4. Brazil: Long Tradition of Renewables-Based Energy Supply and Ethanol Diplomacy

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The Brazilian energy sector has one of the highest renewables shares and remains one of the least carbon-intensive in the world. Electricity supply has long been based on hydropower. In recent years, significant gas, bioenergy and wind capacities have been added. Brazil has been a global pioneer in transforming the transport sector, replacing oil with sugarcane ethanol since the 1970s. Today, almost all new motor vehicles allow for any mixture of gasoline and ethanol. In its international energy policy, renewables – particularly bioenergy – play a key role. With the recent discoveries of deep-water oil reserves, Brazil furthermore aspires to become an international leader in the exploration of deep-water oil and gas.

Brazil is richly endowed with energy resources. It is the eighth-largest energy consumer in the world and the ninth-largest liquid fuel producer. Domestic oil and gas production increased significantly since 2006 when large reserves, primarily of oil but also of gas, were discovered in the deep pre-salt layers on the Brazilian shore. In 2014, Brazil produced 2.2 million barrels/day crude oil and 1.13 trillion cubic feet of natural gas (EIA, 2015).[2] Brazil is the second-largest biofuels producer after the US (REN21, 2016). Due to its vast hydric resources, hydropower has been the dominant electricity source in the country. Brazil has faced strongly increasing domestic energy demand. Primary energy demand doubled between 1990 and 2012 and is expected to increase by a further 80 percent by 2035 (IEA, 2013). The Brazilian population has almost universal access to electricity; however, five percent of the population relies on traditional biomass for cooking (REN21, 2016).

The ongoing economic recession, political crisis and corruption scandals also pose challenges to the Brazilian energy sector, as they hinder public and private investment. Since 2014, the Brazilian economy has been in recession. In 2016, President Dilma Rousseff was replaced following an impeachment process. The state-controlled oil company, Petrobras, has been at the heart of corruption scandals and is under investigation for bribery in Brazil and the US. It therefore has very limited access to international capital (EIA, 2015). Overall, government spending faces severe budgetary constraints.

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[2] Brazil has become a net exporter of crude oil but still remains a net importer of processed oil products. Gas production is for internal use only (IEA, 2016).

The Brazilian energy sector: high renewables-share and low carbon-intensity

Brazil has one of the highest global shares of renewables in its energy matrix, and its energy sector remains one of the least carbon-intensive in the world. In 2015, renewables accounted for 41.2 percent of the country's final energy supply (EPE, 2016). In its intended nationally determined contribution (INDC) to the Paris Agreement (Federative Republic of Brazil, 2015), the Brazilian Government underlines that the Brazilian renewables share is three times the world average and more than four times the OECD average, so that Brazil already qualifies as a low-carbon economy. The high renewables share is not only due to the dominance of hydropower in electricity generation but also due to the widespread use of bioenergy. Brazil has the highest global share of biofuels in road transport: ethanol admixtures varied from 47 to 90 percent between 2008 and 2014 (USDA Foreign Agricultural Service, 2014). In the electricity mix, renewables contributed 75.5 percent in 2015 (EPE, 2016). In the past, the energy sector has played a relatively small role in national greenhouse gas emissions, which have been dominated by land use change and the agricultural sector. With major improvements to slow deforestation over the last decade, Brazil's CO_2 emissions declined significantly from 2000 to 2010 (MSTI, 2016). In future, the energy sector is projected to become a more important source of emissions growth, as emissions from deforestation and land use change are projected to decrease further, whereas oil and gas consumption in Brazil are growing (IEA, 2013). Therefore, in the Brazilian case, the challenge is to maintain the low-carbon intensity of its energy sector rather than to decarbonise a highly polluting energy supply. In its INDC, Brazil commits to an economy-wide reduction of greenhouse gases of 43 percent by 2030, compared to 2005 levels. In the annex to the INDC, it specifies energy-related goals by 2030: 18 percent share of sustainable biofuels in the energy mix, 45 percent renewable energy share in the energy mix (with 28–33% for non-hydro renewables), 75 percent renewables share in the electricity mix (23% for non-hydro renewables) and 10 percent efficiency gains in the power sector. This implies that Brazil aims to maintain its high renewables shares by expanding the deployment of non-hydro renewables.

Hydropower remains the dominant electricity source in Brazil, albeit with declining shares. In 2015, hydropower accounted for 64 percent of electricity production (EPE, 2016), and Brazil had the second-largest hydropower generation after China (REN21, 2016). While hydropower generates electricity at a relatively low cost, the strong reliance on hydropower has increasingly become an energy security risk as Brazil has been hit by severe droughts. The worst impact was felt during the drought of 2001/2002, when the Brazilian Government had to impose a monthly ceiling for all residential, industrial and commercial consumers at 80 percent of their previous year's consumption (IEA, 2013). During the drought of 2015, the government also had to order rolling power cuts. In addition, it is increasingly difficult to exploit the country's remaining hydropower potential, which is concentrated in the Amazon region. New hydropower plants have to meet strong environmental standards; the building of large dams is subject to strong public resistance; and the Amazon region is far from the main demand centres, leading to high transmission and distribution losses[3]

To reduce its dependency on hydropower, Brazil has been striving to diversify its electricity supply, expanding both fossil energy and non-hydro renewables. In 2005, the government implemented a system of contract auctions to steer the evolution of the power mix. Since 2007, some of the auctions were only for new renewables (IRENA, 2015). The auctions led to a significant increase of thermal power generation, particularly gas. However, they also proved successful for building up bioenergy and wind capacities. Bioenergy capacities more than doubled, from 6.287 MW in 2006 to 13.422 MW in 2015, while wind capacity experienced an almost 40-fold increase, from 237 MW in 2006 to 8 715 MW in 2015. Progress on solar capacities has been more limited, reaching only 21 MW in 2015 (IRENA, 2016b).[4] The auctions led to an impressive price development for wind

[3] Despite these constraints, Brazil had the second-largest hydropower capacity additions in 2015 (REN21, 2016).

[4] Within South America as a whole, Brazil accounted for 87% of installed bioenergy and 79% of installed wind capacities in 2015, whereas installed solar capacity represented less than 2%.

energy, which is now the most cost-effective option for new grid-based power in Brazil (REN21, 2016). In 2015, natural gas provided 12.9 percent of electricity generation. As such, it was the second-largest electricity source after hydropower, followed by bioenergy[5] (8%), oil (4.8%), coal (4.5%), wind (3.5%), nuclear[6] (2.4%) and solar PV (0.01%) (EPE, 2016). In 2015, Brazil had the fourth-largest wind power capacity additions and biopower generation in the world (REN21, 2016).

Brazil has been a global pioneer in transforming the transport sector. As far back as 1975, Brazil introduced a comprehensive programme, called Proálcool, to replace oil with ethanol from sugarcane. A major aim of this programme was to reduce Brazilian dependency on oil imports after the 1973 oil price shock. In addition, it was seen as a suitable measure to support the Brazilian sugarcane industry. Proálcool introduced anhydrous ethanol for blending with gasoline and incentivised the production of cars that could run on pure ethanol. The country's broad coverage of filling stations providing pure ethanol is a legacy of that programme. With the market introduction of flex-fuel cars in 2003, the Brazilian ethanol market received an additional boost. Flex-fuel cars run with any mixture of gasoline and ethanol, and enable consumers to choose flexibly between pure ethanol and gasoline containing an obligatory ethanol blend of 27 percent. Today, 95 percent of all new motor vehicles in Brazil can run on any mix of petrol and ethanol (USDA Foreign Agricultural Service, 2014). However, ethanol has not competed on an equal basis with gasoline on the Brazilian market, as oil prices are government-controlled and kept artificially low in order to curtail inflation. Brazilian ethanol production hit a new record in 2015, of 28.2 billion litres. Since 2004, Brazil has also supported the deployment of biodiesel, and is currently the second-largest biodiesel producer after the US. However, at 4.1 billion litres annually (in 2015), Brazilian biodiesel production is significantly less than its ethanol production (REN21, 2016).

In 2015, Brazil achieved the third-largest increase in solar water heating capacity in the world, and the fifth-largest installed capacity. Since 2009, the Brazilian Government has incorporated solar water heating into all new dwellings constructed under the social housing programme. In addition, several cities have established mandates for solar water heating. For example, in Sao Paulo (Brazil's largest city, with at least 12 million inhabitants) 40 percent of water heating in new buildings must be provided by solar energy. Furthermore, sugarcane bagasse is used for industrial heating (REN21, 2016; IRENA, 2015).

The energy intensity of the Brazilian economy – a proxy for overall energy efficiency – is comparable to the OECD average and significantly lower than the average of other BRICS countries (Russia, India, China and South Africa). In 2011, it took 0.11 tonnes of oil equivalent (toe) to produce one thousand USD of gross domestic product in Brazil, compared to 0.12 toe OECD average, 0.19 toe worldwide average and 0.36 toe average among the remaining BRICS countries. This relatively low energy intensity is due to two main factors: in Brazil, very little energy is used for heating and cooling; and hydropower is a highly efficient form of power generation compared to fossil-based electricity, as it incurs no or very small conversion losses (IEA, 2013). Energy efficiency programmes have been in place for decades but have not resulted in major improvements. One of the most important instruments has been the Electricity Conservation Program, which has existed since 1985. It focuses on the labelling of most energy efficient equipment, energy savings in the housing sector and in public illumination, as well as awareness raising and training for energy savings in the public sector, industry and society.

[5] Bioelectricity primarily builds on the combustion of bagasse, a by-product of sugarcane processing.

[6] Brazil operates two nuclear power plants, which started operation in 1984 and 2000. A third plant has been under construction since 1984 (EIA, 2015).

Renewables as soft power and active ethanol diplomacy[7]

Renewables play a key role in Brazilian foreign energy policies. For more than a decade, Brazil has taken an active stance in international cooperation to expand the worldwide use of renewables. For the Brazilian Government, the high share of renewables in the Brazilian energy mix and its international pioneering in transforming the transport sector constitute two important sources of soft power in international relations. As such, renewables – especially ethanol – represent an area where the country can distinguish itself as a frontrunner. Following the pre-salt discoveries of large oil and gas reserves since 2006, the Government furthermore underlines its global leadership in the exploration and production of deepwater oil and gas. It aims to expand this leadership into research and development of these technologies and aspires to become a major oil exporter.

Brazil's international activities to promote renewables concentrate on biofuels, particularly ethanol. Biofuels were a top priority of Brazilian foreign policy from 2006 to 2010, when President Lula da Silva engaged in highly visible ethanol diplomacy. Since then, Brazilian ethanol diplomacy has lost momentum,[8] but continues despite its lower visibility. A major aim of the Government is to facilitate international biofuels trade and to promote biofuels production in developing countries. For the Brazilian Government, engaging in ethanol diplomacy not only provides the opportunity to increase the export strength of the Brazilian economy, but also to leverage its own influence in international policymaking.

South–South cooperation is one important pillar of Brazil's activities to promote biofuels. The Brazilian Government has financed and conducted biofuels viability studies in several African and Central American countries. In addition, it hasset up biofuel cooperation within multilateral South–South cooperation, such as the South American MERCOSUL and the IBSA (India–Brazil–South Africa) forum. Brazil has furthermore entered into bilateral cooperation with industrialised countries, particularly the EU and the US. Here, a major aim has been to open up markets for Brazilian ethanol exports. While cooperation with the EU has stalled due to European concerns on biofuels sustainability, cooperation with the US has proven very successful: Brazilian ethanol is nowadays recognised as an advanced biofuel on the US market, gaining a special market premium.

Brazil furthermore engages in multilateral forums to advance global use of biofuels. Since 2008, Brazil has co-chaired the Global Bioenergy Partnership (GBEP). GBEP was launched at the G8+5 Summit in 2005, and aims to facilitate high-level policy dialogue and international cooperation on biofuels. A major focus of GBEP is capacity building for bioenergy sustainability. At the International Organization for Standardization (ISO), Brazil engages in working groups to facilitate international biofuels trade. Brazil now plans to launch a new, international cooperation initiative on second-generation biofuels,[9] closely linked to the UNFCCC process. With this new initiative, Brazil wants to focus on quick actions that help countries around the world reduce emissions from their transport sectors. According to the Brazilian Ministry of Foreign Relations, second-generation biofuels allow for rapid scale-up (allowing for usage in current vehicle fleets) and can therefore reduce transport sector emissions even in the short and medium term.

Biofuels production has met fierce opposition in various parts of the world – particularly in Europe – whereas in Brazil, ethanol diplomacy builds on widespread political and public support. In Brazil, the country's international leadership on biofuels is a source of national pride. Next to its economic competitiveness, the strong emissions reduction potential of Brazilian sugarcane ethanol is repeatedly underlined – not only compared to oil, but also compared

[7] This section builds on Roehrkasten (2015); interviews with officials from the Brazilian Foreign Ministry in July/August 2016; and Itamaraty (2016).

[8] This was due to a variety of reasons. Internationally, the sustainability of biofuels was increasingly questioned, and domestically the scenario also changed: Lula da Silva had a stronger international presence and was a stronger supporter of biofuels than his successor Dilma Rousseff; and the Brazilian ethanol industry entered a phase of economic downturn and was less interested in opening up new markets.

[9] Second-generation biofuels are derived from cellulose and allow the use of residues.

to biofuels based on other sources, for example corn. Sustainability concerns that prevail in Europe – such as the clearing of rainforest and the 'food versus fuel' dilemma – are, from a Brazilian perspective, hardly relevant to Brazil's ethanol production. The soils of the Amazon rainforest are not suitable for growing sugar cane, which is mainly cultivated in south-eastern Brazil, far from the Amazon. The 'food or fuel' debate implies that the cultivation of biomass to produce biofuels drives out food producers and ultimately leads to hunger. In the case of Brazil, a country with vast swathes of fertile land, these assumptions are misplaced. The Brazilian Government suspects that, by making such sustainability demands, European countries simply aim to protect their own biofuel industries from cheaper and more climate-friendly competitors in Brazil. The Brazilian Foreign Ministry highlights that biofuels production can bring important socio-economic benefits to developing countries: it builds on technologies that poor countries can easily adopt; it is more job-intensive than any other energy source; and contributes to strengthening agricultural sectors. It argues that biofuels production in the developing world actually helps to tackle hunger. As it generates income in agricultural areas, it addresses one of the root causes of hunger: income poverty.

Brazil furthermore engages in international cooperation on hydropower, oil and gas as well as energy efficiency. Brazil's international engagement on hydropower focuses on regional cooperation and power market integration. In cooperation with its neighbouring countries, the Brazilian Government has supported the construction of hydropower plants close to the Brazilian border in order to import electricity. Furthermore, Brazil has bilateral dialogues with a number of countries on oil and gas, the most important being with the US, which focuses on shale gas technologies, and the UK, which emphasises technologies for deep water exploration. Moreover, it engages in bilateral cooperation on energy efficiency – primarily with the US and Germany, but also with China and the UK – to advance its domestic energy efficiency efforts.

Despite its active stance in international cooperation on renewables, Brazil is one of the few countries around the world – and next to Canada the only large country – that has refrained from membership of the International Renewable Energy Agency (IRENA). In the first years of IRENA's creation this was due to concerns by the Brazilian Government that IRENA would be too strongly influenced by industrialised countries like Germany, and that its work would favour renewable energy sources like wind and solar over other technologies such as bioenergy and hydropower. However, these concerns have abated in recent years. Nowadays, Brazil is not able to join IRENA due to budgetary constraints. Since the country is not able to pay the full fees of the international organisations of which it is already a member, it is not able to join further organisations.

Impulses coming from Brazil: (advanced) biofuels and renewable energy auctions

The Brazilian experiences in transforming its transport sector are of great value for a global energy transition. As outlined above, Brazil has vast experience with the production and technological development of biofuels, the adaptation of its fuelling infrastructure and vehicle fleet, as well as with the safeguarding of sustainability requirements. In international discussions on energy transitions, the transport sector has received very little attention and remains heavily dependent on fossil fuels. Several countries aim to increase e-mobility; however, this alone will not suffice to phase out the use of oil in global transport, as it will not be able to fuel aviation, shipping and heavy vehicles in the foreseeable future (IRENA, 2016a). Here, biofuels will have to play a key role.

Other countries could furthermore benefit from the Brazilian experience with renewable energy auctions. Brazil was one of the first countries in the world to implement such auctions and now has almost a decade of experience – both positive and negative. For the expansion of bioenergy and wind energy, Brazilian auctions proved to be quite successful, and also led to impressive price development for wind energy, which is now the most cost-effective option for new grid-based power in Brazil (REN21, 2016). However, there have also been several challenges: progress on solar energy has been rather limited; Brazil experienced difficulties in meeting its domestic content requirements; and project implementation has faced delays (IRENA, 2013; Bayer, 2016).

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