Greening the Brazilian energy grid as a sustainable response to increasing consumption: how feasible and how costly?[1]

Abstract: Increasing pressure on GHG reduction has resulted in successive summits and multilateral agreements on climate mitigation and adaptation policies. Institutional and economic barriers, however, posit a challenge on how to make ends meet. This paper discusses institutional barriers to greening the Brazilian energy grid and estimates the CO_2 emission and economic gains of different alternatives to altering the country's energy production and consumption system. Based on sectorial data and the National Energy Plan guidelines, we use a computable general equilibrium model to simulate the real gain on GNP, family consumption, and CO_2 emissions until 2030 under two different scenarios: (1) increased energy and consumption efficiency and (2) inflated water-wind-solar grid. We found that despite generating a lower growth rate for the GNP when compared to the first scenario, the second scenario would produce larger reductions in GHG emission, coupled with a trajectory of low inflation and important equity gains for family consumption. Policy implications are discussed on the importance of these changes to the success of multilateral international agreements and the future of Brazilian leadership on climate-related adaptation policies.

Keywords: water-wind-solar energy grid; climate change; computable general equilibrium model

Introduction

Increasing pressure for reduction of GHG has been reflected in successive international summits and multilateral agreements on climate mitigation and adaptation policies. Institutional, technological, and economic barriers, however, posit a challenge on how to make ends meet (Biesbroek et al., 2013). This paper discusses institutional barriers to greening the Brazilian energy grid and estimates the CO_2 emission and the costs and benefits of different alternatives to altering the country's energy production matrix.

The significant impacts of recent climate-related events on developed and developing societies raised concern on barriers to effective climate adaptation. Three major institutional barriers are particularly challenging: technological, normative/legal, and economic/political. Climate-robust technological innovations have been proposed to assure stability in agricultural output, to attenuate impact of extreme events, and to reduce GHG emissions (Held et al., 2009). Despite viable alternatives exist, issues related to patent rights and international technological transfers, in addition to implementation costs and net benefits are still largely unknown for many societies, especially for less developed countries.

Normative apparatus has rapidly increased in the last years, including stricter laws on air and water pollution, as well as energy efficiency regulations for durable goods (Biesbroek et al., 2013). The lobby of the fossil-fuel industry (including new discoveries on petrol reserves for Brazil), the Brazilian program on ethanol, and the Brazilian leadership on hydroelectric power supply are still a political challenge for greening the Brazilian energy grid. In this scenario, gains in efficiency among non-electric sources are likely to dominate the energy supply in the country in the following years. Despite the consistent increase in demand for energy consumption following the decline in poverty and inequality for the last 15 years, current change in consumer behavior and awareness in Brazil may counteract the efficiency gains in the production of non-renewable energy sources towards a more sustainable energy grid, likely influencing changes in the sectorial share of energy sources. In this study, we estimate how much the Brazilian economy would gain in terms of real growth of GNP and its macroeconomic expenditure components, as well as decline in the growth rate of GHG emissions, under two

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different scenarios: (1) increased efficiency of energy supply and demand, and (2) shift in the share of electric energy sources.

Material and Methods

To estimate the economic and environmental impacts of different energy grid strategies for Brazil we used sectorial data and the National Energy Plan guidelines within a computable general equilibrium model (Brazilian Energy and Greenhouse Gas Emissions General Equilibrium Model [BeGreen]). We projected the economic impact of changing the current energy grid until 2030 on the main macroeconomic aggregates, and estimated the GHG total and sectorial emissions under three different scenarios: (S1) “business-as-usual”; (S2) increased efficiency in energy input and household energy demand; and, (S3) compositional change towards increased supply of wind and solar energy sources. We calculated economic impacts by macroeconomic compounds, including household consumption, imports, exports, investments, price, and employment rates. We also estimated projected impacts on household consumption by income decile and the share of energy goods in household expenditure under both scenarios. The economic, environmental, and social advantages of the simulated scenarios are discussed within our institutional barriers framework.

Results and Conclusions

The Brazilian National Energy Plan (NEP) 2030, proposed in 2007, was revised in 2014 with updated guidelines for 2050. The very NEP updating reflects important changes since 2006 for the future of the Brazilian energy sector, including the prolonged effect of the 2008 crisis, the growing concern with climate change, gains in input efficiency in Brazil (including increased efficiency of wind power), the impact of recent nuclear disasters (Fukushima) on the nuclear energy sector, and the challenge of recent droughts on water security. In this setting, normative barriers have been progressively dismantled, with propositions of increased participation of wind and solar energy production, change in household energy consumption behavior (despite projected population increase until 2050), and incorporation of greener technologies in the industry, commercial buildings, and transportation.

Under the scenario of increased nominal demand for energy, coupled with technological and normative potential for greener solutions, the economic gains and GHG benefit of alternative paths to a greener economy are largely unknown. Compared to S1, S2 projects a cumulated gain in efficiency for electric energy sources of 8.5%, followed by gains of about 11.3% for non-electric (fuel) energy from 2011 to 2030. S3 projects increased share of wind power from 4.1% in 2014 to 20% in 2030 (with declining share of hydroelectric power and slightly increased share of thermal power to respond to increased economic activity). Also, under S3 households increase their use of solar panels, with a decline in 13% in electric energy demand until 2030.

In terms of environmental benefits, GHG stock would increase at a slower annual rate under S2 (approximately 2.8% lower than S3). The economic impacts in 2015 are virtually inexistent, with real gains on GNP and household consumption under S2 and S3 of less than 0.10%. In 2030, however, S2 would lead to a GNP increase of 1.62% (against 0.11% under S3). The economic gains would be even higher for household consumption (1.89% under S2 against 0.13% under S3). In terms of disaggregated impact by macroeconomic compounds, both scenarios reveal larger gains for household consumption and trade of balance, suggesting that more efficient and greener energy grid would lead to better macroeconomic foundations. Furthermore, none of these scenarios would lead to inflation in the projected horizon. If we look at economic benefits for households along the income distribution, S2 would represent relative higher gains for the richer families, while S3 would benefit more directly the poorer households. These findings reinforce the classical trade-off between economic efficiency and equity, suggesting that a path of low inflation and equitable growth can be achieved within a greener economy framework.

References

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Figures and Tables

Table 1 Macroeconomic Impacts of Increased Energy Efficiency and Compositional Change in the Electric Energy Grid (%Δ in 2030 - Cumulative deviation from the business-as-usual scenario)

Macroeconomic compounds	**Scenarios of Greener Energy System compared to the baseline scenario (cumulative percentage change in 2030)**	
	Efficiency Gain (S2)	Compositional Change (S3)
Real GDP	1.62	0.11
Household consumption	1.89	0.14
Investment	0.17	0.02
Exports	1.59	-0.02
Imports	-1.05	-0.57
Employ	0.64	0.25
Consumer Price Index	-1.15	-0.15

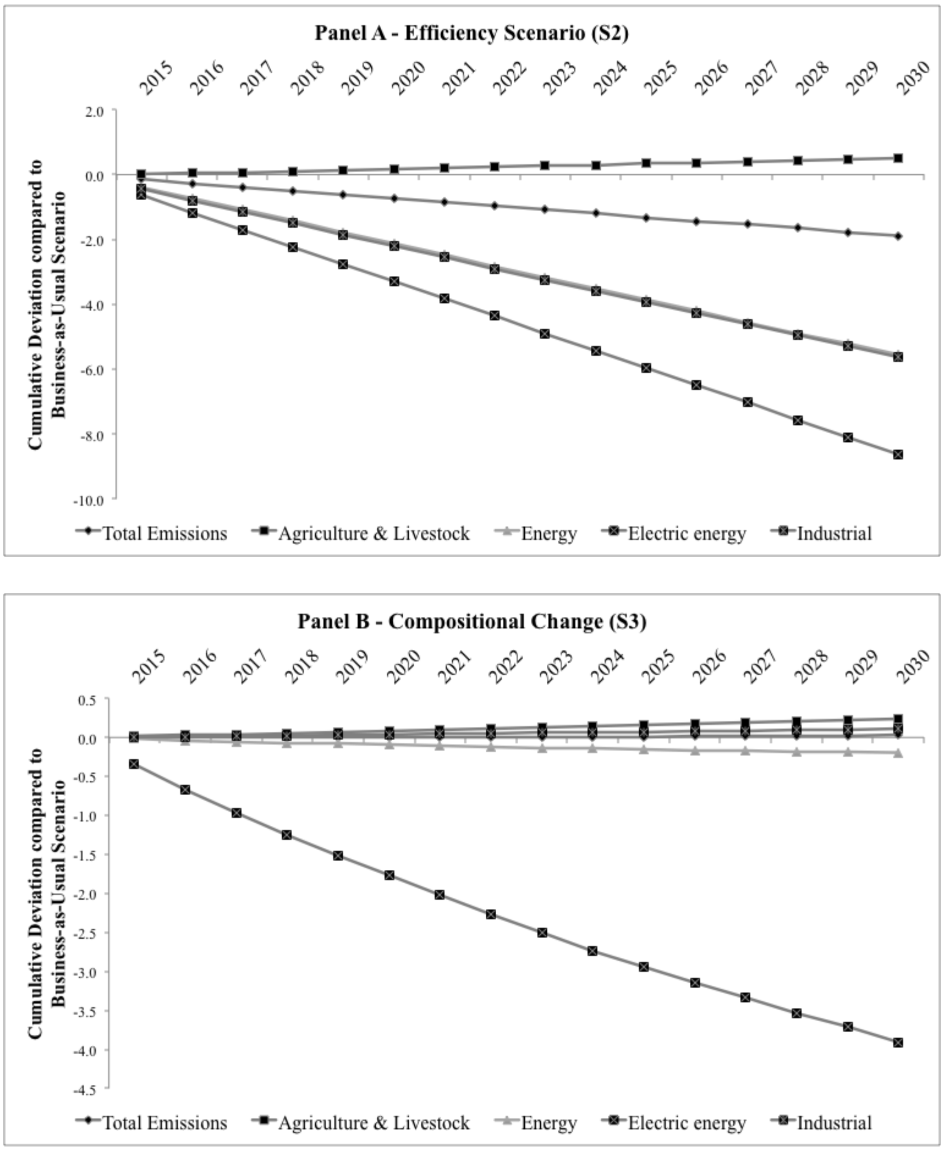
Source: authors' calculations based on the results of BeGreen model.

Table 2 Impacts of Increased Energy Efficiency and Compositional Change in the Electric Energy Grid on Household Consumption (%Δ in 2030 - Cumulative deviation from the business-as-usual scenario)

Household Decile	**Scenarios of Greener Energy System compared to the baseline scenario (cumulative percentage change in 2030)**	
	Efficiency Gain (S2)	Compositional Change (S3)
D1	0.76	0.17
D2	0.84	0.31
D3	0.80	0.26
D4	0.81	0.24
D5	0.83	0.25
D6	0.84	0.25
D7	0.88	0.22
D8	0.94	0.19
D9	1.01	0.16
D10	1.11	0.08

Source: Authors' calculations based on the results of BeGreen model.

Figure 1 Simulated Impact of Different Energy Matrix Scenarios on Greenhouse Gas Emissions by Sectors (%Δ in 2030 - Cumulative deviation from the business-as-usual scenario)



Source: Authors' calculations based on the results of BeGreen model.