1. Introduction and Main Insights from the Study

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With the adoption of the Paris Climate Agreement and the Sustainable Development Goals (SDGs) in 2015, the international community has set itself very ambitious goals for shaping the future global energy system. Limiting global warming to well below two degrees Celsius will not be achievable without a fundamental transformation in how energy is produced and consumed. There is an urgent need to immediately curtail and then phase-out the global use of fossil fuels, which still account for more than 80 percent of the world's total primary energy demand (IEA, 2015). At the same time, the international community must ensure universal access to affordable, reliable, sustainable and modern energy by 2030 (SDG7). This remains a paramount challenge in a world where more than one billion people have no access to electricity and almost three billion rely on traditional biomass for cooking and heating (SE4All, 2016).

In the much-needed global transition to sustainable[4] energy, the G20, a group of major industrialised and emerging economies, plays an important role. It comprises major energy producers and consumers as well as key players in international institutions. The G20 countries account for 80 percent of the world's total primary energy consumption (G20, 2015) and 82 percent of global energy-related CO_2 emissions.[5] As a high-level political forum, the G20 can be a powerful agenda-setter and exert leadership in global energy governance. Moreover, the decisions and actions of G20 countries have the capacity to significantly impact global energy systems. The G20 energy agenda has evolved in recent years. The task of the German presidency in 2017 and of its successors is to seize the momentum of the Paris Agreement and the SDGs to foster G20 action towards a sustainable, decarbonised global energy system. This will be a challenging undertaking, as G20 members are highly heterogeneous, often with divergent interests in energy-related issues.

This IASS study analyses the G20's potential for advancing a global transition to sustainable energy. It comprises short studies on the energy trends and the domestic and international policy priorities of 13 G20 countries (Argentina, Brazil, China, France, Germany, India, Indonesia, Japan, Russia, Saudi Arabia, South Africa, Turkey and the United States) plus the EU.

The cases were selected to represent the heterogeneity of the G20: they include industrialised and emerging countries, renewable energy frontrunners and major fossil fuel producers, major donors to international energy cooperation and countries with prevailing energy poverty. The country studies help identify both potential conflicts of interest and existing common ground within the G20. Each offers an assessment of potential impulses originating from the respective country, which could provide major additional value for international cooperation towards a global energy transition.

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[4] We regard energy supply as sustainable if it complies with the SDGs and the Paris Agreement. The country chapters, however, show that there is no general agreement among the G20 countries about what sources constitute sustainable energy.

[5] Own calculation, based on the International Energy Statistics of the U.S. Energy Information Administration.

GUIDING QUESTIONS FOR THE COUNTRY STUDIES:

1) What energy transformations are under way in the G20 countries?

- What are the key overall trends and challenges in the countries' energy systems?
- What are the major trends with regard to renewable energy expansion and improvements in energy efficiency?
- What are key drivers and/or barriers to decarbonising the countries' energy sectors?

2) How are the G20 countries engaging in international energy cooperation and policies?

- What are the major overall priorities and strategies?
- How do the international activities contribute to decarbonising the global energy system?

3) What impulses from individual G20 countries might be relevant for a global transition towards sustainable energy?

All of the G20 members covered in this study remain highly dependent on fossil fuels. Final energy consumption in all members is strongly reliant on oil, particularly within the transport sector. Coal plays a major role in the electricity supply of countries like China, India, Indonesia, Germany, South Africa and the US. Gas is a key energy source in the final energy consumption of most of the countries, with shale gas being promoted in countries like Argentina and the US.[6] Countries such as Indonesia, Saudi Arabia and South Africa are important exporters of oil or coal. Moreover, fossil fuels play an important role in the international energy policies of most countries.

Despite their dependence on emission-intensive fossil fuels, all G20 members covered in this study have adopted the Paris Agreement. Even the petro-state Saudi Arabia no longer maintains its opposition to international climate protection efforts. Moreover, a growing number of countries now address climate protection in their international energy policies.

Renewable energies are on the rise in all G20 members assessed in this study. They all have renewable energy targets and policies in place and have experienced growth in renewable energy capacities over the last ten years, albeit from very different baselines (IRENA, 2016). In line with global trends, the expansion of renewables is concentrated in the electricity sector. In all countries except for Germany and Saudi Arabia, hydropower makes up the largest share of renewable power capacities.[7] However, non-hydro renewable electricity sources, in particular wind and solar energy, have rapidly increased their shares in a number of countries. Germany has the largest share of non-hydro renewable energy in its electricity mix, which accounts for more than 26 percent of power generation, while China has the largest total installed capacity at almost 200 GW (REN21, 2016). In Russia and Saudi Arabia, on the other hand, the use of non-hydro renewables remains embryonic. In Brazil, electricity supply has long been based on hydropower, and biofuels represent a significant share of the energy consumption in the transport sector. Brazil's longstanding support for ethanol as an alternative transport fuel has made it a world leader in this field.

[6] Own calculation, based on IEA country statistics for 2013.

[7] Own calculation, based on IEA country statistics for 2013.

The promotion of renewables is also a longstanding focus of international energy policies among front-runners such as Brazil and Germany. Corresponding to their domestic energy developments, Brazil is a major international proponent of biofuels, while Germany strongly supports the development of wind and solar energy. With the rise of renewables around the world, support for their development is also gaining importance among other countries, including France and the US.

It is important to note that the expansion of renewables implies a reduction of fossil fuels only in saturated energy markets with stable or even declining energy demand. However, the emerging economies among the G20 members are all confronted with strongly rising energy demand. Countries such as India and Indonesia face the additional challenge of suppressed energy demand, due to unstable supply, energy poverty and the widespread use of traditional biomass with significant negative impacts on human health and ecosystems. In these markets, not only renewables but also fossil fuels are on the rise. To assess whether these countries are gradually moving towards a more sustainable energy system, it is important to compare absolute growth in renewables and fossil fuels. In China, for instance, capacity additions in renewables have outpaced those in fossil and nuclear energy in recent years.

Most of the case study countries have vast potential for improving energy efficiency. While all countries have committed to improve energy efficiency within the G20, advances on the ground have been much more limited than those in the area of renewables. Here, the experience of the EU is symptomatic: though on track to meet its renewable energy targets, the EU is lagging behind on energy efficiency. Due to budgetary constraints, Russia has even downsized its energy efficiency efforts. Important progress has been made by China and India, in increasing energy efficiency within the industrial sector, albeit from a relatively low base. While China has mainly relied on top-down command-and-control measures, India's Perform Achieve and Trade scheme represents an innovative policy model based on tradeable energy efficiency certificates. Japan, a longstanding leader in energy efficiency, has legislation in place to enforce demand management, and relies on its Top Runner programme to encourage manufacturers to develop technologies with the best efficiency performance. The phase-out of fossil fuel subsidies, an important focus of G20 efforts, has also seen the first signs of progress in recent years. In an effort to reduce fiscal pressures, Indonesia utilised the window of opportunity afforded by low global oil prices to eliminate subsidies on gasoline and drastically reduce diesel subsidies. Saudi Arabia, under pressure to increase its revenues from oil exports, has introduced a carefully crafted reform of energy prices, which aims to increase prices mainly for large consumers.

Nuclear energy remains a dividing topic between the countries covered in this study. Historically, Germany has been strongly reliant on nuclear energy but is now phasing out its capacities by the year 2022. France – the country with the world's highest nuclear share in electricity generation – aims to reduce the nuclear share from 75 to 50 percent. In Japan, the Fukushima disaster of 2011 has weakened public support for nuclear energy. The majority of nuclear plants remain closed, due to more stringent safety regulations. Although the Japanese Government remains committed to nuclear energy, it has abandoned its previous plans to further increase nuclear power over the coming decades. Instead, it now aims to limit its share to 20–22 percent of electricity generation by 2030. Despite increasing public opposition to nuclear power in many countries, Argentina, China, Russia, Saudi Arabia, South Africa and Turkey are all aiming to expand their nuclear capacities. However, in the field of nuclear energy the mismatch between targets and actual implementation is particularly pronounced. Nuclear energy is furthermore an important pillar in the international energy policies of nuclear powers such as France and Russia.

While the expansion of renewable energies and improvements in energy efficiency are key pillars of a decarbonised global energy supply, the progress in most of the study countries is not driven primarily by concerns about climate change. In France and Germany, reducing the use of nuclear energy represents a central driver of renewable energy expansion. In Germany, this has been coupled with aspirations to gain a leadership position in an emerging renewable industry, a goal shared by countries such as China and the US. In a number of countries, promoting

renewables is a strategy for meeting rising energy demand while simultaneously diversifying the energy mix. In Argentina, for instance, investments in renewables are accompanied by support for an emerging shale gas industry. Resource availability and low costs have long been a central reason behind the utilisation of hydropower. Falling costs have also driven the development of solar and wind power. In Brazil, for instance, wind energy has outcompeted fossil-based generation in a number of its power auctions. Local environmental benefits – primarily air quality, but also water security – represent additional drivers in countries such as China and India.

To accelerate the promotion of sustainable energy, several barriers still need to be tackled. Overcoming path dependencies and vested interests in fossil and nuclear energy remains challenging in all countries. In Turkey, for instance, energy security concerns are driving increased investment in domestic coal resources. In the field of nuclear energy, geopolitical ambitions often trump the unresolved issues of nuclear safety and waste treatment. Infrastructure challenges hinder the expansion of renewables in several countries. Even in a frontrunner country like China, the grid operator has been slow to adopt the measures needed to effectively integrate wind and solar power into the electricity system. In the transport sector, progress has been even slower. Notably, Germany, an international frontrunner in renewable power generation, has taken a very reluctant stance towards increasing the fuel efficiency of German-made cars.

Concerted action by G20 countries can offer an important boost to building a sustainable, low-carbon energy system. First steps have already been taken since the launch of the G20's energy agenda in 2009. The G20 has established work streams on some of the most pressing issues for a transition to sustainable energy: renewable energy, energy efficiency, phasing-out of fossil fuel subsidies and access to energy. These are all central steps towards the implementation of the SDGs and the Paris Agreement. Yet, even in the dynamic field of renewable power generation, observed progress only represents a first step towards the establishment of a sustainable, low-carbon energy system. It is, therefore, essential that the G20 deepens its engagement in all the mentioned areas. Strengthening the links to global climate mitigation efforts and embedding sustainable energy into the G20's core track on finance and economic policy could provide additional impetus – not only for a strong G20 energy agenda under the German presidency in 2017, but also for subsequent presidencies in the years to come (see also Roehrkasten et al., 2016).[8]

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