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Opportunities for a low pollution economic recovery in Brazil

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This paper is part of a series of briefing papers that examine the climate change policies of the countries key to the Paris Agreement and its effective and ongoing implementation.

Executive Summary

With Brazil struggling to revive its stagnant economy, there are opportunities to do so in a low pollution manner. Taking the low pollution path out of recession will cost less, can potentially reap large economic benefits, and carries benefits for health, social welfare, indigenous people and the environment.

This briefing paper argues that the low pollution development pathway—which involves scaling up wind power, forest conservation policies, and modernising urban public transport networks—can act as an accelerator, rather than a brake, on economic growth and social inclusion in Brazil.

Key findings:

The Government of Brazil is in the unique position to demonstrate to the world that it is possible for a country to recover from of an economic crisis by adopting low pollution policies. A low pollution economic recovery can be achieved by:

1. Scaling up wind power capacity and other renewable sources of energy, rather than expanding thermal or large hydroelectric projects
2. Protecting forests and using land more efficiently, rather than expanding agricultural enterprises into rainforest and savannah regions
3. Modernising urban public transport networks, rather than expanding road systems, which will be quickly appropriated by automobiles, requiring more oil and ethanol.

In sum, the rapid roll out of a policy program that allows low pollution infrastructure and enterprises to flourish may help propel Brazil back into a position of economic health; as well as deliver strong social (poverty alleviation), economic (job creation and wage growth), and environmental (reduced greenhouse gas [GHG] emissions) dividends for Brazil. This pathway will also help Brazil meet its Nationally Determined Commitment to the Paris Agreement to reduce GHG emissions by 37% below 2005 levels by 2025, which will help tackle global climate change.

Introduction

The first decade of this century saw almost 40 million people in Brazil—one fifth of the entire Brazilian population—lifted out of poverty. This period of strong economic growth in Brazil also resulted in record low unemployment, rising wages and falling inequality.

However, more recently, Brazil's economy has worsened. Economic growth has been replaced by the worst recession ever recorded in Brazil: from the first quarter of 2015 to the third quarter of 2016, there were seven consecutive quarters with negative rates of growth. The 2016 gross domestic product (GDP) was smaller, in real terms, than the 2010 GDP, even though the population increased 5.4% in the same period. The Brazilian real has fallen 48% against the US dollar from May 2013 to February 2017, a necessary shift, but one that adds to the burden of the R$1.2 billion ($US40 million) in foreign debt owed by Brazilian companies that falls due this year. Investment declined by more than 25% from 2013 to 2016. There are yet no clear signals that this prolonged recession will be over in the short run.

Unemployment has reached its worst record, at more than 12 million people (11.9% of the total). Inflation is slowly declining, but interest rates remain at extraordinary high levels (around 12%), real incomes are contracting, and Brazil's prized investment grade credit rating has been degraded.

To get the Brazilian economy back on track some economists have suggested an overhaul of the country's outdated labour laws, a simplification of the taxation system, cutting red tape, and/or reducing protectionism. However, this typically *Western* neoliberal agenda sits uneasily with the bipartisan sense of social justice in the formation of Brazilian policy and politics.

A more compatible option worthy of consideration is the low pollution development pathway.

This pathway is premised on the notion that green policies—low carbon, resource efficient and environmentally concerned—can act as an accelerator, rather than a brake, on economic growth and social inclusion (eg. investment, job creation, and wage growth).

At times this logic has been adopted by Brazil's leaders. In September 2014, at the UN Climate Summit in New York, the former President of Brazil, Dilma Rousseff, asserted that 'we (the international community) must overcome the logic that preventing climate change negatively impacts the economy'.[1] Policy initiatives soon followed; in June 2015, Brazil announced that they intend to increase the share of renewables—beyond hydropower—in their electricity generation mix to the level of 20% by 2030, and commit to a target of a zero illegal deforestation rate between now and 2030, all in an effort to avoid dangerous global climate change.[2]

After the impeachment of Ms Rousseff in May 2016, the government of President Michel Temer has revived and reinforced the push towards unsustainable, *brown* economic activities, especially those intensive in carbon emissions.

Nevertheless, the possibilities for a greener redirection of the economy remain in the many opportunities that still exist for low pollution investment, growth and jobs in Brazil. This briefing paper aims to highlight these opportunities in the electricity, land-use, and cities and urban transport sectors. We explore each in sequence.

Scale up wind power capacity

This section examines the electricity generation sector. We find that policies that assist to scale up wind power capacity have the potential to deliver more economic, social and environmental benefits than policies that promote large-scale dam building.

Brief policy history

Brazil's large scale hydroelectricity plants were mostly built between 1968 and 1984.[3] The justification for this development path was that Brazil had very limited coal reserves, and that in the aftermath of the 1973 oil crisis, national energy security had become a top priority. The military were uninterested in the environmental and social costs of hydropower, and as such, large swathes of native vegetation and many villages succumbed to the rising waters—displacing indigenous people—brought on by the construction of several mega dams.

However, as global concern about the environment grew in the late 1970s and 1980s, this approach to electrici-

ty generation was increasingly criticised. Furthermore, democratisation in Brazil in the mid-1980s led to non-state actors having a much greater influence over environmental policymaking, Brazil's leading role at the 1992 Earth Summit held in Rio de Janeiro was indicative of this increased influence.

However, it wasn't until a severe drought in 2001—which reduced water levels in several key reservoirs causing widespread blackouts—that Brazilian policymakers began to actively search for alternative ways of generating electricity.

In 2002, the Program for Incentives for Alternative Energy in Electricity (Proinfa) was enacted. This *alternative electricity* program kick started Brazil's renewable program. In its first stage, the program sought to promote the use of wind, biomass and small hydro through subsidies and incentives. In its second stage, the program mandated an increase in renewables' share of annual energy consumption to 10% by 2020.[4]

The Proinfa was regulated in 2004. Wind power boomed. From 2005 to 2011, installed wind capacity in Brazil grew from 30 megawatts to 1000 megawatts.[5] At the same time, large scale hydroelectric capacity was also expanded. Between 2007 and 2013, the Jirau and Santo Antonio hydroelectric plants were built on the Madera River, and construction began on the Belo Monte Dam on Xingu River. All were located within the Amazon region.

At present, installed wind capacity in Brazil is projected to increase to 16 400 megawatts by 2019.[6] And as part of that goal, in June 2015, Brazil pledged under the Brazil-US agreement on climate change, that it would double the share of renewables—other than large scale hydropower—in its electricity generation mix to 20% by 2030.[7]

The Belo Monte Dam complex is due for completion in 2019, at which time it will be the third largest in the world. It began operations in April 2016, with less than 5% of its potential, but there is an ongoing judicial process against businessmen and government officials due to one of the largest bribery scandals in Brazilian history. Many of the owners and directors of the building companies and politicians are facing judicial prosecution because of that (some are already in jail).

Advantages and disadvantages

At present, job opportunities in the wind sector mainly exist in civil construction and the provision of income to local landholders that permit wind towers to be erected on their land. This is good news for the population living in the northeast of Brazil. Favourable geographical conditions in this region, including an extensive shoreline and strong trade winds, provide the best conditions for wind power generation in the country. This region is Brazil's poorest.

Brazil's poorest are in desperate need of new skills to exit poverty permanently. Since 2003, Brazil has made impressive progress in reducing nationwide poverty. Between 2001 and 2013 poverty in Brazil fell from 24.7% to 8.9%.[8] However, according to the World Bank, a lack of work ready skills is the main reason why more than one third of the Brazilian population remains in a condition of economic vulnerability, that is, they are on the brink of falling back into poverty. Equipping this group with job ready skills for use in an industry with huge potential growth can help ensure this group escapes poverty permanently.

High skilled jobs mainly exist in the production of equipment. These jobs are yet to be fully realised because about half of the wind components used in Brazil are imported. Establishing incentives and price signals to encourage research and development into national wind technology would generate high skilled jobs in the country.

Wind energy is currently cost competitive—without subsidies—with hydroelectric and coal power. The production and investment cost per unit of electricity output for wind has been declining, and for the following reasons it is believed this decline will continue:

1. The wind industry is relatively young, particularly in Brazil. Therefore, technological breakthroughs, which research and development programs in Brazil can contribute to, have the potential to further reduce costs.

2. Adjustments to the turbine design can change the economic calculations. For example, the total potential for wind power generation in Brazil is officially estimated at 144 gigawatts, or 270 terawatt-hours/year (about half of the national current electricity consumption).

However, these figures assume that the rotors only extend 50 meters above the ground, but if the rotors were positioned at 100 meters, the potential for power generation would exceed 300 gigawatts, more than the potential of hydro power.[9]

3. Brazil has a comparative advantage in the wind sector, compared with foreign countries, because it has experience in running a successful wind power expansion program. The Proinfa scheme—which combined a mandated feed-in-tariff, a national content requirement, long-term contracts for power producers, auctions for licences to supply electricity to the national grid, and subsidised credit from the Brazilian Development Bank (BNDES)—successfully attracted private firms, from home and abroad, into the sector. Between 2008 and 2014, foreign wind component manufacturers operating in Brazil grew from one to four, accompanied by thirteen new tower manufacturers, seven turbine assemblers, and more than a dozen parts and components suppliers.

In terms of the environmental advantages, 'wind energy', the Intergovernmental Panel on Climate Change explains, 'has significant potential to reduce (and is already reducing) GHG emissions'.[10] The International Energy Agency forecasts that wind energy will play an increasingly prominent role in Brazil's future low pollution energy mix.

Hydroelectricity, by contrast, is becoming increasingly problematic.

Brazil's electricity supply is heavily reliant on hydroelectricity. Hydropower constitutes 80% of Brazil's total electricity built capacity. This level of dependency means that Brazil's electricity supply is highly exposed to changes in weather patterns, particularly drought.

The older style dams, which comprise a single very large reservoir, and the new run-of-the-river design, which comprise smaller dams to avoid disturbance to natural river flows, suffer under drought conditions. The former loses capacity to generate electricity if its reservoir runs low. The latter loses capacity because it doesn't have a reservoir (ie. storage capacity). Both methods are dependent on seasonal variation in precipitation patterns and periods of drought, and in low rainfall periods, both designs need back-up power.

Brazil is mostly using natural gas for back-up, along with fuel oil and coal fired power plants. Brazil's domestic coal supply is very limited, so it has been importing natural gas, coal and electricity from abroad, which contradicts the principal justification for creating dams in the first place, energy self-sufficiency.

Some other problems associated with traditional hydroelectric dams include the displacement of local communities and the disturbance of ecosystems, especially in the Amazon where most of the unexploited hydropower resides. In addition, flooding forests causes huge amounts of methane to be released, and the run-of-the-river design cannot be boosted during periods of high electricity demand such as during heatwaves, which can result in increased heat related stress and illness.

There is a strong case to be made for a hydro-wind integrated system in Brazil. Both hydro and wind energy have storage problems that could be overcome by wind providing electricity when the turbines are spinning, which results in water savings in large-hydro systems, that could then be switched-on when the wind stops blowing. This combination has the advantage of establishing a resilient, carbon dioxide (CO_2) emission free, power generation system at competitive costs. Further, because of where the two power sources are located in Brazil, they also have seasonal compatibility, more wind when hydro is low and vice versa.

Hydropower and São Paulo's drought

The Metropolitan region in São Paulo, about 11 million people, is heavily reliant on hydroelectricity. It recently suffered through its worst drought in 80 years. Key reservoirs were at historic lows. This caused rolling power cuts, in some areas for days. Utility companies were forced to import fossil fuel power from Argentina. Electricity prices spiked as distributors recouped losses.

São Paulo is responsible for more than half of Brazil's economic output, and serves as the financial centre for most of South America. Power outages, and the social instability this creates, deter commercial activity.

In summary, greater diversification away from hydroelectricity is a good way of protecting Brazil's poorer communities, boosting business opportunities, and ensuring future energy security.

Policy opportunities to help grow Brazil's wind industry

1. Knowledge about the wind sector in Brazil remains relatively low in comparison to hydropower. Technological and knowledge transfer from countries with a mature wind industry could assist its development in Brazil.

2. The share of imported components remains relatively high. Brazil should seek to gain technological control over the wind power manufacturing process by way of establishing a national innovation scheme that focuses on developing national technology and high skilled jobs in the country.

3. Expanding Brazil's wind power capacity is dependent on the outcome of negotiations with companies, lobbyists and bureaucrats that support hydropower. To date, this network, which is deeply embedded in the policy-making process in Brazil, has made it extremely difficult for wind power stakeholders to get an equal hearing. Strategies and support for this group may generate positive results for wind power expansion.

4. Other opportunities include deploying international finance to help upgrade Brazil's outdated electricity supply infrastructure. Most of Brazil's electricity is transmitted through the National Interconnected System. But the lines are of inferior quality, poorly maintained, and do not have cheap electronic leak detectors. Also, the lack of smart grids that allow electricity to be quickly redistributed inhibits the expansion of complementarity renewable sources. Electricity theft is also a problem.

These initiatives could help Brazil increase its wind power capacity. According to the Brazilian Association of Wind Power, in February 2017, wind power capacity in Brazil was 10.79 gigawatts, equivalent to 7.1% of the electricity power capacity in the country.

Protect forests

This section examines the land use sector. We find that policies that protect forests, for instance, by using already cleared land more efficiently, have the potential to deliver more economic, social and environmental gains than clearing more forests for agriculture.

Brief policy history

In the 1960s and 1970s, massive swathes of Amazon rainforest were bulldozed and burnt to make way for agricultural enterprises. Based on fears that the Amazon—largely void of communications and infrastructure—posed a weak point in national defenses, the government offered a number of wide ranging incentives and subsidies to attract agribusinesses, mostly cattle ranching and soybean farmers, and mining speculators, to the region.

The so-called slash-and-burn policies of this era, at their peak, led to more than 31 000 km^2 of forest–an area the size of Belgium—being destroyed each year.

This style of agricultural rollout in the Amazon continued into the 1980s. Between 1978 and 1987, the total area deforested rose from 152 100 km^2 to a massive 372 700 km^2, which is nearly 10% of the total area. Reports confirm that about 71% of total deforestation in the Amazon up to 1985 was due to agricultural expansion.[11]

In the 1990s things got worse as a combination of high global food prices, and ironically, forest protection laws introduced in 1996—which were deemed virtually impossible to enforce or comply with—incentivised cattle ranching and soybean farming expansion.[12]

It wasn't until the 2000s that deforestation declined. A series of policy reforms, largely championed by Marina Silva (Brazil's Minister for the Environment, 2003-2008), caused annual average deforestation to drop from of 27 800 km^2 per year in 2004 to 6400 km^2 per year in 2011.[13]

Minister Silva argued that deforestation generated few economic benefits in comparison to the gains that could be made from protecting forests. She assembled a fractious coalition of agribusiness, mining, energy utilities, and NGO leaders to back this argument.

Policy reforms and social changes in this period included:

- increased funding for policing and enforcement
- expanded farming exclusion zones
- increased public concern about climate change

- product boycotts
- a decline in soybean and meat prices
- a rising Brazilian currency
- improved cattle breeding techniques
- engagement with international climate mechanisms such as Reducing Emissions from Deforestation and Forest Degradation (REDD).

In 2012 annual deforestation reached its lowest point at 4700 km^2. In 2013 it increased to 5600 km^2. And in 2014, it declined again to 4800 km^2.[14] Higher food prices, highway improvement in the region, and a resurgent *ruralista* lobby, with the reduction of the governments capacity to fight deforestation, have contributed to the worsening results in recent years.

But has this deforestation reduction been converted into reductions in GHG emissions?

Figure 1 shows a steady decline in GHGs from mid-2000s to about 2011-12, which parallels reduced annual deforestation rates in this period. But from 2011-12 to 2015, GHG reductions have plateaued or slightly risen, again paralleling the hovering annual deforestation rates. Broadly speaking, it can be said that there have been no further reductions in emissions in the 2010s and deforestation remains the largest single source of GHG emissions in Brazil.

On 30 June 2015, under the US-Brazil climate agreement, Brazil pledged that it would restore and reforest 12 million hectares of its forests—an area about the size of England—by 2030 and pursue 'policies aimed at eliminating illegal deforestation'. However, governments persisted in their efforts to convert native forest land into *productive frontiers*, and at present there are many initiatives to lessen the conservation status of nature and indigenous lands, and a strong pressure to reduce the environmental conditions in the licencing process.

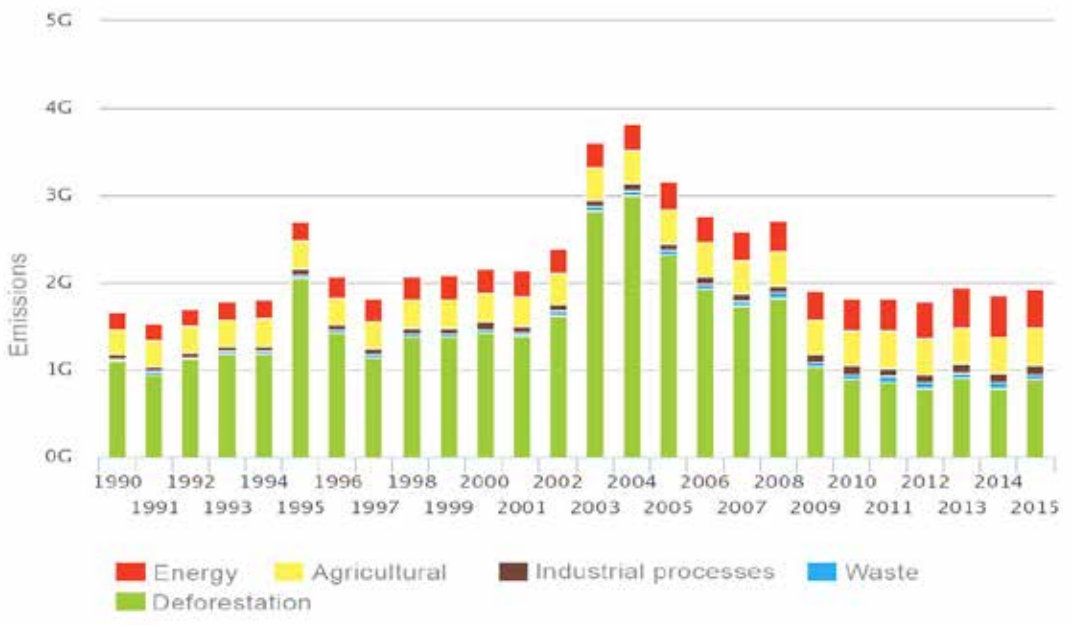
The advantages of protecting forests

The social and economic advantages of protecting forests abound:

1. The production of timber in the Amazon's national and state forests, from areas managed according to the model forest concession, has the potential to generate between $R1.2 billion (US$ 38 million) and $R2.2 billion (US$70 million) per year, more than all of the native timber currently extracted in the country.

2. Visitors to Brazil's 67 National Parks have the potential to generate between $R1.6 billion (US$51 million) and $R1.8 billion (US$57 million) per year (based on 2016 tourism estimates).

Figure 1: Total emissions of GHG's in Brazil 1990-2015 (in million T CO_2 GWP)



Source: The Brazilian System of Greenhouse Gas Emissions Estimates (SEEG)

3. Studies indicate that public visitation in federal and state conservation areas of about 20 million people has the potential to generate approximately $R2.2 billion (US$70 million).

4. In relation to the different uses of water by society, 80% of the country's hydroelectricity comes from sources that have at least one tributary downstream of a conservation area, 9% of drinking water is directly collected in conservation areas, 26% is collected from sources downstream of conservation areas, and 4% of the water used in agriculture and irrigation is taken from sources inside or downstream of conservation areas.

5. In watersheds and water sources with the greatest forest cover, the cost associated with treating water for public supply is less than the cost of treatment in areas with low forest cover.

The environmental advantages of forest conservation policies are not only significant for Brazil, but the world.

- The Brazilian Amazon stores 60 billion tonnes of carbon, or 8% of the total carbon present in the atmosphere.[15] Slash-and-burn policies would cause this locked up carbon dioxide to be released into the atmosphere, adding very significantly to the rate of global warming. Indeed, if Amazon clearance rates had remained at their 2005 levels of 19 000 km^2 per year, the atmosphere would contain an extra 3.2 billion tonnes of carbon dioxide.[16]
- Strong forest conservation policies would also help reduce erratic rainfall and subsequent river flow in Brazil, as well as reduce soil nutrient depletion, erosion, loss of biodiversity, and the extinction rate of various plant and animal species.

Indigenous people and farmers

Brazilian governments have long been criticised for land use policies that disrupt and displace indigenous populations. But tensions between farmers and indigenous groups still run high.[17] Adopting policies that help farmers use already cleared land more efficiently holds great potential to satisfy the key players on both sides of the debate.

Policy opportunities to help protect Brazil's forests

1. Supporting the adoption of policies that help improve land use efficiency is critically important to address the dual challenges of forest conservation and supporting agriculture.[18] One of the most important policy discussions in this space involves technology. Agricultural research has largely relied on cooperation between the state-run Brazilian Agricultural Research Corporation and local private producers. This cooperation has proved fruitful in helping modernise soil management, cultivation techniques, biochemical techniques, the adaptation of soybean varieties, and cattle raising efficiency, among many others.[19] Allocating international resources to boost agricultural research and development, with the overarching goal to make land use more efficient, would prove very useful in further reducing deforestation.

2. Improved satellite monitoring technology could further increase the effectiveness of Amazon law enforcement activities. The implementation of the Real Time System for Detection of Deforestation (DETER), a satellite-based system that enables frequent and quick identification of deforestation hot spots, was a significant driver of the 2000s deforestation slowdown in the Amazon.[20] Overcoming DETER's incapacity to see through clouds and obtaining land cover imagery in higher resolutions are two examples of technological advances that could enhance law enforcement targeting capability and add significant value to Brazil's conservation efforts.

3. Brazil should consider reallocating incentives and subsidies that encourage deforestation.[21] For example, reducing the availability of credit has encouraged small landholders to sell their farms to large agri-businesses and relocate to the frontier parts of the Amazon where land is cheaper, pushing the frontier further North and Centre-West. This frontier has also seen the rapid expansion of highways and roads, mainly funded by the states and local sources, which has further incentivised agricultural-induced deforestation. Indeed, decisive action is required to establish secure property rights, for without these, settlements will continue to expand.

4. The benefits of forest conservation policies need promotion. At present in Brazil, the dominant perception of these policies is that they constitute an obstacle

to economic and social development. This view is shared by most political groups, decision-makers and the private sector. Cultivating and participating in an alliance with sympathetic groups in-country to reverse this perception would help maximise the benefits generated by forest conservation. Special attention should be paid to counter the growing influence of the *ruralista* lobby over land use policymaking.

5. Financial support could be provided to help regenerate areas already open and degraded.[22] Despite the argument that Brazil's Intended Nationally Determined Contributions is independent of any expectations of receiving foreign financing, if that were to become available, goals could be revised or met earlier than expected. Finding an international funding mechanism that can funnel significant amounts of money to reforestation or restoration can be of tremendous importance for Brazil over the next 15 years. The same is true for research on how to decrease the cost of reforestation/restoration.

6. International certification of agricultural products originating from low carbon agriculture practices can create a differentiated market for these products, and perhaps should be given easier or cheaper access to markets that traditionally place barriers, such as the EU and the US.

Modernise public transport in megacities

This section examines the urban transport sector. We find that policies that help upgrade and expand public transport networks—particularly in Brazil's two megacities, Rio de Janeiro and São Paulo—can deliver more economic, social and environmental benefits than expanding roads and highways, and could also instigate a low pollution economic recovery.

A brief policy history

In the 1950s and 1960s, Toyota, Volkswagen, Chevrolet, Ford and Fiat made Brazil their foreign production base. Autos were produced in increasingly larger quantities for domestic consumption and export. The expansion of the auto industry caused urban public transport systems—trains and trams—to be gradually replaced with asphalt roads and cars.[23]

The 1973 oil crisis altered this direction. In 1976, decision-making for urban public transport was centralised, removing responsibility from the states, and upgrades and new rail and bus systems in several metropolitan areas commenced. Soon after, the World Bank described Brazil's bus transit plans as 'the most imaginative and radical in the world'.[24]

In the 1990s, Brazil's urban public transport suffered from a lack of interest from private investors and governments at all levels, national economic woes, and the Constitutional reform of 1988, which shifted responsibility for urban public transport back to the states and municipalities.[25]

By the 2000s Brazil's urban public transport was woefully inadequate. In São Paulo and Rio de Janeiro, horrendous traffic congestion, dangerous neighbourhoods that prohibited walking or cycling, poor subway systems, and crooked sleepers on train lines—which are rarely realigned, causing trains to wobble and often derail, deterring commuter patronage—has meant commuters would spend hours on crammed busses for short trips.[26] As a 2005 report by the Federal Ministry of Cities suggests, this situation was unlikely to improve:

> …there is little public investment destined to service urban public transportation infrastructure, contrary to the expansion of roads systems, which is rapidly appropriated by automobiles.[27]

In 2012, the federal Growth Acceleration Program (PAC) allocated $R110 billion (US$46 million) in funding for urban mobility development.[28] This funding was to incentivise cities with over 20 000 inhabitants—about 3065 cities—to incorporate urban mobility planning into their larger development plans (eg. affordable public transportation, exclusive bus lanes and bike routes, and implementing congestion pricing policies).

More recently, Rio has received dedicated federal, state and local government funding packages to upgrade public transport, such as bus rapid transit systems, in preparation for the 2014 soccer World Cup and 2016

Olympic Games.[29] São Paulo, by contrast, is considering creating more highways and widening existing roads, a short-term solution to reduce congestion that critics say only reinforces a car culture.

Brazil's automotive industry is currently in steep decline. In 2014 vehicle sales—including cars, light vehicles, trucks and buses—were down 7.1% on 2013 figures.[30] And more than 12 000 automotive jobs were slashed over the corresponding period of time.[31] Despite this, car ownership rates in Brazil are expected to more than double by 2030.[32]

The advantages of modernising urban public transport networks in Rio and São Paulo

Significant public health benefits stem from reduced road traffic and fuel usage. The World Health Organisation (WHO) finds that outdoor air pollution—particulate matter (PM2.5 and PM10)—in São Paulo and Rio de Janeiro far exceed recommended levels (Table 1). Indeed particulates in Rio are over three times recommended levels.[33] The WHO explains that reducing particulates from road traffic and fuel usage can reduce the burden of disease from stroke, heart disease, lung cancer and both chronic and acute respiratory diseases, including asthma. The Lancet Commission of 2015, comprising the world's preeminent medical professionals, strongly supports this view.[34]

Traffic congestion also produces tremendous economic costs. A recent study found that traffic congestion cost the cities of Rio de Janeiro and São Paulo US$43 billion in 2013 alone. The loss amounts to about 8% of each metropolitan area's GDP, and 2% of Brazil's entire GDP.[36]

Public transport modernisation, by contrast, combats traffic congestion while also providing benefits such as better health, lower stress levels, lower road accident rates, reduced noise and air pollution, and better quality of life.[37]

Brazil's public transport modernisation is already attracting strong international interest from private investors (eg. Rockefeller 100 Resilient Cities programme), NGOs (eg. World Resources Institute Ross Centre for Sustainable Cities), and governments (eg. China). Significant employment opportunities exist for Brazilians by expanding infrastructure programs for rapid mass-transit systems.[38]

In 2012, Brazil's transport sector accounted for about half of the country's energy-related CO_2 emissions from the combustion of fossil fuel, road usage was overwhelmingly the most prominent contributor (Table 2). These emissions were largely generated in urban areas and were due to increased motorization and congestion. Fuel combustion is clearly the main culprit.

Oil and ethanol expansion, which would accompany urban road expansion, presents considerable risks. First, the ongoing corruption investigations into Petrobras, a state-controlled oil company, combined with the rapid expansion of US shale gas, the increasing competitiveness of Mexico's energy industry, and growing global concern about climate change make investing in Brazil's off-shore pre-salt oil reserves a risky bet.

Also, the economic viability of the ethanol industry is premised on high oil prices, and low food prices, but price volatility is the hallmark of both, discouraging long-

Table 1: WHO Urban Air Pollution Database of 2014[35]

	PM 2.5	PM 10
WHO recommends	not >10 ug/m3	not >20 ug/m3
São Paulo	19 ug/m3	35 ug/m3
Rio de Janeiro	36 ug/m3	67 ug/m3

Units: micrograms per cubic metre of air on average per one year

Table 2: International Energy Agency assessment of CO_2 emissions from fuel combustion by sector in Brazil in 2012.[39]

Total CO2 emissions from fuel combustion	**440.2**
Electricity and heat production	54.2
Other energy industry own use	27.6
Manufacturing industries and construction	121.4
Transport	**198.9**
of which: *road*	179.3
Other sectors	38.1
of which: *residential*	17.4

Units: million tonnes of CO_2

term investors.

The benefits of these industries are also contested. For example, the World Energy Council (WEC) confirms that 'to fuel its transportation sector, Brazil has embarked on developing its pre-salt reserves',[40] however, the limited capacity of the atmosphere and oceans to absorb the ensuing carbon emissions has led some to describe the pre-salt discoveries as the world's *carbon bombs*.[41] In addition, studies show that the rural employment opportunities generated by expanding the biofuel industry have been significantly overstated largely due to mechanisation replacing workers.[42]

Policy opportunities to help expand Brazil's urban public transport networks

1. International finance could be allocated to help maintain and upgrade existing public transport networks in São Paulo and Rio (among others such as Salvador, Belo Horizonte, Manaus), as well as expand urban public transport infrastructure. In these cities, day-to-day maintenance and upgrades are not seen as priorities for governments. Moreover, both cities need plenty of new railways and other public works. The World Economic Forum ranks Brazil 107th out of 144 countries on the quality of its infrastructure. China, and some private investment banks and equity firms, are allocating money for public works in Brazil. However, programs such as the PAC, and agencies such as the BNDES, are reducing infrastructure investment.

2. The expansion of urban public transport networks requires an influx of experienced engineers. Rio's mountainous terrain, proximity to the sea, and complex soil structure pose major engineering challenges to the development of a subway network, however they are not insurmountable with experienced practitioners as well as quality teaching and training.

3. Public transport needs to be more affordable for the poor, the people who use it most. In São Paulo and Rio, the much utilised bus service is low quality, uncomfortable, and slow—a bus trip can take twice as long as in an efficient system. Relocations of inner city favela residents often result in communities being pushed further from the fringes. As a result, many people have to spend a major share of their income and their time on long commutes to low paying jobs. For a daily commuter, a bus fare can amount to about a sixth of the minimum wage of $R724 a month. Despite this, in February 2014, bus fares in Rio were raised by $R0.25, from $R2.75 to $R3.00, causing widespread protests.

4. Future bilateral and multilateral agreements on climate change could stipulate a specific emissions reduction target on transport. Transport is conspicuously absent from the recent US-Brazil agreement, despite the sector being responsible for nearly half of Brazil's energy sector emissions.

5. The strategic deployment of tollways can deter automobile expansion. The WEC found that the use of efficiency policies (tollways) could cut the vehicle expansion rate in Brazil by 20% to 30% by 2030.[43]

Conclusion

This briefing paper shows that a low pollution economic recovery—which involves policies that would help scale up wind power, protect forests, and modernise urban public transport networks—is not only possible, but can generate a combination of economic, social and environmental advantages that the alternative high pollution policy options struggle to match.

Brazil has a number of choices to make that will shape its future economic growth and social development pathway. The low pollution pathway, which the current Temer administration can pursue through adjustments to its current policy approaches, can deliver growth and prosperity while improving eco-systems and potentially offsetting some of the damaging impacts of climate change.

The Brazilian government now has the chance to seize the opportunity for a low pollution economic recovery.

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