies to drive a new paradigm of sustainable economic development and job creation, while mitigating climate change. In this context, the marginalization of civil society in some G20 countries is alarming. Regarding climate change, foundations have a crucial role to play as a bridge between public sector, private sector, and civil society. This report represents a commitment from the participating foundations. As partners to both the public sector and the open society, they will ensure that climate change is at the core of philanthropic work going forward.
4. Despite the emergence of a global transition, the pace of change is insufficient to achieve the global community's objective of limiting warming to well below 2°C, much less 1.5°C. A strong and coordinated strengthening of public policies is required, and G20 countries have a particular responsibility in this regard. The Paris Agreement and the Sustainable Development Goals should form the basis of a new mandate to be established for the G20, to make climate protection and sustainability one of its core objectives. In this context, the F20 platform condemns unreservedly the decision of the US Administration to withdraw the United States from the Paris Agreement, an agreement which has rightly garnered unprecedented global support.

Executive Summary

- This report has been commissioned by a group of foundations in G20 countries, which have come together under the F20 platform in order to engage with the issue of climate change and sustainability in the context of the G20. The report analyzes the emerging energy transition towards efficient and renewable energy systems at global level and in specific G20 countries. On the basis of this analysis, and of the country specific case-studies that have also been conducted in the report, it provides recommendations for foundations and the G20 aimed at enhancing climate change mitigation and sustainability.

Context and Opportunity

- A deep and rapid transformation of energy systems and other emitting sectors in all countries is required to address the urgent threat of climate change. It is also essential to the achievement of other policy goals, such as energy access and security, economic development and job creation, and clean air. Fortunately, as this report demonstrates, there is a significant energy transition emerging across the globe and in specific G20 countries. For the first time, the technologies, financial instruments and policies exist to drive the required transformation of the global energy system.
- At the same time, the world is navigating a difficult period. Within many countries, slow economic growth, low levels of job creation, and rising inequality have led to a difficult social and political context. At the international level, governance is fragile and questioned by some who see the solution to the above-mentioned social and economic tensions as a retreat from international cooperation. Both of these domestic and international trends risk creating a more difficult context for climate policy, which will itself require rapid and potentially disruptive change, despite its overall benefits.
- Not responding to these domestic and international challenges in a cooperative manner would be a mistake. We are living in an era when legitimate national interests cannot be achieved without international cooperation. What is required is a refashioning of international cooperation to address the primary issues of the 21st Century: climate change and environmental degradation, enabling domestic policies for improved equality and economic security, and rapid development for poor countries.

The Emerging Energy Transition and Lessons from the Case Studies

- For the first time in a context outside of economic recession, for the last three years, emissions of energy-related CO2 have been essentially flat. While not sufficient to limit warming to well below 2°C, this trend provides encouragement that the required energy transition is emerging (Climate Action Tracker, 2017) (see section 3 of this report). Indeed, three important evolutions can be seen. Firstly, the cost of renewable energy has fallen precipitously in tandem with its increasing deployment around the world. As a result, for the first time renewables were responsible for nearly 100% of global electricity supply growth in 2015. Secondly, energy efficiency and structural change in the global economy are significantly curbing energy demand growth. In many developed countries, peak energy demand appears to have been reached in multiple sectors, while developing countries now have options to extend much-needed energy services to their populations, but with much lower energy demands. Thirdly, technologies to shift the transport sector away from oil and onto renewable electricity have been making tremendous progress, with battery costs for electric vehicles falling by more than 20% per year. For this reason, disruptive transition in the transport and oil industries is likely to occur over the next decade.
- The energy transition has huge significance for the global economy, the financial sector, and economic policy-making (see section 2.2 of this report). It implies a wholesale shift of energy investment, away from fossil fuels and into renewables and efficiency. This in turn will impact financial markets: 11.3% of global equity market capitalization is accounted for by companies

directly involved in fossil fuel extraction, and 15.8% of global bond markets. The risk of poorly anticipated and disruptive shifts in financial markets cannot be discounted, and must be addressed by concerted public policy to increase the transparency of financial assets as well as the visibility and credibility of public policy around energy transition. Given its status as the premier financial and economic governance institution, the G20 has a crucial role to play on the policy nexus between energy transition and economic governance.

- This report also conducted four case studies to provide a more 'on-the-ground' impression of this emerging energy transition. A number of key insights can be drawn. Firstly, the emergence of competitive renewables and grid management technologies can provide for the first time the opportunity for developing countries to leapfrog into a new paradigm for the electrification and industrialization of their economies (see section 4.1). The old equation that industrialization necessitates a high-coal development pathway no longer holds. The coal sector will thus face a short-term future of high uncertainty and long-term decline. Secondly, the competitiveness of electric vehicles coupled with social concerns around energy security and local air pollution means that developing countries like China will be among the key drivers of an emergent disruption in the transport sector, as it shifts towards a combination of electric vehicles, automation and the decline of the private ownership model (see section 4.3). With oil demand in decline in developing countries due to demand saturation and energy efficiency, oil producers can no longer bank on rapid demand growth in developing and emerging countries. Finally, social acceptance and buy-in are crucial ingredients for a successful transition, as demonstrated by the importance of policies to cushion disruptive change for affected communities, such as coal sector workers (see section 4.2). Many models are being developed and used to foster enhanced civil society dialogue and consensus building, and foundations can be at the forefront of such initiatives (see section 4.4).
- As these case studies demonstrate, many G20 countries are moving forward with policies and strategies to drive their domestic energy transition, based notably on domestic interests, such as clean air, energy security, and industrial development. However, further international cooperation is required in order to accelerate this energy transition and make these domestic goals achievable, as well as limiting global warming to well below 2°C.

Recommendations for the G20

- For this reason, the climate change and energy transition agenda must be at the heart of the G20's work. This report sets out four key recommendations in this regard (see section 5.2 for more detail):

I. **Establish a core G20 mandate to better integrate the issues of climate protection and sustainability for which the principles and objectives of the Paris Agreement and SDGs provide the key international frame of reference.** With the acute phase of the crisis now passed, the G20 in coming years should revise its core mandate to better integrate issues of climate change and environmental sustainability, as set out in the Paris Agreement and the Sustainable Development Goals (SDGs). The coherence of G20 action on climate change and sustainability should be improved, including by ensuring that climate change is integrated into ongoing work on growth strategies, infrastructure investment, fiscal policy, and labor market and structural policies. Indeed, the objectives of G20 annual growth strategies should be adjusted to include the objectives of climate-friendly, resilient growth.

II. **Implement the Paris Agreement through domestic policies and further G20 action:** The Paris Agreement and the SDGs provide a fundamental new pillar in the architecture of international cooperation. G20 countries should implement their engagements (NDCs) adopted under the Paris Agreement, and engage with negotiations under the UNFCCC to develop an effective and dynamic 'rule-book' for the Paris Agreement.

III. **Strengthen policy frameworks for 'greening finance':** The G20 should continue the work of the Green Finance study group and over time strengthen its operational outputs. The G20 should monitor progress in the implementation of the recommendations of the Financial Stability Board's Task Force for Climate-Related Risk Disclosure: It should map and ensure the sharing of best practice domestic policies for greening finance, and support the market development for green finance notably through improved standardization and monitoring. The G20 should also promote the use of climate-friendly fiscal policies, such as carbon pricing and fossil fuel subsidy removal. (T20, 2017; CPLC, 2017).

IV. **Strengthen the global transition to renewable and affordable energy:** The G20 should set out a high-level long-term vision for the global energy transition, in order to provide guidance to policy-makers and the private sector. This vision should entail renewables taking a dominant share in power generation by the 2030s, based on recent cost reductions.

Recommendations for Foundations

- Foundations also cannot ignore the importance of climate change and energy transition for their work. In most developed and some developing countries, foundations have been growing in importance, as measured for example by the size of their capital under management or their grant-making. This makes the choices that foundations make with regard to climate change all the more important. With these factors in mind, this report suggests a number of recommendations that could be considered by foundations:

I. **Play the role of bridge on climate change between the public sector, the private sector, and civil society:** Foundations have a unique capacity to bridge various sections of society, provide a space for different voices to be heard, and develop consensus around complex, long-term social objectives. The speed and scale of the change required to address climate change means that stakeholder buy-in is essential to success. At the same time, the above-described context of social tension around trends of inequality, economic disruption, and the fragmentation and fractiousness of public discourse make obtaining this social buy-in all the more difficult. Foundations can and should be part of the solution.

II. **Increase global coordination around addressing climate change and sustainability:** Existing coordination mechanisms between foundations working on climate change should be expanded to increase their geographic scope, notably concerning foundations outside the OECD countries and those foundations working in areas outside the field of climate change and sustainability but related to it.

III. **Mainstream addressing climate change and strengthening sustainability as core objectives of foundations' strategies:** Climate change is such a vast issue that even foundations working outside the direct field should consider in what way climate change impacts their work and how their social investments can contribute to addressing climate change.

IV. **Foundations should take into account climate change in how they invest their capital:** Some foundations contribute to the global divestment movement. Foundation capital can be invested where it is most effective and complementary, pushing into new frontiers of climate and energy policy.

1 Introduction: Context and Opportunity

1.1 An Unsustainable Status Quo

Earth Overshoot Day - the date on which humanity's resource consumption for the year exceeds Earth's capacity to regenerate those resources that year - came earlier than ever before in 2016: our ecological deficit that year started on 8th August (Global Footprint Network, 2016). Humanity already uses the resources of 1.6 planets, and without a change of direction this number will continue to grow given economic and demographic trends. Between now and 2050 the global population can be expected to grow by about 2 billion, and the global economy to more than double from USD 68 trillion to about USD 182 trillion (OECD, 2017). Economic growth is necessary to lift hundreds of millions of people out of poverty. But it would place untold pressure on the global environment, including climate change, if current economic patterns do not change significantly.

At the same time, societies around the world are confronted with important social pressures. In recent years, economic outcomes have been disappointing in many countries, even including developing and emerging countries (Alder, et al., 2017). Paradoxically, there is the perception that the rate of economic and hence social disruption is increasing, with concerns, for example about the impact of automation, initially its effect on manufacturing jobs, but now also on service sector jobs. The combination of slow growth and fast economic disruption is underpinning widening dissatisfaction with economic outcomes in many societies, particularly concerning the issue of inequality. Thus while the issue of climate change and sustainability demand a global transformation of the economy, the economic system as it stands today is not adequately achieving its inherent goals of lifting people out of poverty or ensuring a sufficiently equitable distribution of resources.

Societies themselves are changing rapidly. An increasing share of global economic power and with it geopolitical and military power is shifting towards emerging and developing countries, notably in Asia. Within societies, information technology is transforming the relationship between citizens and politics. Globalization is providing tremendous opportunities to help lift millions out of poverty in places like China, and to drive innovation and economic growth more broadly. At the same time, the globalization of trade, and finance in particular is a constraint on the capacity of sovereign nations to deliver desired social outcomes, for example an equitable distribution of tax burdens between labor and capital, rich and poor (Summers, 2016).

Thus while millions continue to aspire and hope for improved livelihoods, there is an increasing sense that the current global economy is not delivering: economically, socially, and of course environmentally. The solution must be a 'new global social compact', to deliver sustainability across the three pillars of economy, society and environment. The pillars of this 'new global social compact' were established in 2015 with the adoption of the Paris Agreement and the Sustainable Development Goals (SDGs).

1.2 A New Global Paradigm: the Paris Agreement and the SDGs

Historians will look back to 2015 as the year when international cooperation changed fundamentally. In three respects, the Paris Agreement on Climate Change and the SDGs represent a paradigm shift for global governance:

- *Interdependence of domestic interests:* the agreements recognize that countries are fundamentally interdependent, in a world increasingly linked by global trade, capital, innovation, financial and resource flows. Fundamentally, it is no longer possible for any country to deliver domestic objectives in isolation, as can be seen in the debate around the difficulties of fairly taxing internationally mobile capital at a national level. Climate change is the global problem par excellence which reveals this interdependence. As argued by Martin Wolf, in this new world of interdependent national interests: "global governance, while essential, must be oriented towards doing things countries cannot do for themselves. It must focus on providing the essential global public goods. Today this means climate change is a higher priority than further opening of world trade or capital flows" (Wolf, 2016).
- *Universality of responsibility and solidarity:* previous efforts to tackle the problem of climate change and sustainable development had allocated responsibilities to act almost solely to the developed world. The Paris Agreement showed that such thinking was a dead end. Firstly, the voices of all countries mattered, in particular the most vulnerable and the poorest. Secondly, developed

countries alone were becoming too small a share of the global economy to solve the problem on their own. This is why the Paris Agreement and the SDGs resulted in a major paradigm change, in stating that all countries must take efforts to mitigate climate change and ensure sustainable development. This was accompanied with a recognition that solidarity was a fundamental principle of the international community: developed countries and richer emerging countries took on new financial commitments to support sustainable development in the poorest countries.

- *Global partnerships with non-state actors:* the Paris Agreement recognized that while nation states must remain at the center of efforts to address climate change, non-state actors occupy a hugely important role in global governance, in a world of globalized corporations, finance and civil society networks. The Paris Agreement included a number of revolutionary, bottom-up partnerships between non-state and state actors to enable and reinforce action. Perhaps the most interesting and important is the global divestment movement, which has already mobilized trillions of USD of capital with commitments to divest from fossil fuels and finance low-carbon sectors instead. The inclusion of non-state actors within the Paris Agreement makes it much more resistant to short-term changes in political constellations, as it generates multiple fora and actors through which action can be driven forward.

This universal approach based on cooperation and solidarity in the face of shared problems represents a fundamental change of course for the international community and an unprecedented expression of political will.

Ultimately both the Paris Agreement and the SDGs were driven by a social demand for change in key countries. This gave policy-makers both the legitimacy to act at the national level, as well as to commit to the Paris Agreement and the SDGs. The best example of this is China where local air pollution from fossil fuels has emerged as a primary social concern and hence led the Chinese leadership, together with President Obama, to drive forward the negotiation of the Paris Agreement. Another key driver of civil society concern and policy action has been the science of climate change. Robust science formed the basis of the international community's establishment of the goal of limiting warming to well below 2°C above pre-industrial levels. Above this level, the adverse effects of climate change would be "severe, pervasive and irreversible …for people and ecosystems" (IPCC, 2014). A further driver of this paradigm shift has been changes in the real economy. Policy-driven technological progress has fundamentally changed the equation, opening new opportunities for policy-makers, businesses and investors alike, as will be explored in this report.

1.3 What Role for the G20 and Foundations?

The G20 leaders' summit was established in 2008 at a time of crisis: the world economy was teetering on the brink of another Great Depression. The G20 coordinated a series of fairly robust fiscal and regulatory responses to the Global Financial Crisis, which certainly helped to avoid the worst of the possible outcomes. The G20 occupies a unique position at the apex of the global financial and economic governance system, guiding decision-making on economic governance issues. Major international institutions like the International Monetary Fund, the Financial Stability Board, the Basel Committee on Banking Supervision, and the International Organization of Securities Commissions report directly to the G20 (Spencer & Hipwell, 2013).

Certainly, it has been criticized for being too remote from citizens, non-transparent and unrepresentative of the poorest developing countries. But it does have a crucial role to play. With the acute phase of the crisis passed and national differences on a variety of subjects increasing, the effectiveness of the G20 has clearly declined. Now the G20 needs to adopt a new decisive role with the capacity to pilot the transition to sustainable development. Given its function in the financial system governance, the G20 has a role in coordinating the financial system response to the challenge of climate change (see section 2.2). Moreover, over the years G20 leaders have already taken on dozens of significant commitments regarding climate change, from phasing out fossil fuel subsidies, to providing climate finance, to cutting coal use (G20 Research Group, 2016). Compliance with these commitments has, unfortunately, been relatively low at about 45% (Warren, 2016).

Thus the G20 has an unfulfilled potential as an engine of climate change governance, and a clear responsibility to fulfill the commitments enshrined in the Paris Agreement and SDGs. In 2015, G20 countries made up 90% of global investment, 84% of global economic activity, and 85% of CO_2 emissions from energy (Enerdata, 2017).

But the transition to low-carbon energy systems cannot only come from the 'top-down'. The required rate of change to mitigate climate change is massive and rapid; if not based on societal engagement and consensus, it runs the risk of social disruption in affected sectors and communities. Foundations have a unique role to play as a nexus between the public sector, the private sector and civil society. They can invest to complement the efforts of governments in social, policy and technological innovation, and in consensus building. Given the impacts of climate change on the global economy and on the financial sector (see section 2.2), foundations' assets under management will ultimately depend on a successful global response to climate change. As partners to the public sector, they are a crucial part of civil society engagement with climate change and sustainability issues.

1.4 About This Report

This report represents the contribution of a leading group of global foundations to the work of the G20 and its member countries. It aims to provide supporting evidence regarding the energy transition and decarbonization of the economy that is already underway, its benefits and consequences, and the need to strengthen it through robust public policies from the "top-down", and broad social engagement from the "bottom-up". It sets out key policy recommendations for the G20 and its Member States, and highlights good practice that can be drawn on to inspire action in other countries. **Above all, it represents a commitment from the participating foundations. As partners to both the public sector and the open society, they will ensure that climate change is at the core of philanthropic work going forward.**

The report is structured as follows. Section 2 presents the economic transformation required to mitigate climate change to well below 2°C, including in terms of the transformation of investment flows and the financial sector more broadly. Section 3 surveys the emerging energy transition in the broader context of economic and social change. Section 4 develops a series of country and sector specific case studies that showcase the energy transition that is underway, and provide best practice that can be taken up elsewhere. Section 5 provides conclusions and recommendations for policy-makers, including foundations and the G20.

2 The Shift to a Low-Carbon Economy – What is Required

2.1 Transforming the Global Energy System

In the 2015 Paris Agreement, the global community committed to limiting warming to *"well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C"* (UNFCCC, 2015, Art. 2.1a). This requires that emissions peak as soon as possible, decline rapidly thereafter, and reach net zero by the second half of the present century (UNFCCC, 2015). It is important to realize just how ambitious this objective is. Presently every single human activity, every economic sector, and every economic process, emits greenhouse gases (GHGs). The metabolism of the most complex system on the planet, the global economy, is based on fossil fuels and the emission of GHGs. Not only is this system hugely complex, but it is also characterized by high inertia. The 'physical capital' of power plants, urban structures, buildings, vehicles, ports etc. that emit GHGs often have very long lifespans, from multiple decades to a century or even more.

Previous transformations of the global economy of comparable scale to the one that must now be achieved to mitigate climate change have taken decades to unfold – the industrial revolution and the emergence of the oil age after WWII being two examples.

However, the physics of carbon dioxide (CO_2), the main greenhouse gas, determines the rapidity of the transition that must take place. CO_2 is a very long-lived gas in the atmosphere, and thus every ton of CO_2 emitted into the atmosphere from the combustion of fossil fuels is essentially irreversible[1]. To halt climate change, humanity must stop net emissions into the atmosphere before the stock of GHGs in the atmosphere reaches a level that will inevitably drive warming above 2°C. The analogy with filling a bath is perfectly apt: to stop the bath overflowing, the tap must be turned off in time.

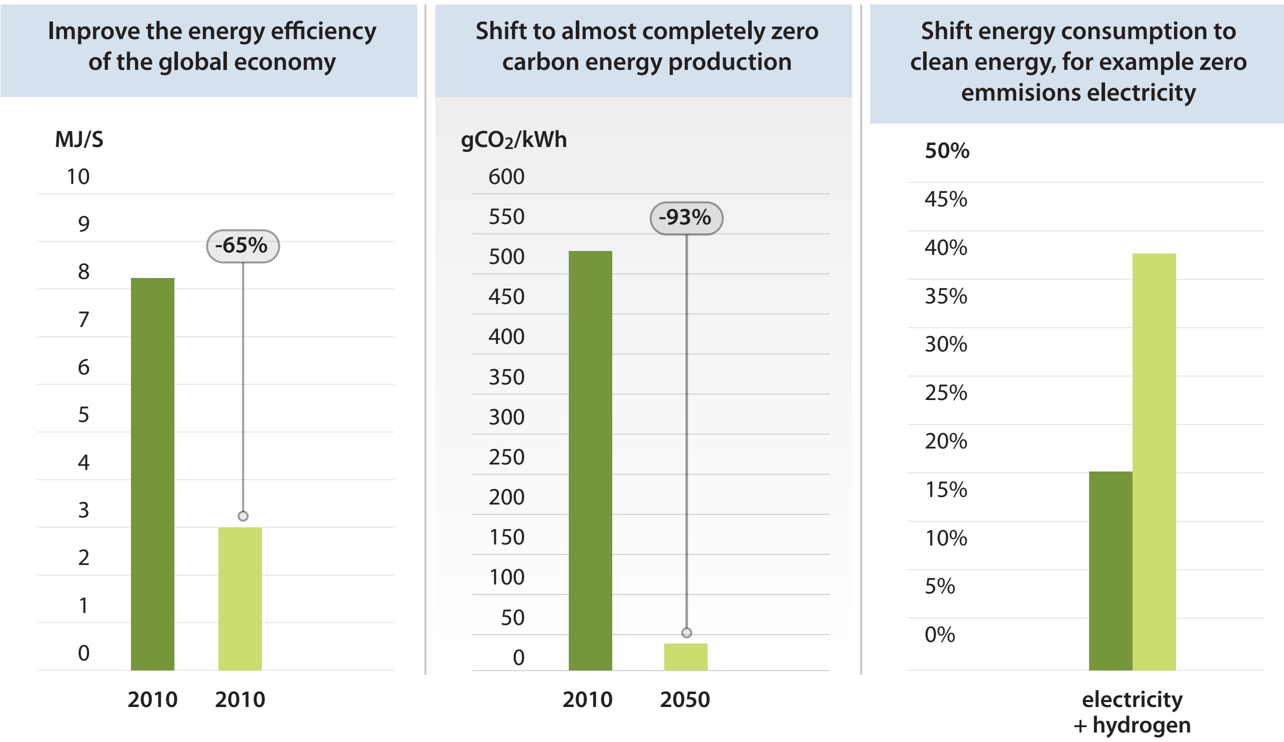
1 In the absence of currently unproven large-scale technologies to scrub CO2 from the atmosphere.

Thus we are faced with a double race against time. Every year we build a vast amount of additional GHG-emitting infrastructure (opening the tap wider and increasing the flow, thus extending the time taken to turn it off). And every year the concentration of GHGs in the atmosphere inches up (the bath continues to fill). The science of this equation is simple and very well known (Solomon, Plattner, Knutti, & Friedlingstein, 2009).

The largest contributor to GHGs is the global energy system. Reducing emissions thus requires the transformation of this system on an unprecedented scale and speed - a dynamic known as 'energy transition'. We can think of this energy transition as being composed of three pillars. The first is energy efficiency, reducing the amount of energy required to meet human needs (heating, mobility etc.). The second is to transform energy production to low-carbon energy sources, notably renewable sources of electricity (wind, solar, hydro, biomass). The final pillar is to shift to low-carbon energy sources in consuming sectors, such as transport, buildings and industry, notably through replacement of fossil fuels with low-carbon electricity. Renewable electricity is thus one prerequisite for the decarbonization of other sectors. The classic example of this is the shift in transport from internal combustion engine vehicles to electric vehicles.

Figure 1 shows what the G20 countries must achieve in terms of these three pillars by 2050, if the rise in temperature is to be kept below 2°C.[2] This entails more than doubling the energy efficiency of the global economy, shifting almost completely to zero emissions energy by 2050, particularly electricity production, and shifting consumption sectors like transport, buildings, and industry to zero carbon energy. This is a daunting challenge, but it is also one that would provide multiple benefits, such as faster rates of innovation, growth and job creation, along with cleaner air, not to mention the benefits of mitigating climate change. Multiple studies have shown that such a transformation will be extremely challenging, but technically and economically feasible (IDDRI and SDSN, 2015).

Figure 1: The three pillars of a low carbon energy system



Source: (IDDRI and SDSN, 2015)

2 It should be noted that the scenarios presented in Figure 1 imply a 50% likelihood of limiting warming to below 2°C during the course of the century, and are not consistent with the Paris objective of limiting warming to 'well below' 2°C. Scenarios to limit warming to 'well below' 2°C display similar characteristics as those displayed in figure 1, but notably require even faster and larger scale substitution of fossil fuels for renewable electricity in end use sectors. See (IEA and IRENA, 2017) for a presentation of a recent energy system scenario consistent with the Paris objective of limiting warming to 'well below' 2°C. The data presented in Figure 1 is an aggregate of 16 of the G20 countries. Turkey, Saudi Arabia, Argentina and the EU as a whole are not included here.

Reaching such low emission levels requires immediate, rapid and comprehensive transformation of all emitting sectors in all countries. Overall, a structural transformation of our economic system is needed far beyond the marginal technical adjustments envisioned by some: it requires a fundamental rewiring of the 'software' of our economies, including market structures, business models, trade, and investment. New partnerships between governments, civil society and the private sector are required to drive this transformation. Open and inclusive societies are necessary to ensure that the public and private sector take heed of the social demand for a clean environment. An example of this is the so-called Dieselgate scandal, in which a coalition of foundations and civil society NGOs (notably the European Climate Foundation and the European Federation for Transport and Environment) uncovered wide-spread cheating on vehicle emissions tests. The consequences in terms of stronger regulation and redesigned corporate strategy will be a major driver of the shift to electric vehicles. Another example of this kind of transformative partnership is the role that community financing has played in deploying renewables in Germany, or the C40 network of cities implementing policies and commitments to decarbonize cities, or the network of global foundations funding the provision of data to organizations campaigning against new coal power projects.

We focus below on the investment requirements and financial market implications of this transformation.

2.2 Transforming Global Finance to Shift Investment to Renewable Energy Systems

The shift to a low-carbon energy system and a low-carbon economy more broadly requires two important things. The first of these is a massive shift of investment away from fossil fuels (divestment) and towards renewable energy systems (investment). Secondly, it implies a much smaller increase compared to today's level in the total amount of investment in the global energy sector. The *shift* in investment is much more significant than the *increase* in investment required by the transition (ETC, 2017). In macroeconomic terms, mobilizing this increment of capital investment is more than feasible (IDDRI and SDSN, 2015). The real challenge is the supportive policies required to incentivize and engineer the shift in investment, and doing so in a way that is not overly disruptive to the financial sector.

In 2015, the global economy invested about USD 1.8 trillion in the energy sector. Investments in fossil fuels represented about USD 1.1 trillion (including fossil fuel-based power production), or about 5.4% of global investment across the whole economy (IEA, 2016 ; IMF, 2016). The pathway towards a low-carbon economy requires a significant and rapid reallocation of this investment. Between 2016 and 2050, a reduction of about USD 20 trillion in cumulative investment in fossil fuel extraction would be needed to remain in a 2°C scenario, but with a commensurate increase in investments in clean power supply (USD 13 trillion), energy efficiency and fuel switching in final consumption sectors (USD 31 trillion) (IEA and IRENA, 2017). Thus the energy transition requires taking a very significant share of investment out of one sector (fossil fuels), and putting it into another (renewable energy and energy efficiency).

There is mounting evidence that this investment shift, if not accompanied with long-term, visible and credible policies to allow investors to plan ahead, could cause serious instability in financial markets. About 80% of the present value of a representative financial portfolio is based on expectations about cash flows beyond the short-term horizon of 5 years (Naqvi, Burke, Hector, Jamison, & Dupre, 2017). If climate policy and related technological change reduce the demand projections for fossil fuels, expectations about both future prices and quantities will fall and hence so will immediate valuations. If such a revaluation of future revenues is limited in scale, investors are protected to a certain extent by their ability to sell assets whose valuation has taken a hit (liquidity – defined as the capacity to sell an asset without experiencing a concurrent drop in its value). The problem arises if a critical mass of investors were to simultaneously reach the same conclusions regarding a fundamental revaluation of fossil fuel based financial assets, and all try to sell at the same time. Here liquidity no longer provides protection, since the supply of unwanted financial assets outstrips demand, and prices (values) for these assets therefore fall (a so called 'fire sale'). This is exactly what happened in the Global Financial Crisis. That such a thing could happen in the energy sector is evidenced by the recent evolution in the coal industry: over the past five years (between 2011 and 2016), the market capitalization of major US coal producers lost 92% of its value, falling from USD 62.5 billion to less than USD 5 billion.

Could such a thing happen due to climate policy and technology change undermining the future valuation of fossil fuel based financial assets? How big is the stake of financial markets in the fossil fuel industry? Researchers at the Bank of England calculate that a full 11.3% of global equity market capitalization is accounted for by companies directly involved in fossil fuel extraction, and 15.8% of global bond markets. If companies that would be indirectly affected by the transition to a renewable energy system (such as energy intensive sectors, conventional vehicle manufacturers, etc.) are included in the calculation, this share of 'value at risk' rises to 28.6% and 33.7% respectively for equity and bond markets (Baranova, Jung, & Noss, 2017). In short: the global financial sector is significantly exposed to the transition risk arising from policies to shift to a low-carbon energy system. Equity market capitalization and outstanding debt issuance by companies directly involved in fossil fuel extraction amounted to USD 9.1 trillion; and USD 12.7 trillion if this group is expanded to include sectors indirectly affected by the energy transition. This also demonstrates the scale of vested interests that need to be managed in the transition to low-carbon economies.

It is interesting to note that the scale of US residential investment prior to the subprime mortgage crisis which triggered the global financial crisis was not that big, peaking at just USD 856.1 billion in nominal terms in 2005 and falling to a low of USD 381.1 in 2010 (BEA, 2017). This starting point in 2005 was of comparable size to global investment in fossil fuel extraction today (USD 1.1 trillion). Of course, the 2007-8 financial crisis was not precipitated just by the drop in the annual *flow* of residential investment, but ultimately by the downward revaluation of the value of the *stock* of investments, as markets realized that a significant share of homeowners were not able to repay their mortgage. In the Great Financial Crisis of 2007-8, the US housing market lost USD 7 trillion in value, split between household equity and financial market claims for mortgages (and related financial products). We can compare this to the above mentioned equity and debt market share of fossil fuel companies of USD 9.1 trillion. In the case of the global financial crisis, the complexity, interconnectedness and structural fragility of the global financial system propagated and amplified the proximate shock into a much larger crisis of the financial sector and eventually the real economy. Thus while the analogy has its limitations, the scale of the financial systems stake in fossil fuels is more than comparable to previous large-scale asset bubbles.

It is urgent therefore that global and national policies give strong, credible and long-term signals to guide both the energy transition and associated financial market decision-making. Such policy should be on the demand side for capital (i.e. carbon pricing, regulatory standards, support for renewables); as well as on the supply side to guide investment decisions. Of particular importance among these supply-side policy instruments are risk disclosure tools, such as the inclusion of environmental and climate policy risks in corporate reporting, portfolio stress testing and tools to understand the climate policy exposure of financial portfolios. Such disclosure policies can help to overcome the current barriers to the effective allocation of capital and avoid the risk of mis-investment highlighted above.

This has been recognized by the G20 for the first time at the Hangzhou Leaders' Summit in China, which recognized the need to provide *"clear strategic policy signals and frameworks"* to promote sound investor decision-making regarding climate policy and energy transition (G20 Leaders Communique, 2017). Concurrently in 2016, the Financial Stability Board, the regulatory arm of the G20, set up the Task-Force on Climate Related Risk Disclosure (TCFD) with the objective of developing industry guidelines for corporate disclosures related to climate change, marking the first time that global financial regulatory policy has directly addressed the issue of climate change (TCFD, 2016). The TCFD issued its preliminary report for public consultation in December 2016, and will issue its final report to the FSB in June 2017.

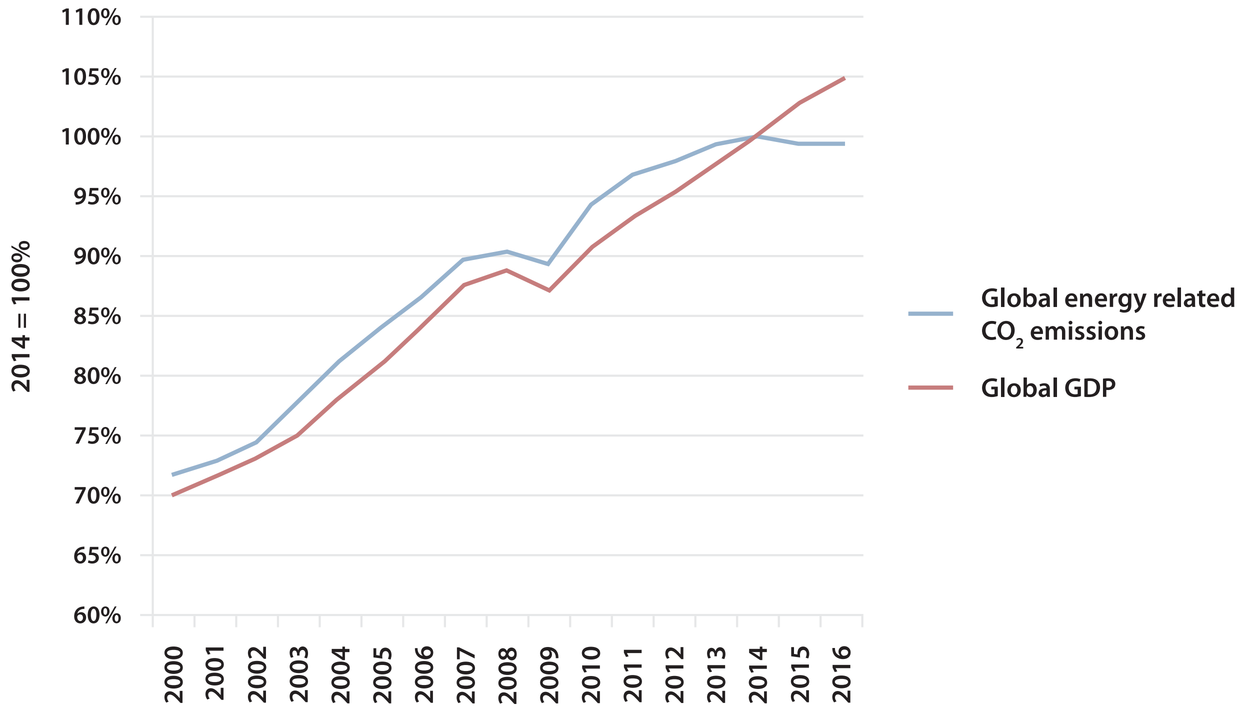
It is thus crucial that both investors, but also foundations as institutional investors with their capital tied up in financial markets continue to engage alongside governments to strengthen regulatory policy on climate change and energy transition. To date, the financial sector's engagement in climate change has been among the most effective in terms of driving policy forward, but investors also stand to lose much if an orderly transition is not achieved.

3 The Energy Transition: How Far Along the Road are We?

3.1 Dip or Blip? The Global Stall in Energy Related CO_2 Emissions

The inexorable rise of CO_2 emissions from energy production has long been the depressing backdrop for policy efforts to address climate change. But this is no longer the case. For three years from 2014 to 2016, global CO_2 emissions from energy have been essentially flat, while global GDP has continued to grow robustly. This is the first time in history that a multi-year stall in emissions has been observed, outside the context of war or global economic downturn.

Figure 2 : Global GDP CO_2 emissions stall, global growth continues



Source: own elaboration based on data from (Enerdata, 2017) and (IEA, 2017)

The global stalling of energy-related CO_2 emissions should be taken as encouragement, not an excuse for complacency. It has been driven by a number of policy-related, technological and structural economic trends that have spurred the remarkable growth in renewable and energy efficiency, and led to the moderation of the growth in energy demand. The global economy is becoming cleaner and needs less and less energy to supply more people with increasing needs. But as will become clear throughout this report, such trends are by themselves insufficient to limit warming to well below 2°C. Acceleration is easier when already in motion. If the tools to transform the global economy to a cleaner, more resilient future are emerging, the hand of policy must seize the opportunities they present to make the transformation a reality.

3.2 Three Megatrends that Structure the Climate Policy Context

Part of the stalling of emissions is related to technology innovation in the broad sense, which has driven the growth of renewable energy and improvements in the energy intensity of the global economy. Indeed, the world is currently witnessing a rather unprecedented phase of technological innovation and faces three interlinked revolutions, namely:

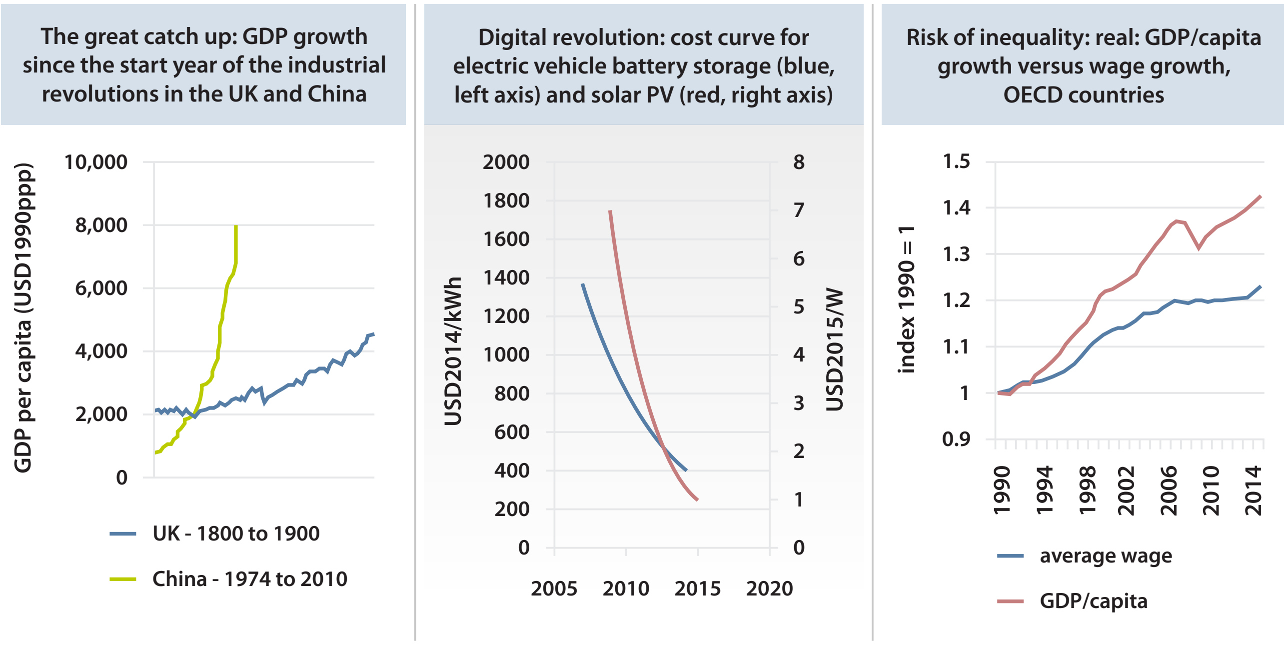
- *The "great catch up" of emerging economies:* it is hard to convey just how rapid and massive the recent growth of emerging economies has been. While Great Britain took roughly 125 years to double its per capita income during its industrialization, China has grown its per capita income by a factor of 10 in the 37 years since the start of its industrialization in 1973. This growth in per capita income in China has occurred with a population two orders of magnitude greater than that of the UK during the corresponding period. This faster acceleration was possible because China has been able to benefit from the accumulated human knowledge and technology built up over the 250 years of industrial development, and to deploy it with great purposefulness. This trend will continue as China carries on growing and as the catch-up extends to India and Africa. If poorly managed 'the great catch-up' will place untold pressure on the global environment; if well-organized it offers the opportunity to leapfrog into a new development paradigm while driving forward the deployment of sustainable development solutions around the world.

- *The "digital revolution" and the emergence of new energy technologies:* the world is experiencing another wave of innovation in digital technology, in the area of artificial intelligence (AI), robotics, and digitally-enabled manufacturing technologies. This will profoundly transform all spheres of human life, including manufacturing, labor markets, but also the energy sector. The potential for negative consequences exists; indeed, automation is one of the drivers of growing inequality in advanced economies (see below). However, in conjunction with the emergence of smart grids, high performance renewable energy and storage technologies, this wave of innovation holds the potential to transform energy systems with a rapidity and scope that perhaps industry actors and politicians are not yet grasping (Helm, 2017). Thus the digital innovation revolution is for the first time providing a set of necessary tools to tackle climate change, in particular cost effective renewable energies, and energy management and storage technologies.
- *The underperformance of the global economy:* economists are confronted with a paradox: we are simultaneously experiencing very rapid technology change, along with a clearly observable trend towards lower growth in productivity and hence in GDP per capita in advanced economies. This has been accompanied with growth in inequality, and a slowing of GDP growth cannot be relied on to ensure a reasonable distribution of income.

These three mega-trends are represented in Figure 3. The left hand panel shows the growth in GDP per capita in the UK and China, since the start of their respective industrial revolutions. It illustrates the tremendous rate at which the "great catch up" of emerging economies has occurred, lifting hundreds of millions of people out of poverty and dramatically transforming the global economy. The middle panel shows an example of the energy-related aspects of the broader digital revolution, with the cost curves since 2005 for two key energy technologies: solar PV and battery electric storage. Both technologies have been experiencing learning rates in excess of 20% per year. While revolutionary in itself, this pales in comparison with the learning rate of information technology, which could be a crucial enabling technology for the energy transition (Helm, 2017).

The right hand panel illustrates a darker side of the economic and social transformations underway, namely the growing risk of inequality, particularly in slower growing advanced economies. The graph shows GDP/capita growth and *average* wage growth since 1990 in advanced economies. Average wages have grown more slowly than GDP/per capita, indicating that the gains of economic growth have not been equally shared. This is partly due to direct trade impacts, but mostly due to changes in technology that have decreased the labor value of lower skilled workers. The data in the right hand panel in Figure 2 only pertains to OECD countries, but rising domestic inequality is also an issue for a number of emerging countries (Chancel, Hough, & Voituriez, 2017). Thus while in the last 20 years there has been some impressive, albeit incomplete, convergence in incomes between countries ("the great catchup"), economic and political changes have driven a worrying rise in inequalities across a large section of both advanced and emerging countries.

Figure 3 : the three megatrends that structure the transformation to clean energy and stable societies



Source: own elaboration based on (Maddison-Project, 2013)

Source: own elaboration based on (GlobalData, 2017) and (Nykvist & Nilsson, 2015). NB exponential line of best fit on ca. 100 datapoints

Source: own elaboration based on (OECD, 2017)

This then is the back-drop for considering the global transformation to renewable energy systems: one that offers tremendous opportunities but also considerable risks. For the first time, technology evolutions and policy are opening up the potential for competitive renewable energy solutions. The rapid growth of emerging countries provides a crucial chance to leapfrog into cleaner development pathways, while at the same time creating the necessity to do so: resource-intensive growth at such a rate and for countries of such size would place immense pressure on the local and global environment. At the same time, trends of inequality, stagnant wage growth and job creation, and a perception of accelerating economic disruption are creating social and political pressures. In this new and rapidly changing economy, inequality and economic disempowerment risk creating understandable resistance to change, which if not carefully managed could create barriers to the energy transition.

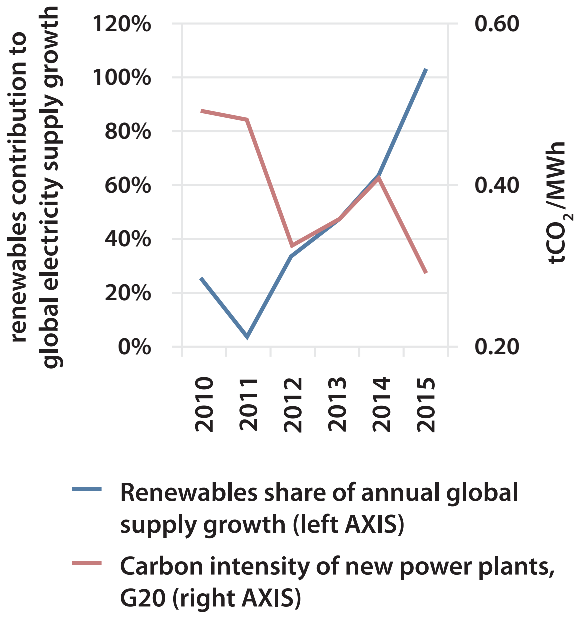
3.3 We are Seeing Transition Towards Renewable Energy Systems

The stall in global CO_2 emissions from energy seen in Figure 2 is being driven in part by structural changes in the global economy, notably by China's shift towards a cleaner, less energy intensive economic model (see section 4.2). But it is also being driven by the increasingly rapid deployment of renewable energy solutions, on the back of the technology learning curve that was highlighted in section 3.2. This section takes stock of the emerging energy transition.

We start first of all with the electricity sector, which is responsible for around a third of global emissions. Since the middle of the 2000s, policy initiatives kick-started the deployment of renewable energy, starting first in developed countries but spreading to emerging countries with the increasing competitiveness of renewable energies. As a result, investments have been increasingly shifting towards renewable technologies and energy efficiency. We calculate that the amount of CO_2 produced annually by new power plants across the G20 declined by 50% from the peak in 2006, as renewables began to take the lion's share of new investment and the retirement coal fired power plants in advanced economies began. **As a result, for the first time renewables were responsible for nearly 100% of global electricity supply growth in 2015.**

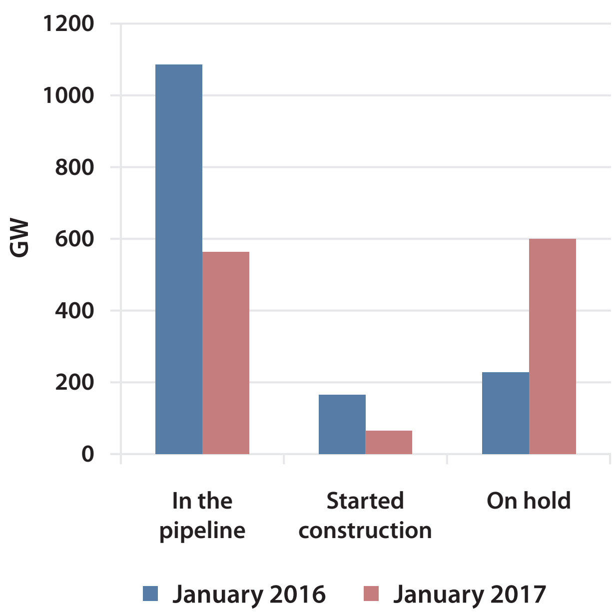
At the same time, there is evidence that the growth of renewables is finally starting to bite into 'king coal', the primary source of global emissions. Coal's share in the global energy mix actually grew in the mid-2000s, as China powered its extraordinary growth with the only fuel that could be built up at sufficient scale at the lowest cost: coal. That equation no longer holds. With renewables experiencing a dramatic technology learning curve (Figure 3) and now delivering cost effective alternatives, the growth of coal power plants has finally started to show an inflection. In the year between January 2016 and January 2017, the global coal power investment pipeline fell by almost 50% as a record number of plants were shelved (Figure 5). Even existing coal is increasingly coming under competition from other technologies and from the lower than expected growth of power demand as energy efficiency measures take effect: power plant utilization rates have been in free fall even in rapidly growing emerging economies. The 'coal bubble' is looking increasingly fragile (see section 4.2).

Figure 4 : the shift to renewable power production



Source: own elaboration based on (Enerdata, 2017) and (GlobalData, 2017). N.B. carbon intensity of new power plants is net capacity additions, i.e. including retirements

Figure 5 : the shift away from coal

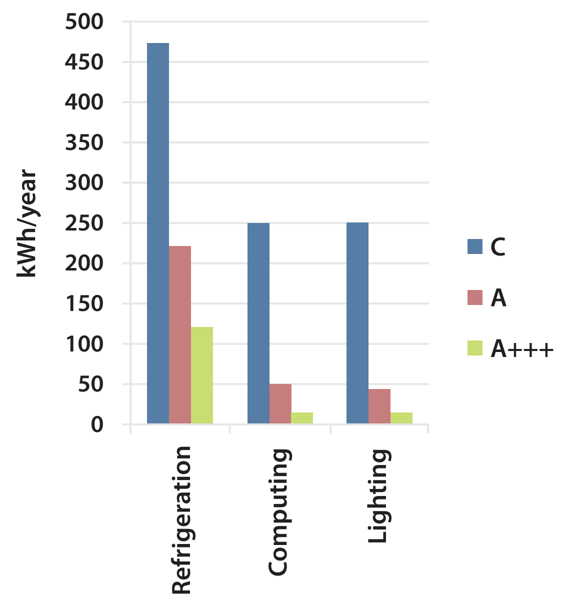


Source: own elaboration based on (Shearer, Ghio, Myllyvirta, Yu, & Nace, 2017)

Part of the challenge for coal is that electricity demand in numerous countries has grown more slowly than expected by project planners when their projects were being designed and approved. Part of this is due to slower than expected economic growth (see section 3.2). But a significant share is also due to the structural shift towards more energy efficient economies, and the deployment of improved energy efficient technologies. Figure 6 shows the extraordinary technological innovation that has been made over the past 10-15 years in improving, for example, the energy efficiency of household appliances. Between technology vintages of the early 2000s and the most efficient technologies today, improvements in energy efficiency in the order of 40-95% have been made, without sacrificing either performance or cost. It is thus possible to power all the needs of a developed country household with roughly a third of the electricity required in the early 2000s. To show that such evolutions can have a material impact on absolute demand, Figure 7 shows absolute electricity demand for lighting services in the European Union (EU), which has fallen by a full 26% *in* absolute terms since the peak in 2007 (while at the same time household consumption expenditure has grown, albeit modestly certainly, so this change is not due to declining purchasing power). This correlates well with the market share growth of ultra-efficient "light-emitting diode" (LED) bulbs (Figure 7).

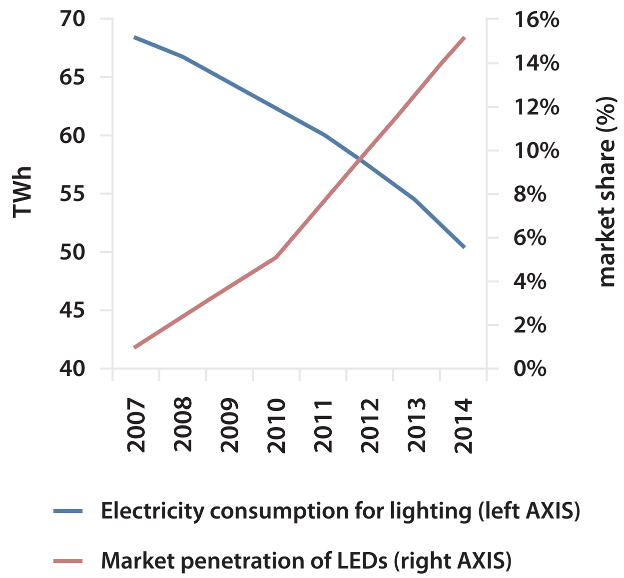
Of course, demand for energy services will grow in emerging and developing countries. However, thanks to the technology innovation occurring in the last 10-15 years, these demands can now be satisfied cost-effectively with a fraction of the energy requirement that would have been needed in the 1990s. In the context of ongoing urbanization (more than two thirds of the world's population will be urban by 2050) seizing the potential for smart, energy efficient urban development is crucial: the wave of digital innovation in energy technologies highlighted in section 3.2 provides the way forward.

Figure 6 : energy efficiency improvements in selected household appliances



Source: own elaboration based on (RTE, 2016)

Figure 7 : absolute decline in electricity demand for lighting in the EU versus LED bulb market share



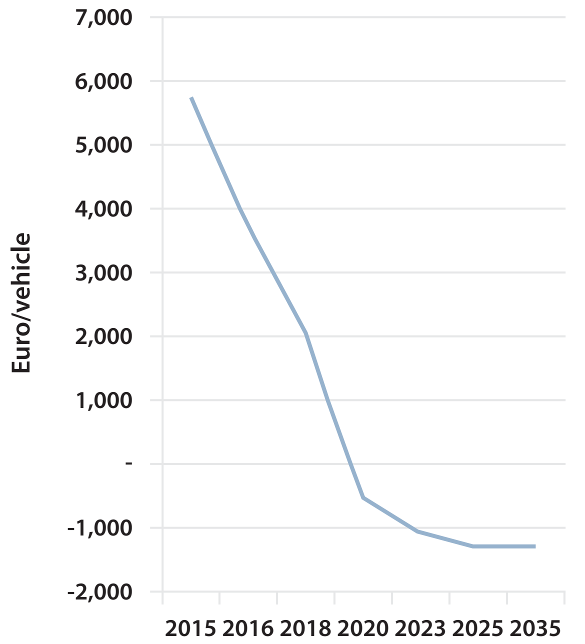
Source: own elaboration based on (Enerdata, 2017)

Alongside the shift to renewable electricity and the increase in energy efficiency, the shift to non-fossil fuel sources of energy in the so-called "end-use" sectors of industry, buildings and transport is the final crucial pillar of the energy transition. We can take as the example here the transport sector, which is overwhelming powered by oil (94.5%). Oil is transport and transport is oil. The age of oil, which roughly began following the end of the WWII, drove a remarkable period of global growth, accompanied by the ascendency of oil to the position of the world's dominant fuel. This equation is starting to break down. The rapid technological progress in electric vehicle battery packs, coupled with ever more stringent fuel economy standards and local pollution regulations is driving the emergence of electric vehicles as a viable alternative to the internal combustion engine. Global sales of electric vehicles (both plug-in hybrid electric vehicles and battery electric vehicles) have grown at an impressive rate of about 60% per year over the last five years. A step-change in the decline of battery costs and significant investment from the major global vehicle manufacturers augurs well for the future of the sector.

Thus, there is now a live debate within the oil industry and among energy forecasters about the potential for the world to reach peak oil demand, as efficiency improvements and electric vehicles start to make serious inroads into oil demand. The McKinsey & Company consulting firm predicts that the technology opportunities associated with electric vehicles, if fully adopted, coupled with shared mobility solutions including autonomous vehicles, could cause oil demand to peak as early as 2025 before starting a slow decline. It should be noted that this is a technology-driven scenario, not a policy driven one: it does not automatically imply greater efforts on climate change, but it does show what technology could do to enable further policy efforts (MGI, 2017). This would be a tectonic shift in global energy and financial markets, which are substantially dependent on the dividends and capital gains from fossil fuel companies (see section 2.2). While such a scenario is not a given, and policies will be needed to support the transport sector transition, for the first time competitive technology options are becoming available.

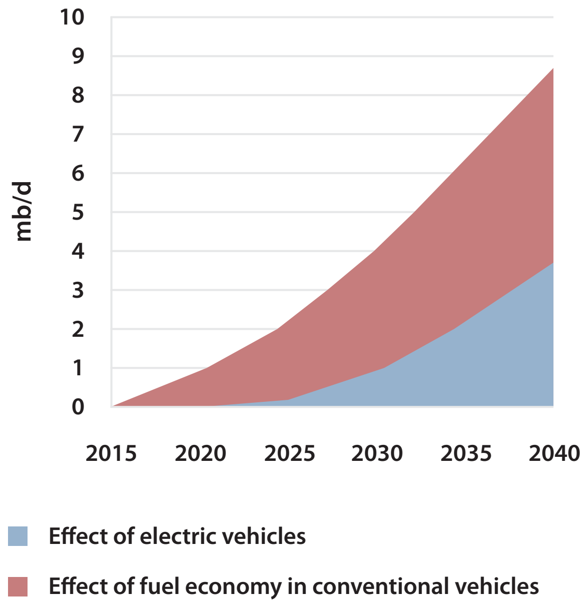
Figure 8 shows the 'technology learning curve' for electric vehicles, representing their incremental lifetime cost compared to conventional internal combustion engine vehicles. On current innovation and deployment pathways, it can be expected that electric vehicles will become cost competitive on a lifecycle basis (i.e. once fuel savings are taken into account) compared to internal combustion engine vehicles as soon as the early 2020s. Of course, electric vehicles would still be somewhat more expensive to purchase, all other things being equal; and the charging infrastructure needs to be developed. Thus further policies are required to ensure that the enabling conditions are met for the technology potential that is emerging. In Figure 9 we model the impacts on incremental oil demand of a reasonably aggressive scenario for electric vehicle deployment, combined with improvements in the efficiency of internal combustion engine vehicles. It can be seen that this scenario would avoid significant oil consumption, underpinning a peak, plateau and decline for global oil demand in the 10 to 15 years to come.

Figure 8 : incremental lifetime cost for an electric vehicle versus a conventional vehicle



Source: own elaboration based on literature review and modelling conducted in (Sartor, Spencer, & Fryatt, 2017)

Figure 9 : effect of vehicle efficiency and vehicle deployment on incremental oil demand



Source: own calculations

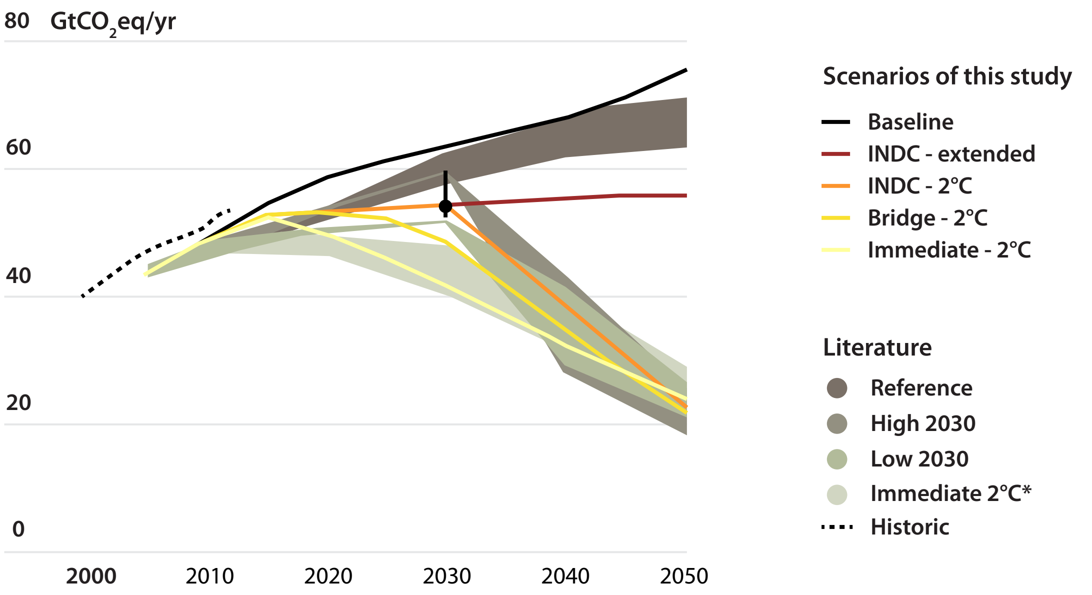
3.4 The Need to Open New Paths to Strengthen the Transformation

We are now at a watershed moment for the shift towards a low-carbon and resilient economy, and renewable energy systems. Unprecedented technology innovations are occurring across a range of key energy system technologies, combined with rapid innovation in pervasive enabling technologies, such as information technologies and artificial intelligence, robotics and advanced manufacturing, and new materials and biotechnologies.

However, currently these trends are significantly off track if we are to limit warming to well below 2°C, as has been agreed by the world community under the Paris Agreement. The aggregate global GHG emissions trajectory has been tilted significantly downwards thanks to the policy commitments undertaken under the Paris Agreement (Spencer et al, 2015). The trends described above will probably tilt this curve further down too. But nonetheless: a vast gulf exists between this global emissions trajectory and the emissions trajectory required to limit warming to well below 2°C.

Figure 10 shows the global emissions pathway implied by current policy commitments (the "INDC – extended pathway"), as well as global pathways required for meeting the 2°C target (notably the Bridge 2°C scenario and immediate 2°C scenario).[3] Delaying further policy action would have serious implications at the global level, including significantly higher costs, financial system disruption and risks to feasibility compared to a scenario of earlier, stronger action.

Figure 10 : the global emissions pathway implied by current policy commitments and the gap with 2°C



Greenhouse gas emissions in the scenarios of this study (solid lines), compared with the 2030 range and best estimate from the country-level analysis of conditional INDCs of PBL (www.pbl.nl/indc, vertical black line and dot), and the inter-quartile ranges of the FullTech-450-OPT (Immediate 2°C), FullTech-450-LST (Low 2030) and FullTech-450-HST (High 2030) scenarios of the AMPERE study, as well as the reference policy scenarios of the AMPERE and LIMITS studies. While section 4.3 discusses the INDC-2°C scenario, section 4.4 explores the possible effect of an early announcement of 2°C compatible policies (Bridge-2°C). Total greenhouse gas emissions were calculated based on global warming potentials from IPCC's second assessment report (SAR).*

* with action starting after 2010

Source: REMIND model calculations, EDGAR (IRC/PBL, historical emissions), PBL INDC Tool Calculations (www.pbl.nl/indc INDC range and best estimate) and IPCC AR5 scenario database

Source: (Spencer et al, 2015)

Current trajectories display three characteristics that need to be addressed by more stringent policy objectives in order to limit warming to well below 2°C:

- *Speed:* the currently emerging energy transition, while moving in the right direction, is not moving at the necessary speed to reduce emissions in line with a global emissions pathway to limit warming to well below 2°C. This is crucial because the longer we wait to reduce emissions, the more steeply they must be reduced, if the stock of CO_2 in the atmosphere is not to exceed the level consistent with limiting warming to well below 2°C. This can be seen in Figure 10 above by examining the gradient of the curves between the 'INDC-2°C' scenario after 2030 and the 'Immediate 2°C scenario'. Reducing emissions at the rates implied in the 'INDC-2°C' scenario would be significantly more disruptive, costly and at a greater risk of failure than taking earlier, more stringent action (Spencer et al, 2015).
- *Scope:* the emerging energy transition is also unevenly spread between sectors and technologies. Technology innovation, deployment, and emissions reductions are proceeding quite well in some sectors such as renewable electricity (although too slowly even here, as mentioned above). However, in other sectors such as the manufacturing sector, in particular energy intensive

3 It should be noted that the scenarios presented in Figure 10 imply a 50% likelihood of limiting warming to below 2°C during the course of the century, and are not consistent with the Paris objective of limiting warming to 'well below' 2°C

manufacturing, the energy transition is close to non-existent (Spencer et al, 2015). Policies are not being deployed in these sectors, and innovation is lagging behind. Part of this is due to the fact that countries and companies are particularly sensitive to the (perceived) impact of policies on economic competitiveness in these sectors. This also demonstrates the need for coordinated policies, particularly among the countries of the G20 in order to alleviate these concerns.

- *Risk:* the current landscape of the global energy transition involves too much risk, in terms of both the actual capacity to achieve the objectives of limiting warming to well below 2°C, as well as the risk of cost and disruption in doing so. For example, too little is being done to limit lock-in into high emissions infrastructure, such as coal-fired power plants. Given these investments and the current state of the deployment of carbon capture and storage (CCS), it seems probable that the well below 2°C target will have to be met through the massive stranding of coal-fired power plants combined with the much more rapid deployment of renewables, electrification and efficiency. At the same time, CCS would still be required to mitigate CO_2 emissions from the heavy industry sector, which currently lacks alternative mitigation technologies. Moreover, the difficulty of mitigating emissions in some sectors means that the objective of reaching net zero in the second half of this century requires some level of negative emissions, necessitating in turn the deployment of unproven technologies such as bio-energy CCS (BECCS) or direct air capture (IPCC, 2014). These points highlight the importance of continued, rapid and large-scale energy system innovation, beyond the trends identified in this report.

What is required therefore is a comprehensive partnership between policy, civil society and investors to accelerate the global energy transition. The good news is that the necessary tools are there. The main question is whether the social and political will for change can be developed and harnessed at the required speed and scope. The following case studies demonstrate the in more concrete and granular detail the progress that can be made, and is being made, through the deployment of this partnership between policy, civil society and investors.

4. Case studies

4.1 Renewable Energy in India: Aligning Development and Environmental Protection

India is currently the world's fastest growing emerging country and is an increasing powerhouse in the global economy, energy markets and geopolitics. India is faced with a threefold energy challenge. First, India's current level of GDP and energy consumption per capita is low; the country ranks 138th in the world in GDP per capita at market exchange rates and 116th in the world in energy consumption per capita. Thus India's energy demand will grow significantly alongside its economy as it strives to bring modern energy to its people. Secondly, India's energy security is a major concern, given its low indigenous (fossil) energy resources. Over the last decade, India's net energy import bill has averaged 6% of GDP, creating significant macroeconomic pressures on inflation and foreign exchange reserves. Thirdly, India is facing significant environmental stress, of which local air pollution is perhaps the most acute with India ranking among the worst affected countries in the world (HEI & IHME, 2017).

For these reasons, the Government of India has progressively turned to renewable energy as a keystone of an energy strategy to address this triple challenge. A step-change occurred in 2014, when the Government of India announced a series of policy targets, which amounted to achieving an installed capacity of 175 GW of renewable energy by 2022, excluding large hydropower. This is an extraordinarily ambitious target: in the year of the announcement, *global* installed renewable energy capacity was about 640 GW, excluding large hydropower (Enerdata, Global Energy and CO_2 Database, 2017). Thus India set out to add 27% to the global renewable energy capacity at that time within 8 years. Most of this capacity should come from solar (100 GW), wind (60 GW), and other renewables, such as biomass (15 GW). Subsequently, this target was reflected in the international engagement that India took on in the Paris Agreement, which included the target of 40% non-fossil fuel capacity installed in the power sector by 2030 (Government of India, 2015).

These new policy commitments represent a significant deviation from a 'business as usual' (BAU) development trajectory, which would assume no climate or environmental concerns. Compared to a BAU trajectory, implementing India's renewables targets would lead to an 18.4% lower coal demand in 2030, and 13.6% lower CO_2 emissions in 2030, equivalent to an amount slightly less than the combined emissions of France and the United Kingdom today (IIMA and IDDRI, 2017).

In order to implement this commitment to renewable energy, the Government of India and the State Governments have put in place a range of supporting policies. These range from accelerated tax depreciation, low-interest loans, and tax credits. The high-level commitment provided by the ambitious 2022 targets; combined with specific policies, has created a favorable environment for the deployment of renewable energy. Figure 11 shows the current installed capacity of solar PV as of 2016, which has grown at 160% per year from 43 MW (0.043 GW) to reach an estimated 13 300 MW in 2016 (13.3 GW). Similarly, wind power has displayed very strong growth, reaching an installed capacity of 30.2 GW in 2016. The figures also show the impressive amount of projects in both solar and wind, which are at different stages in the pipeline.

Figure 11 : current installed solar capacity and future project pipeline

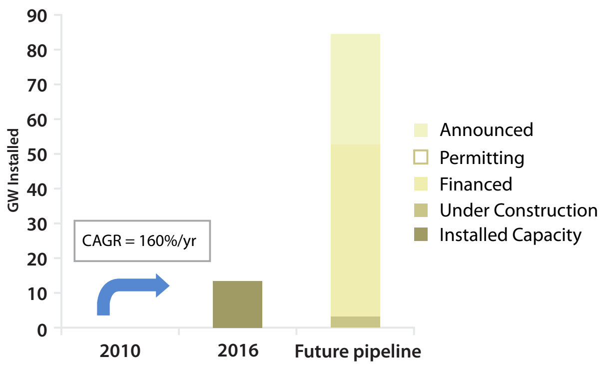
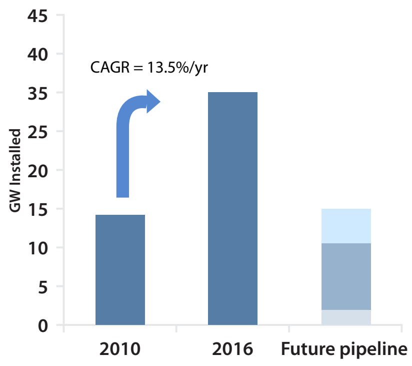


Figure 12 : current installed wind capacity and future project pipeline



Source: own elaboration based on data from (GlobalData, 2017).
N.B. Years given are fiscal years, March-April, not calendar years.

This impressive growth has been made possible by supportive policy settings, but also by the very rapid technology learning curve that has taken place in recent years due to the innovation pull of strong global deployment, as well as open global supply chains. Project costs for solar energy have fallen spectacularly from over USD 6 2015/W in 2009 to just under USD 1 2015/W in 2016, amounting to a cost decline rate of over 24% per year. Wind technology costs, a more mature technology, have fallen also at an impressive rate of 6.5% per year. This has allowed renewable energy to come in striking distance of being economically competitive, without subsidies, compared to coal. Currently, the cost of solar electricity in India is hovering around USD 0.06 /kWh, roughly on par with the generation cost of coal-based electricity, if one excludes the significant social externalities of coal combustion from the pricing, such as local air pollution and climate change; it is widely expected that solar will go below this price in 2017 (Upadhyay, 2017).

Figure 13: reduction in investment cost of solar PV in India

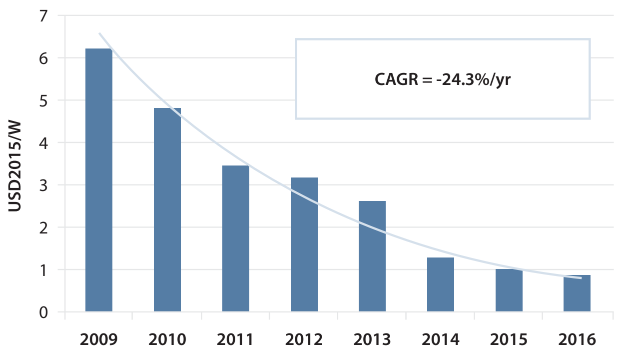
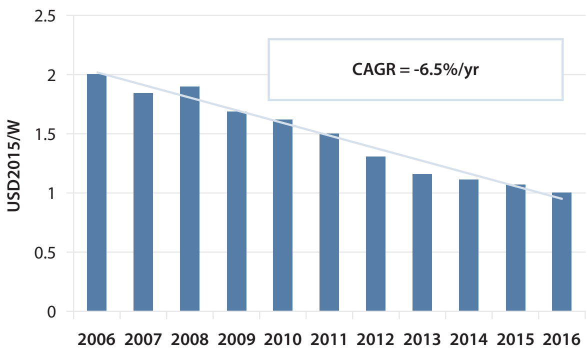


Figure 14: reduction in investment cost of wind power in India



Source: own elaboration based on data from (GlobalData, 2017)

> *"I think a new coal plant would give you costlier power than a solar plant. Of course there are challenges of 24/7 power. We accept all of that – but we have been able to come up with a solar-based long term vision that is not subsidy based."*
>
> ***Piyush Goyal**, Minister of State with Independent Charge for Power, Coal, New and Renewable Energy and Mines, India (quoted in King, 2016)*

It is interesting to look at who is active in the renewables sector in India, taking for example solar PV. If one examines the owners of the existing stock of active PV plants, one sees the predominance of smaller-scale, pure-play renewables companies, such as Azure Power India (2016 FY revenues of USD 41 million, and 486 MW of installed capacity). Major industrial groups such as Adani or Tata are certainly present, with existing assets of 898 MW and 124.91 MW, respectively. However, while the market is currently predominately made up of many smaller players, if one examines the pipeline of upcoming projects, the sudden entry of industrial heavyweights into this booming sector is clearly noticeable. This is not to say that smaller players are being squeezed out, as the Government of India targets both utility-scale projects, which are more suited to large industrial corporations, and distributed projects, which should make up 40 GW of the 100 GW capacity target mentioned above. What it does show, however, is the extent to which the transition to a renewable power system is being seen as a business opportunity by major corporations, with traditional interests in the fossil fuel sector. Such large actors, with access to deeper pools of investment capital, will be required to finance the utility-scale part of India's development of renewables.

Table 1 : major industrial actors in the solar PV market

Company	Revenues, FY 2016	Solar PV pipeline
Adani Enterprises Limited	6.8 billion USD	11.9 GW
Indian Oil Corporation Limited	55.6 billion USD	2.7 GW
Reliance Industries Limited	42.8 billion USD	6 GW
NTPC	12.3 billion USD	5.2 GW

Source: own elaboration based on analysis of the power plant database of (GlobalData, 2017)

Indeed, the financing aspect of the transition to renewable power in India is a major challenge. Bloomberg New Energy Finance (BNEF) calculates that reaching India's renewables targets would require investment in the order of USD 150 billion between now and 2022, or about 1.1 % of GDP (3.5% of investment) on an annualized basis (BNEF, 2016; IMF, 2017). A number of factors make this particularly challenging, notably relatively high real interest rates. Part of this is due to sector-specific risk premium arising from technological uncertainty for example. But it is also due to the lack of supply of long-term investment capital, which hence drives up its price (i.e. the interest rate charged to borrowers). Several issues can be highlighted in this regard:

- *Health of the banking sector:* public banks in particular (70% of total banking assets) are saddled with a high share of non-performing or stressed loans, particularly to the infrastructure-related sectors. Stressed loans in the public banking sector reached 17.7% in 2015 (Mohan & Ray, 2017). Importantly, a major source of non-performing bank loans is the coal power sector, with analysts estimating that about 25% of bank lending to the thermal power sector consists of stressed loans (Sender, 2017). This issue will require careful management, as a number of the companies now diversifying strongly into renewables have significant portfolios of potentially stressed coal sector assets.

- *Underdevelopment of capital markets:* the majority of Indian savings go into bank deposits; sources of long-term savings, such as pension or insurance schemes are still in their infancy, representing respectively 0.3% and 3.3% of GDP respectively (Mohan & Ray, 2017). This acts as a constraint on the domestic supply of long-term savings, a critical source of capital to fund long-term investments. For example, funding investments in renewable energy, which have a typical tenor of over 20 years could reveal challenging.
- *Under-availability of international financing:* to ensure financial stability, the Government of India has charted a prudent course regarding the international opening of Indian financial markets. FDI inflows are almost completely liberalized, and represent a significant share of electricity sector investments at USD 10.5 billion in 2016, of which only USD 1.7 billion is for renewables (IBEF, 2017). International portfolio investment in equity and debt is still limited, representing 2% of GDP in 2016 (Mohan & Ray, 2017). Thus there is also a constraint on the availability of international long-term capital, be it public or private.

Thus the promotion of policies for 'greening finance' has been a major plank in the policy strategy of the Indian Government in promoting renewables. The renewables sector is among those that are subject to 'priority sector lending' standards on commercial banks, which requires them to lend 40% of their assets to these sectors (other sectors here are notably related to other social objectives, such as the financial inclusion of poorer segments of the population). The Securities and Exchange Board of India (SEBI), the capital market regulator, has developed a number of regulations aimed at increasing the availability of long-term capital to the renewables sector. These include new regulations governing Infrastructure Investment Trusts and green bonds, both of which are intended to increase the supply of long-term capital to the renewables sector (see BNEF, 2016 for further details). Discussions are also ongoing regarding currency hedging instruments, that would allow international investors to hedge the currency risk of investing in Indian renewables projects (Chawla, 2016). The above discussion highlights the importance of an adequate combination of policies, to create demand for investment in renewables with policies to ensure the supply of long-term investment capital. International collaboration could be particularly important in this regard, to increase the supply of investment to enable India to succeed in its ambitious goals for renewable energy.

4.2 The Global Coal Transition: Preparing the Social Response to Change

Since the industrial revolution, coal has played a crucial role in the global energy system. In 2015, coal accounted for 28% of global primary energy consumption, making it the second largest energy source after crude oil (Enerdata, 2017). Nonetheless, coal is also responsible for significant social and environmental damage, notably 45% of global CO2 emissions and is a key source of local air pollution. Scenarios that respect the objective of limiting warming to well below 2°C require a global drop in the consumption of coal of at least 2.5% to 3.7% per year between now and 2040, even in the case of a significant deployment of carbon capture and storage technology (CCS) (IEA and IRENA, 2017). Curbing coal is thus at the front line of a transition to low-carbon energy systems.

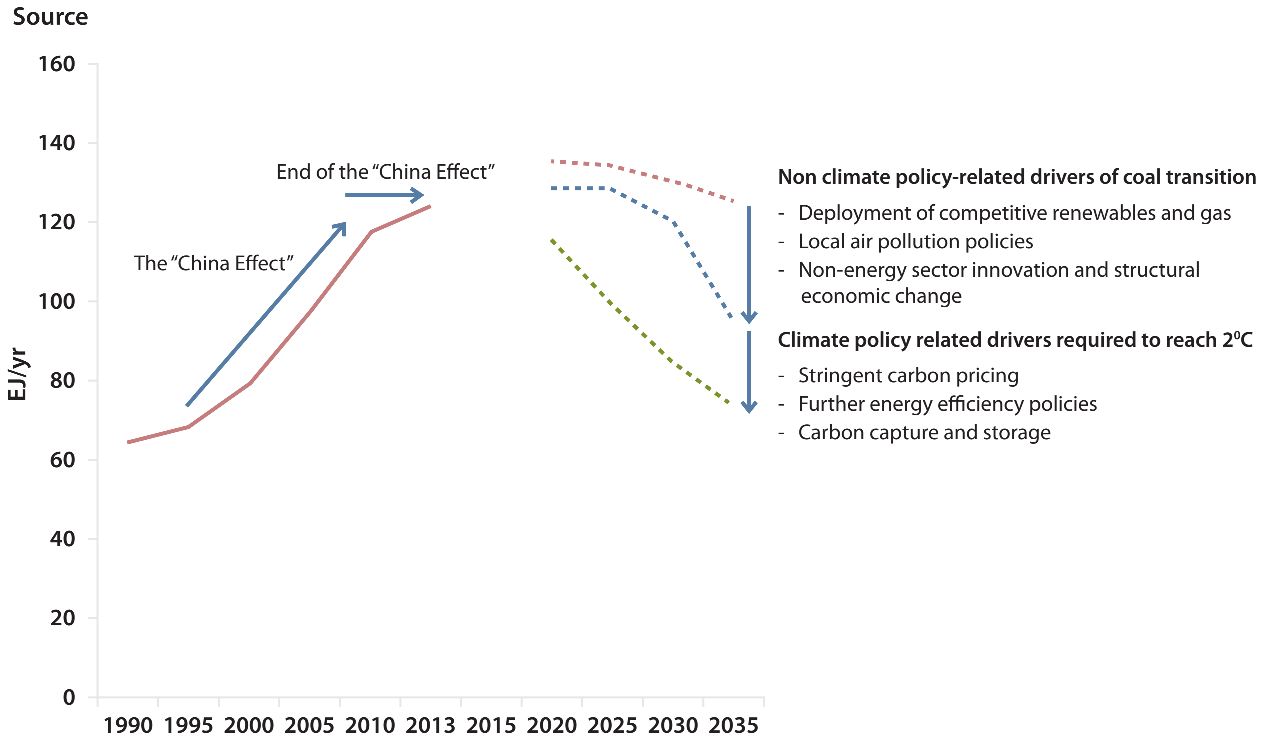
The world is currently already seeing the emergence of a transition away from coal, which further policies must now accelerate. Coal's share in the global primary energy mix has actually grown since the mid-1990s from around 23% to a peak of 29% in the late 2000s. This was due notably to the massive industrialization and urbanization process in China, which was largely fueled by coal. However, several factors make it possible to discern the emergence of a potential pathway to shift future economic development away from coal dependency. Since 2013, coal consumption in the G20 countries has fallen 1.2% per year, after growing at a rate of 4.4% over the preceding 12 years. While there remains a very significant pipeline of coal-fired power plants, there are signs of an accelerating trend towards the cancellation of these plants (Shearer, Ghio, Myllyvirta, Yu, & Nace, 2017). There are a number of reasons for this:

- *Economic and energy system restructuring in China:* the global coal 'renaissance' since the mid-1990s was driven by a series of non-replicable developments in China, namely double digit economic growth based on enormous (and not always economically efficient) investments in productive capital, infrastructure and real estate. The Chinese Government now realizes that this growth model has run its course, and envisages a restructuring of the economy towards a more service and consumption-based model. The impacts of this economic shift, which is only just beginning, can already be seen. Since 2013, coal demand has fallen in China for three consecutive years at a rate of 2.3% per year (Enerdata, 2017; NBS, 2017).

- *The fight against local air pollution:* in China and India particularly, coal combustion is a major cause of local air pollution, which in turn has become a first-order political and social issue. By itself, action to curb local air pollution, which is being demanded by domestic constituencies the world over, would reduce global coal demand by a rate of about 1% per year between now and 2030 (IEA, 2016).
- *Technology innovation:* as highlighted in the case study in section 4.1 above, the emergence of competitive renewable energy technologies is starting to open a real hole in the perceived dominance of coal as the 'cheapest, most scalable' electricity source. In addition non-energy sector innovations, such as robotics, artificial intelligence and new manufacturing techniques, could contribute to significant improvements in materials and the energy efficiency of economic activity which would further reduce coal demand for energy and for the production of materials, such as iron and steel.

For this reason, it is possible to envisage a scenario where a self-sustaining decline in global coal demand takes place, even in the absence of more stringent climate policies than are evident today. Figure 15 represents this dynamic, whereby a combination of economic change in China, local air-pollution policies in major coal using countries, and the adoption of economically competitive technology alternatives to coal, including energy efficiency, leads to a significant bending of the curve of global coal demand as early as, 2020. This by itself would not be sufficient to bring the global trajectory of coal use into line with 2°C objective (see Figure 15); further policies, such as carbon pricing are required to provide other options for moving away from a coal economy. It should be noted that the current pipeline of coal power projects, particularly in places like Turkey, China, and India, is sufficient to exceed the carbon budget of the well below 2°C objective. However, not all of these projects may come to fruition due to regulations, civil society opposition and in particular, pressure from competing technologies.

Figure 15 : coal futures, climate policy and non-climate policy related drivers of the transition away from coal



Source: own elaboration analysis based on historical data from (Enerdata, 2017); future projections from (MGI, 2017; IEA, 2016). N.B. scenarios in (MGI, 2017) have been adjusted downward for 2020 to reflect recent coal use data from China, see notably (NBS, 2017).

> "...we project that global demand for thermal coal could decline by 24 percent over the next 20 years ...In some places, such as India, coal demand is still likely to expand even in the face of high adoption of renewable power and subdued global GDP growth, although our analysis suggests that no new coal-fired plants are required in India over the next six years beyond those that already exist or are being built."
>
> ***McKinsey Global Institute***, *2017. See (MGI, 2017)*

The emergence of the coal sector transition, and the need to accelerate it still further, raises a number of important questions, in particular regarding policies needed to accompany the transition. Two particular challenges can be highlighted here: firstly, the need for proactive social policy to accompany the transition, notably for mining workers; secondly, the need for policy to address the issue of stranded assets in the coal sector. We deal with each in turn below.

Historically, a number of countries have achieved a significant transition away from coal. In the United Kingdom, a combination of policy, economic and social drivers since 1970 has driven a progressive shift away from coal, and towards natural gas and renewable energy. Coal dropped from 44% of the UK's energy mix in 1970 to just 17% in 2015. In absolute terms this represented a rate of decline of coal consumption of 2.9% per year, roughly what is needed at the global level to limit warming to 2°C. It is quite remarkable that the home of the industrial revolution, for so long powered by coal, has been able to succeed in shifting away from coal to such a degree. A combination of strong policies, such as a carbon floor price and support for renewables has been combined with socio-technical factors, resulting in favorable conditions for, firstly, natural gas in the 1990s and secondly, renewables since around 2010.[4]

However, this transition has not been without social consequences. Since 1970, domestic UK coal output has dropped by more than 97%, while coal sector employment has fallen from 290,000 jobs to 1,000 in 2016 (Forthergill, 2017 quoting BIES statistics). One should exercise caution when interpreting these statistics. Between 1960 and 2015, the labor productivity of UK coal mining grew by about 4.9% per year (much more rapidly during the Thatcherite reforms of the 1980s). This was the major driver of job losses. Import substitution has been a factor too, due to the higher competitiveness of international coal. But import substitution has not been a major driver of job losses; if all of the imported coal had instead been produced domestically, this would only have added around 6,000 jobs in 2015. Even if we assume that UK output had not fallen since 1990 but productivity had improved, UK coal sector employment would have still been only about 21,000, an order of magnitude below where it stood in 1980.

Coal is not a major employer at the aggregate level, even in emerging countries with large coal industries. Even in India, coal mining accounted for 358,500 jobs in 2012, out of a workforce of around 490 million – ca. 0.1% (MOSPI, 2016). Productivity improvements are moving faster than the demand reduction that would be required to limit warming to well below 2°C. For example, in India coal production productivity has grown by 7.2% per year from 2000 to 2012, and total coal sector employment fallen by 2% per year. Of course, a combination of productivity improvement and demand decline due to a loss of competitiveness of coal versus renewables would have a compound effect on employment. Thus, while not posing a challenge in terms of overall job losses, the transition away from coal may cause problems at the regional level, where production and hence jobs are concentrated.

The history of social policies to accompany regional transition away from coal is not particularly positive. Unemployment in traditional coal mining basins in developed countries like the US and UK is well above the national averages. We can identify three key ingredients for social policies to mitigate the impact of the coal transition (the "ABC"):

4 Given the current cost performance of renewables and nuclear, it is likely that renewables will be the preferred option for the continued shift away from coal.

- *Anticipation:* historical examples show that coal sector transition can proceed surprisingly quickly, both in terms of a fall in the competitiveness of coal and hence job losses. Likewise, historical examples show that transition strategies were mostly reactive rather than proactive (Forthergill, 2017). Major coal-using countries thus require the early implementation of long-term regional transition strategies to 2030 and beyond.
- *Balanced:* historical examples show that corporate production subsidies often took an unjustifiably large share of support packages, rather than investments in workers or regions.
- *Capability based:* resources for regional coal sector transition have often gone to explicit or implicit redundancy payments, rather than investing in human capital and regional development. The literature on structural adjustment shows that hidden benefits, such as disability payments often make up a large share of government assistance to affected regions, but ultimately do little to assuage social impacts (Autor, Dorn, & Hanson, 2016). Thus proactive policies to invest in human capital and restructure local economies should be a key ingredient of adjustment programs, rather than just compensating workers for leaving the labor force.

The transition away from coal also requires policy efforts to address the risk of stranded assets. In multiple markets, coal power is coming up against increasing competition from competitive gas and renewables. This is manifested in dramatically declining capacity utilization rates for coal power plants in many markets, such as the United States, United Kingdom, India and China. In the case of developed countries, such assets are already amortized. The greater concern is in emerging countries, where there is a risk of investing in coal capacity that is not ultimately economically competitive. For example, stranded assets in the coal power sector have been estimated at USD 320 billion under a well below 2°C mitigation scenario, *even if market actors and policy makers perfectly anticipate the shift to stringent policies* (IEA and IRENA, 2017). If the transition is poorly anticipated and abrupt, stranded assets could eventually be an order of magnitude higher. Importantly, behind these numbers is the real risk that the fight for declining market shares between coal and growing renewables leads to a battle between politics and the economy that blocks the rise of renewables.

Policy makers thus need to proactively manage the coal transition shift. Setting long-term signals for market actors is crucial to ensure against investment in ultimately non-economic coal power assets. Policies to guide investment should be put in place as well, such as emissions performance standards that some banks or countries have been starting to implement. Ultimately, the coal sector transition is on the horizon: policies are required for its acceleration, but also to make it socially and financially as non-disruptive as possible.

4.3 Electric and New Energy Vehicles in China: Industrial Transformation

China has decided to transition towards a low-carbon economy for reasons of climate change mitigation, but also due to domestic drivers, such as the fight against local air pollution and the need to transition the economy to new drivers of growth. To develop an innovation-driven economy, China has been promoting research and development (R&D) in new technologies and ideas. In 2016, total R&D expenditure reached CNY 1,544 billion (roughly USD 245 billion), representing 2.1% of China's total GDP and placing China alongside the ranks of leading developed countries. Seven strategic and emerging sectors were identified in 2010 as key enabling sectors of sustainable economic growth and as major beneficiaries of R&D investment, including new energy vehicles, in particular electric vehicles.[5] These sectors are now central to China's national strategy to transition from an economy based on low-end manufacturing to one based on innovation, high-end manufacturing and domestic services and consumption. This transition is existential for China: escaping the 'middle-income trap' relies on the transition to innovation-based development.

We can expect China to throw everything at this transition; in doing so, it could drive the emergence of cost-competitive, mass-market electric vehicles, which would transform the global vehicle market, and the oil markets, and as a consequence the financial markets.

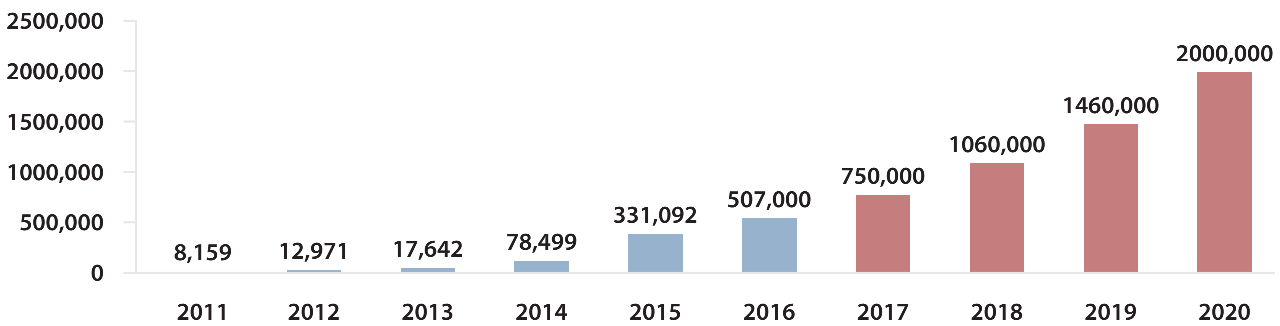
5 Other sectors include energy efficiency and environmental services, new energies, information technologies, high-end manufacturing, bio-technology and new materials.

There are several reasons why electric vehicles are a core part of China's industrial and transport sector strategies. First, the transition to a transport system based on electric mobility would help to ease the macro-economic burden of oil consumption. China's oil import dependency rate reached 60.6% in 2016; more than half of the total final oil consumption is driven by the transport sector. China's energy imports averaged 3% of GDP over the last 10 years, compared to a current account balance that currently stands at about 2.9% of GDP. Thus China's drive to maintain a manufacturing export surplus is the flipside of its need to generate foreign exchange to import raw materials, including oil. Second, a shift to electro-mobility contributes to reducing local air pollution: megacities have been continuously suffering severe air pollution problems in recent years. Third, electric vehicles are considered to be a driver for the industrial competitiveness of China's domestic automobile industries. As China's conventional vehicle industry is considered less competitive compared to global leaders, such as Germany, Japan and the US, electric vehicles are seen in China as an opportunity to catch up with global leading automobile companies in the coming years.

To promote the development of electric vehicles, the Energy Saving and New Energy Vehicle Development Plan (2012-2020)[6] published in 2012 has set several targets. First, the total cumulative purchase of battery electric vehicles (BEVs) and plug-in hybrid electric vehicle (PHEVs) should reach 500,000 by 2015, and second, total annual production capacity of BEVs and PHEVs should reach 2 million with total cumulative purchases at 5 million by 2020.

According to data[7] from the China Association of Automobile Manufacturers, in 2015 the total annual sale of electric vehicles reached 331,092. This marks a huge increase in sales in comparison to total annual sales of 78,499 (2014); 17,642 (2013); 12,971 (2012) and 8,159 (2011). Total cumulative sales in the period 2011 to 2015 of BEVs and PHEVs reached 447,183, i.e. 52,817 vehicles less than the target set for 2015. However, in 2016 total sales of BEVs and PHEVs reached to 507,000, representing a 53% annual growth rate.[8]

Figure 16 : Annual sale of new energy vehicle in China historic and projected, 2011-2020



Source: China Association of Automobile Manufacturers; Zheshang Securities Co. Ltd.

It is important to convey the scale of this growth and these targets. Reaching the target of 2 million electric vehicle sales in 2020 would mean that electric vehicles would reach, in the space of a few short years, a bit less than 10% of the market size of the world's largest and most dynamic vehicle market. All manufacturers will want to provide competitive electric vehicles to sell into this market. There are targets for electric vehicles to reach at least 30% of annual sales by 2030.

The fast development of electric vehicles in China is being driven by strong public policy. During the period 2009-2013, major policies were introduced at the State Council level, giving general guidelines and setting quantitative targets. Further supportive policies were still missing. As a result, total sales of electric vehicles remained low. From 2014, policies implemented by line ministries have been ramped up significantly and cover different dimensions concerning electric vehicle production and sale. Key ministries include the National Development and Reform Commission, the Ministry of Finance, the

6 In Chinese: http://www.gov.cn/zwgk/2012-07/09/content_2179032.htm

7 In Chinese: http://auto.sohu.com/20160112/n434339751.shtml

8 In Chinese: http://auto.china.com.cn/news/20170113/680169.shtml

Ministry of Industries and Information, the Ministry of Transportation as well as the National Energy Administration. Local governments have also been playing an increasing role in promoting electric vehicle sales. By now, several hundred policies in total (including guidelines, plans, standards, subsidies, etc.) have been implemented and most remain in force.

First, macro-level policies put the emphasis on the strategic importance of electric vehicles for socio-economic development, energy security as well as environmental protection and climate change. These policies provide sectoral development guidelines for electric vehicles that were included in the 12th Five Year Plan (2011-2015) through the Environmental Protection Plan and the Energy Development Plan, etc. In addition, there also exists obligatory requirements in public procurement that at least 30% of vehicles should be electric vehicles.

Second, sectoral standards and norms have been introduced to guide the effective development of the electric vehicle sector. Typical examples include the Management Rule for Market Entrance of New-Energy Vehicle Manufacturers and Products[9]), the Policy on Recycling of New Energy Vehicle Battery Technology[10], Sectoral Norms and Specifications for Battery-Powered Vehicles[11], etc.

Third, pilot projects have been launched to promote the use of new energy vehicles at the local city level. Lessons were then drawn and assessed to support better pilot projects in the future. The first pilot named 'Ten Cities - Thousand Vehicles' was introduced in 2009. By the end of 2012, the results of the first pilot projects were assessed, on the basis of which a new round of pilot projects were launched in 2013.

Fourth, pilot projects have notably provided a test ground to calibrate fiscal policies to define the right levels of subsidies. For conventional vehicles sold in China, several taxes are imposed, including consumption tax, value-added tax, custom tariffs (for imported vehicles and parts), vehicle purchase tax and vehicle tax. Electric vehicles receive tax reductions and exemptions (consumption tax, vehicle purchase tax and vehicle tax). Banks are also obligated by the central authorities to reduce the initial down payment required for bank loans for the purchase of new energy vehicles, demonstrating how policies for 'greening finance' can effectively be combined with more traditional climate policies like tax credits. For manufacturers of electric vehicles, a reduction of corporate income tax and value-added tax is also applied, which helps to reduce the factory price of electric vehicles.

Finally, a number of public budget lines have been allocated to promote the R&D activities of electric vehicles and the construction of associated infrastructure (the charging infrastructure in particular). For example, the Guidelines on Electric Vehicle Charging Infrastructure (2015-2020) were released to provide quantitative targets and roadmaps of related infrastructure construction and their prioritization. One example is that a minimum level for electric vehicle parking and charging stations in public car parks has been set at 10%. In August 2014, the National Development and Reform Commission of China (an influential ministry responsible for planning) released the Policy on Electricity Prices for New Energy Vehicles that established a preferential electricity tariff until 2020 that essentially means that electricity is free (at off-peak times) for charging electric vehicle batteries.

Beside central government support policies, local governments have also played an important role in promoting the development of electric vehicles. These policies differ among cities and provinces. A typical example is Shanghai's free license policy: In order to prevent traffic jams, Shanghai has introduced an auctioning mechanism for vehicle licenses, in which average bids reach up to USD 15,000, whereas newly purchased electric vehicles benefit from free car licenses in the city. Another example has been the use of public funds to create an electric car taxi service. In 2016 the Taiyuan City government established a taxi firm with 8,000 electric vehicles in the form of public tender[12] to replace old conventional taxi .

At the end of 2016 China's State Council released the Development Plan of Strategic and Emerging Sectors for the 13th Five Year Plan (2016-2020)[13], which set ambitious targets for electric vehicles. Firstly, annual

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9 新能源汽车生产企业及产品准入管理规则

10 电动汽车动力电池回收利用技术政策

11 汽车动力蓄电池行业规范条件

12 http://epaper.21jingji.com/html/2016-05/06/content_39508.htm

13 In Chinese: http://www.gov.cn/zhengce/content/2016-12/19/content_5150090.htm

production and sales by 2020 should be above 2 million vehicles and total cumulative production and sale quantities should be above 5 million vehicles. Second, the Plan calls for new energy vehicles to be totally commercialized by 2020 (implicitly indicating a future reduction or cancellation of subsidies - see section 3.3 above and notably Figure 8).

Domestic industrial competitiveness is a central issue for future new energy vehicle development. In May 2015 China's State Council released a guideline entitled 'China Manufacturing 2025'[14] which aims to guide a shift of China's manufacturing sectors towards a world leading position in terms of innovation, technology, digital development and environmental protection by 2025. Electric vehicles are clearly highlighted in this guideline with the objective of ensuring domestic R&D capacity and knowhow on key technological contents by 2025.

The Technology Innovation Plan of the 13th Five Year Plan (2016-2020)[15] released in July 2016 by the Ministry of Science and Technology clearly prioritized the development of electric vehicles. Such vehicles are included in this plan as an important element of building modern transportation technology and equipment in China. In comparison to BEVs, PHEVs are generally defined as a transitional solution while certain technologies such as battery life and duration are not totally mastered yet in China. So far China has not taken any official action in terms of plans or policies on the development of hydrogen fuel cell vehicles.

The rapid development of clean energy vehicles will no doubt reduce the impact of local environmental air pollution in megacities, such as Beijing and Shanghai. From a lifecycle perspective, clean energy vehicles may not necessarily result in a huge reduction in GHG emissions if electricity and intermediary inputs (steel, rubber, glass, etc.) are highly carbon-intensive. However, we can assume that this will be gradually addressed due to China's general willingness to commit to a low-carbon transition (which will involve an increasing share of renewable energy, higher energy efficiency and lower carbon intensity). From this perspective, the development of clean energy vehicles is certainly a good option and provides an example that combines the interest in domestic development with the desire to conquer new markets and the global need to fight against climate change.

4.4 Climate and Energy Policy in Argentina: Developing a Socially Acceptable Vision of Long-Term Transformation

Under the previous government, the Argentinian economy and energy sector were subject to significant distortions due to high energy subsidies, in particular for fossil fuels. Annual per capita energy subsidies were estimated at USD 326, or an aggregate 2.5% of GDP (Sovacool, 2017). In part, these subsidies were intended to incentivize the production of fossil fuel resources, through publicly funded support for exploration and development. On the other hand, subsidies held consumer prices of gas, electricity and oil products below market prices to buffer rampant inflation and lower costs for consumers. Needless to say, these two objectives were contradictory. The consequences of this subsidy policy were disastrous:

- From net energy exports of USD 5.5 billion in 2006, an energy import deficit opened up reaching USD 7.6 billion in 2014 (Enerdata, 2017).
- A ballooning budget deficit of 5.7% of GDP in 2016 (IMF, 2017). To put this in perspective, in 2014, when the budget deficit was about 4% of GDP, energy subsidies were 2.5% of GDP, implying that a significant share of the budget deficit was due to energy subsidies.
- Regressive social outcomes, as consumer subsidies were not targeted to the poorer communities (Hancevic, Cont, & Navajas, 2016).
- The energy market became increasingly dysfunctional. Argentina's power sector has been facing severe power shortages in recent years (an average 33 hours of loss of load in 2014 against 4 hours in 2003). Between 2000-2016, the electricity sector only added 700 MW annually of net new capacity on average, while electricity demand grew on average by 3.3% per year.

14 In Chinese: http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm

15 In Chinese: http://www.most.gov.cn/mostinfo/xinxifenlei/gjkjgh/201608/t20160810_127174.htm

After his election victory at the end of 2015, President Mauricio Macri promised to reduce energy subsidies in an effort to tackle the country's budget and trade deficits, and stimulate investment in the energy sector. Subsidies to crude oil producers fell by about 25-30% in 2016, and the domestic price of crude oil moved closer towards the international market price. The government also plans to gradually increase wellhead natural gas prices, which had been kept low.

The Macri government has also focused on promoting investment in electricity generation capacity, in order to overcome the shortages noted above. One of the main reasons for the crisis was that electricity and distribution tariffs had not been increased for a long time and thus investment in the privatized power production sector had been lacking (GlobalData, 2016). This led the government to revise distribution tariffs, and declare a state of emergency in the power sector until 2017. Interestingly, part of the solution has been to develop renewable capacity production in the country to take advantage of the abundant natural resources for renewables.

Argentina, originally lagging behind in renewable energy development, launched an ambitious plan under Law No. 27.191 to develop renewable energy production known as called RenovAr with the objective to reach 20% of power consumption from renewables in 2025 or 10 GW of production capacity. In 2016 a public fund was set up to support the deployment of renewable energy, which should be capitalized on an annual basis depending on how much money has been saved in the previous year through avoided fossil fuel consumption due to renewable energy.

Argentina has successfully completed the bidding process for 1,100 MW of renewable energy which was six times oversubscribed. These tenders delivered very low bids: the average price was USD 57.44 per MWh which compares with the levelized cost of electricity for new fossil fuel projects in Argentina of around USD 60-70 per MWh (see table 2). The total investment size for this bidding round was USD 1.5 to 2 billion. A crucial reason for the low bidding prices for the RenovAr program is the government's commitment to revising energy subsidies to provide a level playing field for renewable energies and a functioning energy market.

Table 2 : leverlized cost of electricity comparison, renewables portfolio versus new natural gas turbine

Parameter	Estimation	Source
	GAS TURBINE	
Investment cost	961 USD/kW	(GlobalData, 2017) database of power plant projects, own analysis
Capacity factor	45%	Current natural gas fleet average in Argentina
Fixed O+M	25 USD/kW-yr	Industry standard
Variable O+M	0.002 USD/kW	Industry standard
Thermal efficiency	60%	Turbine analysis
Fuel cost	6 USD/MMBtu (low) 8 USD/MMBtu (high)	Assumption
Results – levelized cost of electricity for a new gas plant	**59 USD/MWh (low) 70 USD/MWh (high)**	
	RENEWABLES PORTFOLIO	
Average bid price for round one of RenovAr renewables program	**57.44 USD**	

Source: own elaboration and stated sources

As a result of these clear policy signals, Argentina's renewables sector is on the cusp of a boom. About 5,600 MW of wind capacity are currently in the pipeline, compared to an installed capacity of just 279 MW in 2016 (Enerdata, 2017; GlobalData, 2017). In the solar sector, the project pipeline is about 3,400 MW, compared to an installed capacity of just 8 MW today. However, Argentina also has a significant pipeline of new natural gas power plants, at 5,400 MW based on presumed natural gas supplies from Vaca Muerta, which is one of the biggest unconventional natural gas fields in the world. Aside from renewable energy and natural gas, Argentina is also strengthening its partnership with China. Two dams are supposed to be built in collaboration with Chinese companies that will add 1750 MW, while facing strong opposition from civil society due to environmental reasons. Currently, this case has been brought to court and is still pending. In addition, two nuclear power plants are planned that would provide additional 1700 MW. This gas based supply capacity, the dams and nuclear energy could risk being underutilized if electricity demand does not grow sufficiently to absorb the new capacity installed. It is also a capacity with a potential risk being stranded, if for example natural gas prices become too high or renewables prove to be significantly cheaper (see the analysis in table 2). If used, on the other hand, such plants would lock in a significant level of future emissions.

This is why current piecemeal measures to reform subsidies and promote new renewable electricity generation capacity need to be combined with a comprehensive vision for the decarbonization of the energy sector. Such 'long-term low emissions development strategies' enable the examination of the consistency of short-term policy measures with the long-term decarbonization objectives required by the Paris Agreement. The formulation of these plans also provides a crucial opportunity to engage with civil society in order to develop and structure a shared vision for the future of socio-economic policy.

In this regard, the Argentinian government has implemented a number of new governance instruments that could help to produce a socially acceptable, long-term transformation vision for Argentina's energy system. In March 2016, the government institutionalized the National Cabinet of Climate Change, grouping 12 ministries to share their resources on cross-sectoral issues. It includes the formal participation of local provincial governments through a consultative body on environmental issues called COFEMA (established in 1994) and other stakeholders through the Extended Roundtable of the National Cabinet of Climate Change. This includes NGOs, cities, unions, private companies, and the academic and scientific community. Their first task has been a revision of the Nationally Determined Contribution under the Paris Agreement, which was presented at COP 22 and on the basis of which the Extended Roundtable is starting to build the sectorial roadmaps for the implementation of the new NDC.

Regarding long-term scenarios of low carbon transition, the Energy Ministry has taken the lead and produced 4 scenarios for 2025. In line with the shorter time horizon of these scenarios, they are not transformational pathways towards a low-emissions energy sector for Argentina. Nevertheless, in early 2017 the Energy Ministry also signed an agreement with the Energy Scenario Platform to collaborate and propose long-term energy scenarios to 2050, which will contribute to fulfilling the Paris Agreement's provision to submit long-term transformation strategies for each country.

The Energy Scenarios Platform is a multi-stakeholder partnership with a strong leadership of civil society (FARN, Fundación Vida Silvestre, CEARE-UBA, ITBA and Fundación Avina among others) that has been working towards a long-term sustainable energy vision for Argentina since 2012. In 2015, these stakeholders produced a summary of a large variety of scenarios for 2035 in the context of the last presidential campaign (Platforma Escenarios Energeticos, 2015). When the new Minister assumed his position, he created the new "Sub secretary of Energy Scenarios and Project Evaluation" in recognition of the work done by the Energy Scenarios Platform. Now there is an opportunity for government, civil society and private sector to build on their previous experience and contribute to one of the key outcomes of the Paris Agreement, namely the development of a long-term transformational blueprint for the energy system.

Civil society and foundations in particular play a key role in providing platforms for building a social consensus around climate and development policy. In this vein, the following lessons can be learnt from other countries' efforts to develop long-term transformation pathways that can form the blueprint for future climate policies (Waisman, Spencer, & Colombier, 2016):

- *Long-term:* such energy system scenarios should be sufficiently long term, to allow for the assessment of short-term policy objectives in the light of long-term policy objectives. The inertia of energy sector infrastructure and the stringency of the long-term well below 2°C objective for each country means that the right choices need to be taken today in order to avoid lock-in into high emitting infrastructure and technologies. Long-term plans can provide an assessment framework to insure this coherence.
- *Transparency:* long-term transformation pathways should be transparent in their assumptions and results. This means, firstly, that the pathways should present the drivers of emissions trajectories, rather than just the emissions outcomes. Drivers include GDP and population assumptions, as well as their impact on sectoral emissions drivers, such as industrial production trends in household energy demand, etc. Other drivers include technology innovation pathways. The most important role that transparency can play is to enable social debate and consensus-building around the pathway, as well as reveal the trade-offs and co-benefits of decarbonization.
- *Social dialogue:* the depth of the transformation required to address climate change means that social acceptability and buy-in is crucial. As matter of fact, the organization of a structured social debate around transparent long-term pathways has proven crucial to build consensus in countries that have developed or are currently developing long-term decarbonization pathways. (Argyriou, et al., 2016). For example, in France the Hollande government conducted a year-long process of consultation and debate within an institutional setting (the National Debate on Energy Transition), which produced a set of consensual mid-term and long-term objectives for French energy policy. These objectives were ultimately codified in legislation under the National Law on Energy Transition and Green Growth. Canada is another example where a process of social consultation structured around a long-term transformation pathway fed into the commitment by the Alberta state government to diversify the economy away from fossil fuels, to implement a general carbon tax and a cap and trade system for large emitters, and also to adopt regulations for the decarbonization of electricity.
- *Institutionalization:* the production of long-term transformation pathways, their use in policy making and ex post assessment can be supported through the creation of specific institutions within the policy making process. France, the UK, and Germany have all created independent committees charged with social consultation, policy analysis and assessment in order to support the policy-making of legislative and executive branches. In all three instances, these institutions have been crucial in ensuring that governments stick to policy commitments.

Argentina has thus started an impressive and important process of energy sector reform, which has put renewables at the heart of a strategy to meet electricity demand and improve economic outcomes. The strategy has already borne fruit, in terms of the very competitive and cost-effective bids received for the first round of renewable energy projects. However, this reform process needs to be complemented with a longer-term and comprehensive vision of energy sector transformation in line with the well below 2°C objective. In this regard, the development of long-term transformation pathways can be a crucial framework for policy assessment, and social engagement with diverse stakeholders in order to build consensus. There is much that can be learnt from previous international experience in this regard. Fortunately, a process of long-term pathway development has already been launched under the auspices of the Energy Scenario Platform. This is a good example of how a long-term engagement of civil society in building such spaces for social dialogue on policy and development choices can ultimately provide an important support to policy.

5 Conclusions and Recommendations for Foundations and the G20

5.1 Foundations Need to Take into Account this Fundamentally New Context

This report argues that climate change and the necessary energy transition presents policy makers, investors and civil society with a fundamentally new context. The energy transition is underway, and will have fundamental implications for each of these stakeholders. At the same time, the social and political context for the required domestic policies and international cooperation is increasingly difficult. Within many countries, slower economic growth, job creation, and rising inequality have led to social tensions. At the international level, governance is fragile and questioned by some who see the solution to the above-mentioned social and economic tensions as a retreat from international cooperation. Both of these domestic and international trends risk creating a more difficult context for climate policy, which will itself require rapid and potentially disruptive change, despite its overall benefits.

It therefore follows that foundations need to consider the importance of climate change and the energy transition in their work. In many respects, foundations are unique stakeholders in this context. Firstly, on the asset side their capital under management risks being affected by the disruption of financial markets in the case of a poorly anticipated and managed energy transition (see section 2.2). Secondly, their position as (ideally) disinterested stakeholders means they can have the capacity to act as a bridge between different societal groups and stakeholders, including the public sector, private sector, and civil society (Anheier & Leat, 2006). This role of fostering social dialogue and consensus building is even more important in the current climate policy context. The necessary speed and scale of change means that stakeholder buy-in is essential for success, while the context of social tension around trends of inequality, economic disruption, and the fragmentation and fractiousness of public discourse make obtaining this social buy-in all the more difficult.

Thirdly, foundations may have a greater scope for innovation and experimentation than the public and private sectors. The development of new initiatives on public policy or social engagement with the issue of climate change is crucial. Fourthly, although foundations cannot match the financial clout of either the private or public sectors, they are a key source of financial resources for civil society, allowing it to perform its role of promoting transparency, accountability and advocacy. This is particularly crucial in the current context of fragmentary and weak governance of climate change and notably of the financial sector in relation to climate change (Anheier, 2013). Here civil society, supported by the strategic investments of foundations, must strengthen the transnational civil society infrastructure to “fill the governance void” that continues to exist in climate change, despite the significant advances of the Paris Agreement.

For these reasons, this report argues that foundations worldwide have a crucial role to play on climate policy. It makes four recommendations, based on the rationales outlined above:

- **Play the role of ‘bridge’ between the public sector, the private sector, and civil society:** The climate change strategies of foundations need to strengthen this aspect of creating long-term spaces for social dialogue and consensus building on the difficult aspects of climate policy and energy transition. Foundations can and should be part of the solution.
- **Increase global coordination around addressing climate change and sustainability:** Some foundations specialized in the field of climate change and sustainability participate in mechanisms to coordinate their work. In an era where private philanthropy is an increasingly important partner to the public provision of international and domestic public goods, it is important that goal setting is transparent, consultative and coordinated. Existing coordination mechanisms between foundations working on climate change should be expanded to increase their geographic scope, notably concerning foundations outside the OECD countries and those foundations working in areas outside of the field of climate change and sustainability but related to it..
- **Mainstream climate change as a core objective in the strategies of foundations:** Climate change is such a vast issue that even foundations working outside the direct field should consider in what way climate change impacts on their work and how their social investments can contribute to addressing climate change.
- **Foundations should take into account climate change in how they invest their capital:** Some foundations contribute to the global divestment movement. Foundation capital can be invested where it is most effective and complementary to other sources of climate finance, pushing into new frontiers of climate and energy policy. These areas include: policies to manage the decline of fossil fuels rather than just promote renewable energy; policies and tools to support grid integration of renewables in developing and emerging countries; policies and tools to support industrial decarbonization and policies to promote the electrification of fossil fuel consuming sectors such as transport.

5.2 Recommendations for the G20

The G20 occupies a unique position at the apex of the global financial and economic governance system, guiding decision-making on economic governance issues where national action cannot solve collective problems. Major international institutions like the International Monetary Fund, the Financial Stability Board, the Basel Committee on Banking Supervision, and the International Organization of Securities Commissions report directly to the G20 (Spencer & Hipwell, 2013). With the acute phase of the crisis passed and national differences on a variety of subjects increasing, the effectiveness of the G20 has clearly declined. Now the G20 needs to adopt a new decisive role to pilot the transition to sustainable development. Given its position in the financial governance system, the G20 has a role in coordinating the financial system response to the challenge of climate change (see section 2.2). This report makes four recommendations for the G20:

- **Establish a core G20 mandate to better integrate the issues of climate protection and sustainability for which the principles and objectives of the Paris Agreement and SDGs provide the key international frame of reference.** The G20 Leaders' Group was created in the midst of the Global Financial Crisis of 2008. The 2009 Pittsburg summit set out the core mandate of the G20 - its constitutional objective so to speak- in the "G20 Framework for Strong, Sustainable, and Balanced Growth". This document sets out joint and individual responsibilities for the health of the world economy and a number of fundamental objectives for economic policy and a process for the adoption of the mutual review of policy commitments. With the acute phase of the crisis now passed, the G20 should revise its core mandate in coming years to better integrate issues of climate change and environmental sustainability, as set out in the Paris Agreement and the Sustainable Development Goals (SDGs). This should not detract from the existing objectives of financial stability and economic governance, given the importance of effectively addressing climate change for a stable financial and economic system (see Section 2.2 in this report). The coherence of G20 action on climate change and sustainability should be improved, including by ensuring that climate change is integrated into ongoing work on infrastructure investment, fiscal policy, and labor market and structural policies. Too often, such work in G20 working groups and communiques is undertaken without reference to climate change and sustainability, despite their relevance to the rest of the G20's work-program.
- **Implement the Paris Agreement through domestic policies and further G20 action:** The Paris Agreement and the SDGs provides a fundamental new pillar in the architecture of international cooperation. G20 countries should implement their engagements (NDCs) adopted under the Paris Agreement, and engage with negotiations under the UNFCCC to develop an effective and dynamic 'rule-book' for the Paris Agreement. G20 countries should develop transparent national low-greenhouse gas development strategies as per the Paris Agreement. The development of such strategies should be undertaken with civil society engagement, as a tool to develop a shared vision for long-term development and energy policy (see section 4.4). Credible and robust implementation of the Paris Agreement can strengthen signals to the private sector, enable innovation, long-term investment and hence job creation (see notably B20, 2017). Importantly, the G20 could deploy the existing G20 Mutual Assessment Framework and the competence of institutions reporting to the G20, such as the IMF and IEA, to better monitor climate and sustainability policy engagements (such as NDCs), including regarding energy policies and policies for greening finance. Such approaches would not undermine the UNFCCC transparency framework, but would complement it in an area where the G20 and its associated organizations have a particular competence.
- **Strengthen policy frameworks for 'greening finance':** The shift of investments from emitting to non-emitting sectors is the core challenge of climate mitigation, and aligns well with the competence of the G20 in financial and economic matters. The G20 should continue the work of the Green Finance study group and over time strengthen its operational outputs. The G20 should monitor progress in the implementation of the recommendations of the Financial Stability Board's Task Force for Climate-Related Risk Disclosure, it should map and ensure the sharing of best practice domestic policies for greening finance, and support the market development for

green finance notably through improved standardization and monitoring, and also promote the use of climate friendly fiscal policies such as carbon pricing and fossil fuel subsidy removal, etc. (T20, 2017). As mentioned above, the G20 has existing monitoring tools that could be fine-tuned to progressively include such policy engagements by G20 member states.

- **Strengthen the global transition to renewable and affordable energy:** The G20 should set out a high-level long-term vision for the global energy transition, in order to provide guidance to policy-makers and the private sector. This vision should entail renewables taking a dominant share in power generation by the 2030s, based on recent cost reductions. Secondly, renewable electricity should become the primary energy source in fossil fuel intensive sectors that can be electrified given the cost reductions seen in battery technologies. Such a long-term vision can be competitive in terms of cost with a fossil fuel based system (ETC, 2017). To this end, G20 engagements on the deployment of renewable energy, energy efficiency and investment in energy innovation should be strengthened. Monitoring mechanisms could be set up in conjunction with existing reviews by the IEA and scientific experts to inform and support the work of the G20 (T20, 2017b). Together with institutions such as the ILO and OECD, the G20 could study policies to ensure the energy transition is conducted in such a way as to minimize social dislocation for workers.

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