Development Progress

Case Study Summary

Environment

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Sustainable energy in Brazil

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- Between 1990 and 2010, Brazil more than doubled its overall energy supply, while reducing its energy imports from 25% to less than 10% of total production.
- In the same period, 55 million people gained access to electricity, with household benefits including access to communications and better lighting. The number of households without electricity access declined from over 2 million to less than 700,000.
- In 2010, 45.1% of Brazil's energy consumption was from renewable sources.
- Brazil has replaced around 40% of its petrol/gasoline needs with home-grown ethanol fuel.
- Brazil's progress in boosting energy production has not been accompanied by an equivalent effort in energy efficiency.

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Why sustainable energy in Brazil?

This is a case study of development and implementation of national energy policy. Brazil is often cited as an example of good practice and of divergence from the 'norm' among upper-middle-income countries. Brazil's continental-sized territory and broad natural resource endowment offer a range of energy options: hydropower, bio-fuels, wind and solar energy, as well as thermal power including fossil fuels. This presents policy-makers with a number of different possibilities for energy development.

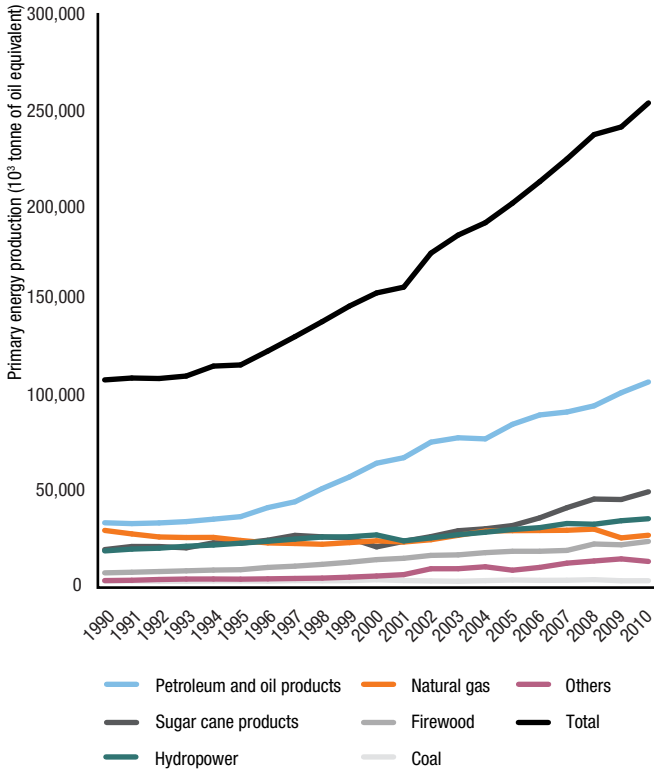
Brazil has certainly achieved impressive progress in increasing energy production to supply its fast growing economy and population, with noticeably lower emissions of greenhouse gases (GHGs) than in comparable countries. What also emerges, however, are some problems and failures – the country's record is more nuanced than its international reputation suggests.

What progress has been achieved?

1. Growth in energy production

Brazil's policy-makers, planners and engineers have been very effective in expanding its energy production. Over the period 1990-2010 – the focus of this study – the country's energy supply more than doubled. This compares with, in the same period, an increase of 32% in population, from 144.82 to 190.75 million (IBGE, 2013), and of 40% in gross national income (GNI) per capita, from $6,984 to $9,891 (at purchasing power parity of US$ 2005) (World Bank, 2013). Energy supply, in other words, has grown at a faster rate than population and national income (per head).

Figure 1: Composition of primary energy production (1990-2010)



Source: EPE, 2011

'God is Brazilian' – President Lula, upon reporting Brazil's discovery of offshore oil and gas deposits

All of its energy sources saw a steady increase[1] in production between 1990 and 2010, according to the research arm Empresa de Pesquisa Energética (EPE) of the ministry responsible for energy Ministério de Minas e Energia (MME), as shown in Figure 1.

From 1990 to 2010, per capita electricity use increased by over 60%, and total electricity power consumption more than doubled, although there was a noticeable decline during the power crisis of 2000-2001 when electricity was briefly rationed.

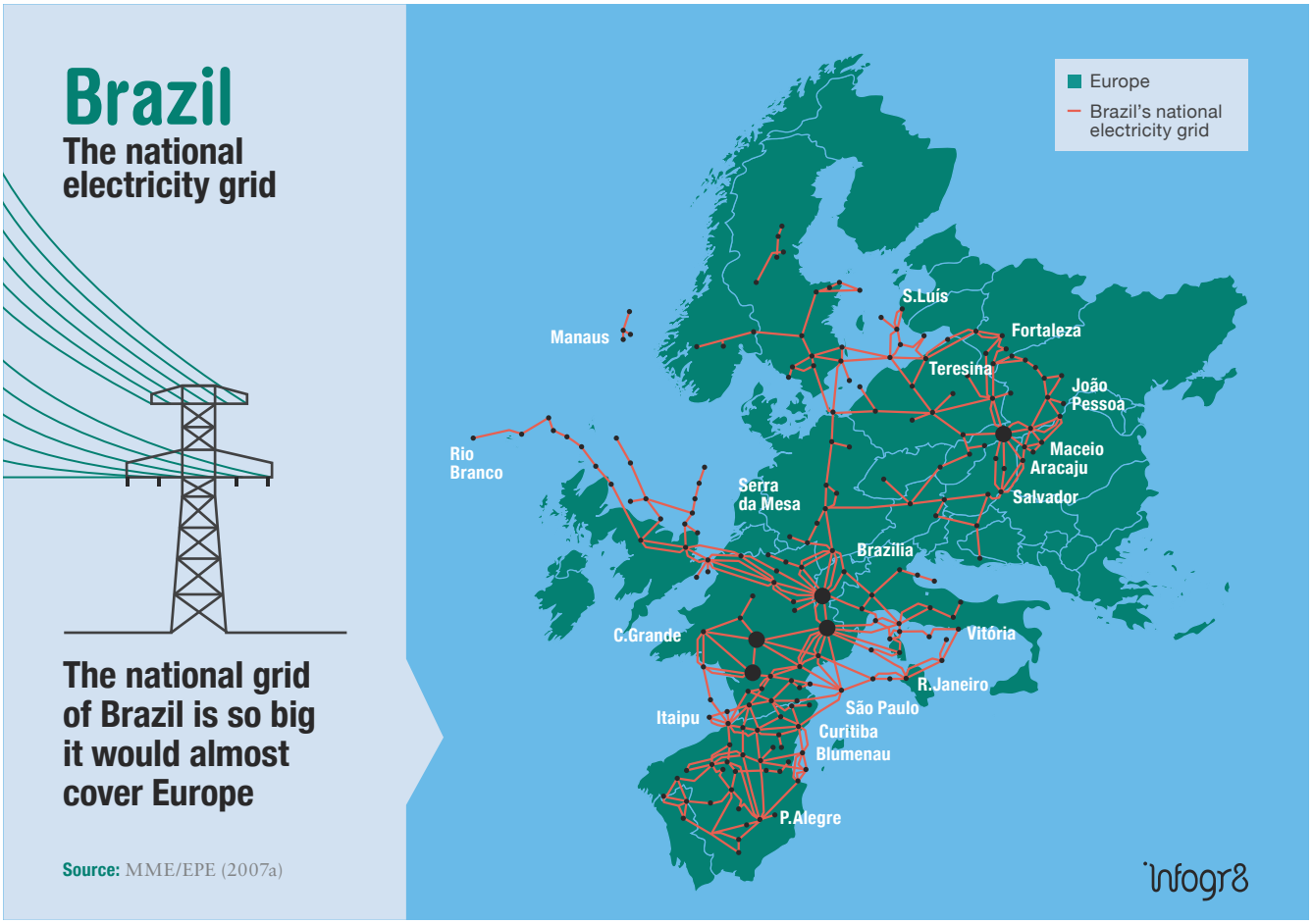
2. Reduction in energy imports

The significant expansion of energy and electricity generation was achieved at the same time as a sustained reduction in energy imports. Between 1990 and 2010, Brazil's dependence on external energy declined from 25% to less than 10% of the country's total production. In the liquid fuel sector, some studies suggest that Brazil has now replaced as much as 40% of its petrol/gasoline needs with home-grown ethanol fuel.[2]

3. Extending access to electricity

The electricity produced has been made more widely available to Brazilian households. The 1990-2010 period saw substantial progress in extending access to electricity and the benefits that it brings – for example, young people being able to study after dark, as well as wider access for adults and children to TV, radio and other media, allowing greater social and political integration. In 1990, 92% of Brazilian households had electricity. From that strong base, by 2010, *urban* electricity access stood at 99.1%. That compares with Latin American and the Caribbean (LAC) overall, where the urban coverage was a little less, at 98%

1 All except firewood – historically the principal energy source.
2 See http://sugarcane.org/sugarcane-products/ethanol.



in 2010. The equivalent figures for *rural* electricity access are 89.7% in Brazil and 84% in LAC – a slightly larger difference.

In terms of absolute numbers, 55 million additional users gained access to electricity between 1990 and 2010. In 2000 (according to the national census), some 2 million Brazilian households had no electricity connection, but by 2010 that figure had dropped to 700,000, of which 200,000 (29%) were below the poverty line (IBGE, 2010). Affordability for poorer households is supported by the operation of discounted tariffs for families on low incomes, assisted by the *Bolsa Familia* and other social protection programmes.

> 'Brazil has achieved a high share of renewable energy in its total domestic consumption' – Sustainable Energy for All, 2013

This progress in expanding connections is even more striking given the size of the Brazilian national grid – see infographic above – which extends for over 100,000 km (EPE, 2013a), a major feat of engineering and management. There are, nevertheless, physical and economic limits to further expansion of the grid; other energy solutions – off-grid or mini-grid – will be required for the remaining most isolated and remote communities. The 'big country' syndrome has its disadvantages.

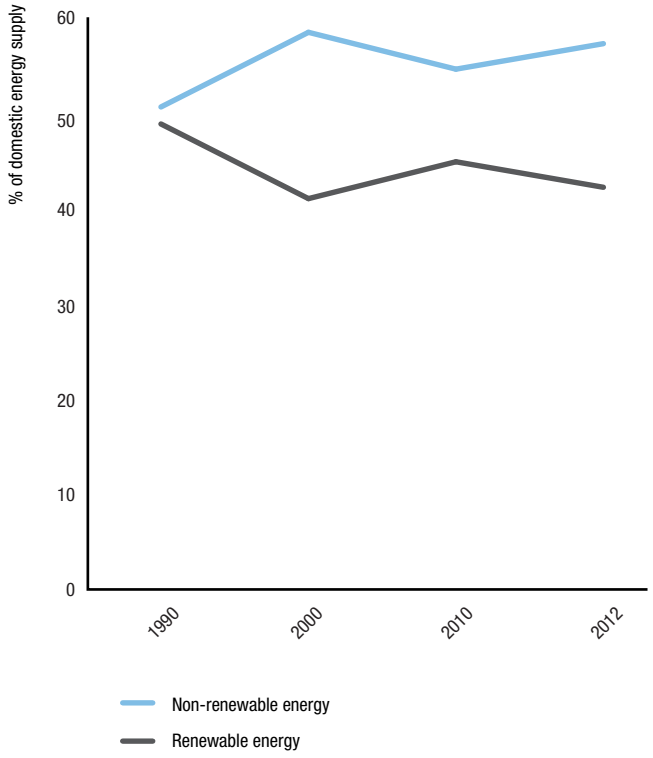
4. Renewable energy

Hydropower is the principal source of electricity supply in Brazil, while ethanol is used as a liquid fuel both in its own right and as a blending agent – 'flex-fuel' engines have been developed, capable of running on both petrol and ethanol interchangeably. The use of bagasse – a by-product of ethanol production that can be burned as fuel to generate power – has also seen rapid growth over the past two decades as extraction of energy from sugarcane waste products has improved (Furtado et al., 2011).

While hydropower's contribution to domestic electricity supply doubled between 1990 and 2010, the *proportion* of electricity produced by hydropower decreased from 86% in 1990 to 72% in 2010 (SE4ALL, 2013). The proportion of electricity generation capacity from thermal power systems as a reserve source – predominantly fossil fuel – has risen correspondingly. Brazil's energy mix is becoming less 'green', as reflected in Figure 2 (overleaf). It is clearly more a country of renewable *electricity* than renewable energy.

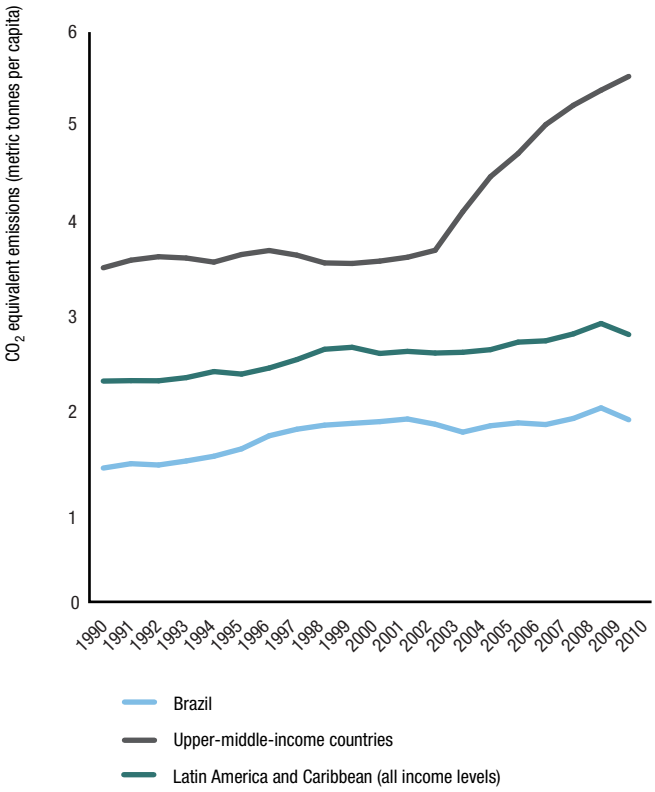
Given its relatively strong performance in delivering renewable energy, Brazil produces low energy-related GHG emissions in comparison with other countries – see Figure 3 (overleaf).

Figure 2: Evolution of renewable and non-renewable elements in domestic energy supply: 1990-2012



Source: EPE, 2013a

Figure 3: CO^2 equivalent emissions



Source: World Bank, 2013

A challenge for Brazil will be to maintain its proportion of renewables as the recently discovered offshore oil and gas deposits become available. Wind and solar power currently make a small contribution, despite wide acknowledgement of their potential and some recent increases in capacity (EPE, 2013a and 2013b).

5. Energy efficiency and intensity

In comparison with the above story of progress in energy production that has supported economic activity and provided benefits for households and other individual energy users, the country's record on energy efficiency is poor. Energy intensity – energy used per unit of production – has marginally *increased* over the two decades, 1990-2010. Government-sponsored programmes for energy conservation have received only modest funding and are either operating at much reduced capacity or have ceased altogether. Brazil is going in the opposite direction to the global target of improvement in energy intensity (SE4ALL, 2013). This lack of attention to demand management is, one sector specialist commented, 'a serious aspect of energy policy requiring urgent change'.

What are the factors driving change?

1. Sustained high-level political consensus

Brazil's energy policy from 1990 to 2010 has shown remarkable consistency in its principal objectives, maintained across successive administrations. A key driver has been the goal of national energy security. The 1970s oil shock with its dramatic rise in the price of oil and corresponding rapid deterioration of Brazil's macroeconomic position strongly influenced the country's energy policy for subsequent decades, making it a priority to reduce imports and develop domestic energy sources: hydropower capacity (for electricity), national oil production and ethanol use (to reduce oil demand). In terms of expanding household electricity access, two government programmes – *Luz no Campo* (Electricity in the Countryside) and subsequently *Luz para Todos* (Electricity for All) – have been delivered since the late 1990s under two different governments. This consistency in policy has sustained the incentives needed for the medium/long-term planning that energy development requires.

2. A positive financing environment

Brazil's progress has also been due to its development of a supportive financing environment. The government has used Brazil's national development bank (BNDES)

to provide subsidised financing for the construction of new electricity generation and transmission. Meanwhile, reforms of the energy sector (see below) allowed for the private finance that now predominates in the funding of new infrastructure. Interviewees familiar with large hydropower projects emphasised that this private finance would not have been available without the complementary concessional funding provided by BNDES, and that the public sector alone would have struggled to provide the quantity of financing required to deliver the expansion in electricity infrastructure that Brazil has seen over the 1990-2010 period.

'The impact of the 1970s oil shocks cannot be underestimated' – Energy sector academic

Some government subsidies have been provided to stimulate investment in renewable energy through two initiatives: PRODEEM – R$60m ($25m[3]) from 2001 – and PROINFA – up to R$5.5bn ($1.83bn) from 2002. In relation to extending electricity access, for *Luz no Campo*, R$2.68bn ($1.48bn) was provided from government sources, and most notably under *Luz para Todos*, public spending totalling R$15.7bn ($8.9bn) to 2010 was made available from federal and state governments.

Brazil has not been a major recipient of official development assistance (ODA), receiving over the 1990-2010 period less than 1% of its GNI as ODA for all sectors, including energy (World Bank, 2013). Brazil's energy development trajectory has, in other words, been the result of domestic, rather than external, provision.

3. Improvements in electricity sector regulation

The energy sector in Brazil has been engaged in a process of 'learning from mistakes'. The first electricity sector reforms of the 1990s resulted in substantial imbalances that most commentators believe were responsible for the mismatch in supply and demand that led to the 2000-2001 power crisis with rolling blackouts, alongside a period of drought that reduced the river flows and water storage on which hydropower depends. The blackouts were very unpopular and their memory is still etched in the minds of policy-makers today. The subsequent 'reform of the reforms' in 2004-2005 left some principles in place, notably the idea of independent sector regulators and the leading role of private finance in new infrastructure, while reintroducing a greater role for state planning – resulting in a 'middle way'.

4. Improvements in the management of large hydropower projects

Sustained high-level policy support for development of technical capacity in hydraulic engineering and associated disciplines was a major factor in Brazil's exploitation of large hydropower from 1990 to 2010. A further driver has been improvements in the development and management of hydropower plants as individual projects – or at least the *capacity* to deliver improved practice.

Improved practice does not mean that there are no 'losers' in hydropower projects, alongside 'winners' (including those who benefit from electricity). Mitigating and compensating for impacts is not the same as avoiding them altogether. The question arises of how many more hydropower plants will be needed in Brazil, particularly in the Amazon (see below).

5. Investment in ethanol-related research and development

A further driver of Brazil's progress in developing sustainable energy has come from sustained investment in new technologies for ethanol production. A significant proportion of this technology development has come from public action. From the beginning of the 'PRO-ALCOOL' programme in the 1970s, there has been public investment in improvement of sugarcane yields and ethanol extraction. The existence of a sustained and robust market for ethanol products as a result of government intervention provided clear incentives for additional private research and development. The structuring of the market to mandate ethanol's application as a blending agent and promote its use as a separate fuel spurred ethanol producers and car manufacturers to develop commercially viable technologies. The ethanol policy is not, however, without difficulty. A careful balancing act is required to create and sustain a market for ethanol-related fuels that remains competitive with traditional petrol.

What are the challenges?

1. Managing exploitation of the oil and gas reserves

The discovery of offshore oil and gas deposits represents a potential 'game-changer' for Brazilian energy policy. Some forecasts see Brazil soon joining the top five oil-producing nations, with the Brazilian government indicating total offshore reserves of around 50 billion barrels – which, at current rates of consumption, would supply Brazil's oil needs for around 50 years (EIA, 2013a; EIA, 2013b).

Managing such a windfall nevertheless brings significant challenges. There are macroeconomic risks arising from a rising exchange rate, often associated with sudden increases in natural resource exports (the so-called 'Dutch disease'). There are also political risks: oil revenues might be used to strengthen dysfunctional patronage politics, entrenching a disproportionately influential natural resource exploitation

3 All $ to Real conversions are based on average exchange rates for the relevant year.

Works at the Santo Antônio hydroelectric plant at Porto Velho, Rondônia. Photo: © Divulgação Furnas

lobby; they might also be used to paper over the cracks of persistent social and economic problems rather than investing in long-term solutions (another form of the 'resource curse'). Further, as noted above, the development of these offshore fossil-fuel resources could jeopardise Brazil's record in low energy-related GHG emissions.

2. Maintaining long-term policy coherence and the independence of sector regulators

Since the reforms of the 1990s and the 're-reforms' of the 2000s, technical bodies – such as ANEEL, the national electricity regulator, ANP, the national petroleum regulator, and ONS, the national grid operator – have been assigned a leading role in implementing the government's energy policy objectives. Interviewees raised concerns regarding government policy decisions since 2010 that may undermine regulation. Examples were cited of regulatory decisions uninformed by technical advice, indicating a reduction of regulators' ability to independently oversee their respective areas. This suggests a risk that the energy and electricity sector may be increasingly subject to wider political influence, particularly in an election year.

3. Improving strategic planning for large hydropower

As noted above, hydropower's contribution to domestic electricity supply doubled in absolute terms between 1990 and 2010. Since then, the MME continues to advance a major programme of large hydropower development. In its plan for 2005 to 2030, the MME proposes 164 gigawatts (GW) as the country's 'exploitable, but as yet unrealised' hydropower potential. Of that 164 GW, 90% (or about 147 GW) is, it says, in the Amazon region. While the growth in demand for electricity in Brazil will require *some* large hydropower projects, the task will be to determine how many plants are needed, and where. Adding 164 GW would have the effect of more than doubling the total installed electricity generation capacity in Brazil – 121 GW in 2012, from all types of power station (EPE, 2013b). To what extent is the MME able to justify this big expansion? Is rising further up the list of the world's top energy producers/consumers seen, somehow, as an end in itself – a matter of national pride?[4] Or, will the proposed 164 GW be key to security of the country's future energy supply – essential to 'keeping the lights on'?

To arrive at the answer to this '164 gigawatt question', the challenge for the Brazilian government is to develop a strategic planning process that provides for all relevant government agencies to be involved in approving major investment decisions and other stakeholders to be actively consulted. What such an alternative approach to decision-making in Brazil could look like is described in the separate ODI Discussion Paper *Advancing hydropower sustainability* that accompanies this report.

4. Managing demand while balancing supply from variable and intermittent sources

Brazil's policy-makers face the challenge – and opportunity – of managing demand more actively (i.e. reducing it), rather than unquestioningly building more supply to meet it. Grid managers, meanwhile, will face the challenge of ensuring continuity of electricity supply as the system moves towards increasing use of renewable electricity sources that are seasonal and/or intermittent in nature, such as wind or solar power. The combination of both these demands on a continental-sized grid represents a difficult and ongoing balancing act.

'The energy produced by Brazil is proportionate to its development. The two are intimately linked' – Construction engineer[5]

4 The construction engineer cited below supports the Belo Monte project because of the contribution the future plant will make to the 'huge energy needs' of Brazil's economy. When completed, Belo Monte will have an installed capacity of over 11 GW – the third largest hydropower plant in the world, after Three Gorges in China and the Itaipú plant in Brazil/Paraguay at 14 GW. The website of the public company operating Itaipú refers to its 'gigantic' size. This prompts the question whether the 'huge' energy demands of Brazil are a product of 'big country' ambitions that sometimes extend towards excessive 'gigantism'. For the inhabitants of the Amazon region, this is certainly a huge issue. As well as citing the views of the construction engineer, Bourcier (2014) also refers to those who have argued against Belo Monte in terms of the 'protection for Brazil's indigenous people and preservation of the Amazon basin'. See the separate ODI Discussion Paper *Advancing hydropower sustainability* that accompanies this report.

5 This is a quotation in Bourcier (2014) from an engineer at the Belo Monte hydropower project.

Lessons learned

The story of progress and setbacks in Brazilian energy policy and practice offers lessons for other countries.

- **Establishing and maintaining a high-level policy consensus.** Governments may usefully take active steps to establish and maintain cooperation among key government ministries, major political parties and other stakeholders on the broad outlines of energy policy, including measures to expand electricity access to reach the most marginal and poor households. *How* this can be achieved will depend on the specificities of the political system, but could include inter-ministerial consultation and dialogue on major energy policy decisions, and the establishment of independently-led 'long-term policy reviews' with representation from all sides of the political spectrum, as well as independent experts.
- **Consolidating the regulatory system.** Other countries can learn from Brazil's experience of energy regulation in terms of striking the right balance between the state and the market. Brazil's energy and electricity regulatory environment moved over the 20 years on which this study has focused from a state-led to a much more market-driven system, and then back to a 'middle way' involving greater state-led planning but a mixed economy of provision.
- **Planning for major infrastructure developments.** Governments should review their systems of strategic planning for major energy investment infrastructure, particularly for large projects such as hydropower plants. More open and transparent processes, as referred to above, can increase the political legitimacy of decisions taken.

'Despite its particular features, there are lessons for other countries in Brazil's experience' – International energy specialist

View of Recife by night. Photo: © Filipe Oliveira

This summary is an abridged version of a research report and one of a series of Development Progress case studies being released at **developmentprogress.org**

Development Progress is a four-year research project which aims to better understand, measure and communicate progress in development. Building on an initial phase of research across 24 case studies, this second phase continues to examine progress across countries and within sectors, to provide evidence for what's worked and why over the past two decades.

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