

## Chapter 55

# Low Carbon Energy Innovations Systems in Natural Resource Rich Developing Countries: The Case of Brazil

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### ABSTRACT

*The transition to low carbon economy requires deep changes in the energy systems of the great majority of developing countries. However, only a small group of these countries is engaging significant efforts to develop renewable energies. The success in the diffusion of renewable energy technologies requires dynamic systems of innovation. In this chapter we analyze the recent evolution Brazilian sugarcane innovation system that was pioneering in the development and diffusion of bioethanol. This system is increasingly challenged by the acceleration of the technological regime, which is provoked by the energy crisis and the transition to the low carbon economy. The Brazilian innovation system has different capacities to cope with this challenge. In this chapter we differentiate the agriculture subsystem, which function in a STI (Science, Technology, and Innovation) mode from the industrial subsystem, which operates in a DIU (Doing, Using, and Interacting) mode. The agricultural subsystem has demonstrated a better ability to cope with the technological challenges of the new biotech research methodologies while the capital goods industry has much less propensity to deal with the second generation technologies for bioethanol. We describe also the present ethanol supply crises and its probable causes.*

### INTRODUCTION

The transition to Low Carbon Economies entails significant challenges for most of the developing countries. Their future seems to be related to fossil fuels by two main reasons. At one side their energy demand is increasing rapidly, in part because important sectors of their population are excluded from modern energy welfare benefits, and at the other side most of their energy supply lend on fossil fuels<sup>1</sup>.

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As it is unfair to suppose that energy demand in developing countries could be contained, even if energy efficiency has an important contribution to give<sup>2</sup>. Thus we should expect that fossil fuel consumption will continue to increase if nothing happens at the side of renewable sources of energy. These dynamics makes the non Annex I countries responsible also by most of the increase in the world CO<sub>2</sub> emissions since 1990 (IEA, 2012).

In present days most of the renewable used by developing countries are related to biomass. Biomass accounts for 10% of the global primary energy supply, mostly (6%) related to traditional uses of biomass like cooking and heating in the rural areas of developing countries. The share of traditional biomass is expected to decline since urbanization increases and modern energy carriers penetrate in poor households. Otherwise modern renewable energies technologies are projected to increase their share in future energy system. The main new sources are modern biomass, wind, photovoltaic, thermal solar, geothermal, and hydropower. Their share in the world energy supply was 10% in 2012 (REN 21, 2014).

Modern renewable have progressed impressively in developed countries during the recent years due to their environmental policies that determined quantitative targets for renewables, and also because of their innovation and industrial policies related to these technologies. In 2013, European Union and United States had 58.6% of the world renewable electric power generation capacity without hydro. However we notice also that a group of emerging economies is well positioned in the promotion of these new sources of energy. BRICS countries have a 28.9% share that is rapidly increasing mainly due to China. This country alone has the world largest wind power capacity (28.6%) in 2013. For solar thermal heating the Chinese hegemony is impressive with 64% of the world capacity. In hydroelectricity China also is first placed with 26% of the generation capacity, followed by Brazil (8.6%). More than being a world leader in power generation capacity, China also is at the forefront position for equipment supply. In Photovoltaic and Wind energy, Chinese companies are among the world leaders (REN 21, 2014).

Biomass is a very promising primary energy source for many developing countries. It is already an important energy source mainly due to traditional Biomass. In the future, modern biomass will increase its presence in the energy matrix (Goldemberg & Coelho, 2004). The leadership in modern biomass always belonged to developed countries. However, Brazil had been longtime the world leader for liquid biofuels. Nevertheless, more recently the Brazilian sugarcane ethanol lagged behind the USA corn ethanol. In 2013, US and Brazil accounted for 57.6% and 29.4% of the world bioethanol production. In the other kinds of biomass, developed countries still the world leaders like in biomass power generation, biogas and wood pellets, where European Union and United States are the world leaders (Ren 21, 2014).

In this paper, we would like to consider the effective potentials of a resource rich developing country to become a world leader in modern biomass supply and technology. Our argument is that, alongside favorable resources endowment, national innovation system requires continuous learning in order to advance in the absorption and the development of new technologies.

## **BIOMASS IN THE BRAZILIAN ECONOMY**

Brazilian economy has a very dynamic biomass production system. Biomass commercial production, not only connected with energy, and related industries had an impressive evolution in the present century. The production of grains rose from 100 million tons in 2000/2001 harvest to 198 million tons in 2014/2015, most of it soya and corn. Sugarcane expanded impressively from 254 to 642 million tons in the same period (CONAB, 2015). Other biomass activities are also expanding quickly. Cellulosic Pulp

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