Energy Policy 101 (2017) 170–184

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Energy contribution to Latin American INDCs: Analyzing sub-regional trends with a TIMES model

Sebastien Postic*, Sandrine Selosse, Nadia Maïzi

MINES ParisTech, PSL – Research University, CMA – Centre de Mathématiques Appliquées, France

ARTICLE INFO

Keywords:
TIMES
Latin America
Climate change
Energy
Prospective

ABSTRACT

Central and South America and the Caribbean countries share energy and climate features that are quite different from the rest of the world, including a highly renewable energy mix and very high renewable energy potentials, along with high deforestation and degradation rates which call for regional answers to regional issues. This paper assesses the impact of national contributions to the United Nations Framework Convention on Climate Change using an energy prospective model from the MarkAl/TIMES family. This approach enables a bottom-up comparison between past pledges (Nationally Appropriate Mitigation Actions) and the Nationally Determined Contributions (NDCs) agreed on at COP21. Long-term economic optimization leads to decarbonizing the power sector even in the absence of climate constraints. Stringent climate policies as modeled here achieve emission reductions of 40% below the current baseline by 2050. NDCs produce stronger emission reductions than NAMAs at regional scale; however, the first contributor to emission reductions in absolute terms in Latin America is the Agriculture, Forestry and Other Land-Use (AFOLU) sector, not energy.

1. Introduction

The most optimistic Representative Concentration Pathway (RCP 2.6) in the fifth IPCC Assessment Report predicts a 0.3–1.7 °C global mean temperature change in 2100, putting natural species and systems at risk, possibly triggering large-scale irreversible natural damage, and strongly impacting human activities (IPCC, 2014). In Central and South America and the Caribbean, the latest estimates point to a 1.5–5% GDP loss by 2050 in the case of a 2.5 °C global temperature increase (ECLAC, 2014).

On the other hand, the region represents a relevant share of global GHG emissions: 8.5% in 2010 (World Resources Institute, 2015), more than its share of the world's population (6.9% in the same year). Brazil already ranks fourth in the world when it comes to national contributions to global warming (Matthews et al., 2014) and a strong increase in GHG emissions can be anticipated in the years to come throughout the region on a BAU basis (Carvallo et al., 2014; Fundación Bariloche, 2008; van Ruijven et al., 2015).

Central and South America and the Caribbean (CSA-C later on) thus have a relevant role to play in mitigating global emissions. Most countries in the region proposed Intended Nationally Determined Contributions (INDCs) as a prelude to the Paris Climate Conference in December 2015. An evolution of the Nationally Appropriate Mitigation Actions (NAMAs) encouraged after the Copenhagen Accord in 2009, INDCs provided a flexible framework within which non-Annex I countries could pledge voluntary actions aimed at deviating from BAU emissions (Sharma and Desgain, 2014). As an outcome of COP21, these INDCs should automatically transform into NDCs (Nationally Determined Contributions) with the ratification of the Paris Agreement, unless a country decides otherwise. All Parties have not yet ratified the Paris Agreement as we write these lines; however, only two Central American countries (Belize and Panama) revised their initial submission[1] as of Sep 22nd, 2016; we will thus consider in the framework of this paper that all INDCs will eventually convert into actual NDCs.[2]

The energy sector shows promising potential to achieve GHG emissions mitigation worldwide (Akimoto et al., 2010) and CSA-C NDCs consider it extensively. However, this potential may remain below world averages (Bassi and Baer, 2009; Borba et al., 2012; Di Sbroiavacca et al., 2015), because of an already-renewable energy mix, fast energy growth –the electrification rate jumped from 75% in 2009 to around 90% in 2012 in Peru and Bolivia (CIER, 2013, 2011) – and the use of energy as a tool for domestic and international policy (Colgan, 2014).

* Corresponding author.
E-mail address: sebastien.postic@mines-paristech.fr (S. Postic).

[1] These two countries submitted in fact an NDC while ratifying the Agreement, without having previously proposed an INDC.

[2] A review of national NAMA and NDC submissions in CSA-C is given in Appendix A. For an up-to-date compilation of these pledges, the reader may refer to the UNFCCC website.

http://dx.doi.org/10.1016/j.enpol.2016.11.023
Received 30 May 2016; Received in revised form 23 September 2016; Accepted 16 November 2016

Given CSA-C's regional specificities, what can be the contribution of its energy sector to the fight against climate change? We present in Section 2 the past (NAMAs) and current (NDCs) pledges proposed by CSA-C's countries to the United Nations Framework Convention on Climate Change (UNFCCC), and derive five contrasted policy scenarios. In Section 3, we study these scenarios' impact, focusing on the energy sector, by means of a bottom-up energy prospective model.

We start by considering the specific case of the power mix then expand our study to the whole total primary energy supply, underlining the added value of NDCs in driving the energy transition in CSA-C. We also consider the links between the Afforestation, Forestry and Other Land-Use (AFOLU) sector, the energy sector and the fight against climate change in CSA-C, then conclude.

Let us highlight the fact that Mexico is not part of our geographical scope, as will be detailed in Section 2.1. However, the CLIMACAP multi-model comparison exercise which ended in December 2015 (van der Zwaan et al., 2016) proposed an extensive analysis of energy and climate change mitigation in South America, including one specific analysis for Mexico (Veysey et al., 2016). To our knowledge, our work is the first analysis of this kind conducted with a dedicated regional tool, yet our results mostly complement and support the findings of the CLIMACAP project for CSA-C.

2. Methods and scenarios

2.1. The T-ALyC model

The results presented and discussed in this paper are based on the T-ALyC model, standing for *TIMES para América Latina y el Caribe* (TIMES for Latin America and the Caribbean). T-ALyC is a bottom-up, linear representation of CSA-C's energy system, inherited from the *TIMES Integrated Assessment Model* TIAM (Loulou and Labriet, 2008; Ricci and Selosse, 2013; Syri et al., 2008); the full model is presented in detail in (Postic, 2015). T-ALyC describes the whole regional energy system from resource extraction to end-use energy demands, in what is called the *Reference Energy System* (RES). The RES, as displayed in Fig. 1, includes both existing and potential new technologies, that is, a portfolio of some thousands processes described through their physical features (efficiency, investment costs, O & M costs, life, emission factors, etc.) and the energy commodities they consume/produce. The model then optimizes the investment in, and operation of, energy processes so as to satisfy an exogenous energy

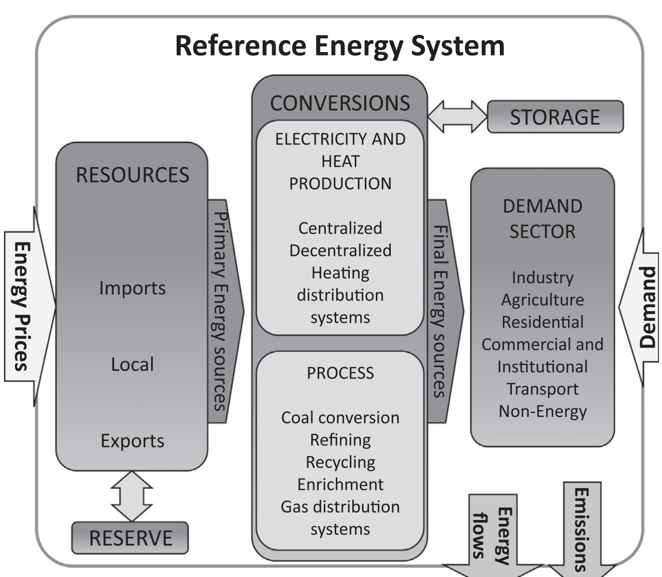

Fig. 1. Synthetic view of a TIMES Reference Energy System (Ricci and Selosse, 2013).

Table 1
T-ALyC geographical disaggregation.

Region name	Region description
AND	Peru, Ecuador
ARG	Argentina
BPU	Bolivia, Paraguay, Uruguay
BSE	Brazil – South and Southeast administrative regions
BWC	Brazil – North, Northeast and Center administrative regions
CHL	Chile
COL	Colombia
CYC	Central America and the Caribbean
SUG	Suriname, Guyana, French Guyana
VEN	Venezuela

service demand at the lowest possible cost. Demand satisfaction is subject to *resource constraints* (resource availability, extraction cost), *technical constraints* (physical balances, availability factors, etc.) and *non-technical constraints* (market penetration limits, policy scenarios, environmental specifications, etc.). For more information on the TIMES paradigm and its implementation, please refer to (Loulou et al., 2005). The outputs of our model are the evolution and final structure of the energy system, individual investment and operation costs for each modeled technology, process-related and fuel-related emissions and energy trade flows between model regions and with the rest of the world.

T-ALyC considers the entire Latin America and the Caribbean region, excluding Mexico. This geographical scope corresponds that of the so-called *Central and South America* region in TIAM-FR, allowing for result comparison and limited model coupling between the two models. T-ALyC relies on an *ad hoc* disaggregation of the area into 10 sub-regions (cf. Table 1 and Fig. 3) to address region-specific issues including the role of hydropower and interrogations about its future development, the current and future role of biofuels in the energy mix, challenges, opportunities and time dynamics of regional integration, climate and energy interactions, etc. The base year for model projections is 2010 and the end horizon is 2050. This time span is divided into 7 time periods of unequal length, centered around 2010, 2012, 2015, 2020, 2030, 2040 and 2050.

Energy potentials and end-use demands are calibrated based on a wide variety of sources, including (ALACERO, 2013; Garcés et al., 2012; Global Energy Observatory, 2013; Hoornweg and Bhada-Tata, 2012; IEA, 2014; IER, 2006; IMF, 2014; Riegelhaupt and Chalico, 2009; Smeets et al., 2007; UNDESA, 2012; UNEP, 2012; US-EIA, 2014; World Nuclear Association, 2008) and national sources. Base-year energy service demands are described in useful energy service units (e.g. ton-km for freight transportation) then projected through 2050 using exogenous projections for macroeconomic drivers such as GDP, population, number of households, etc. The full description of T-ALyC end-use demands is too large to be specified here; however, the interested reader may refer to (Postic, 2015) for a complete description of these demands and their drivers up to 2050. For this study, prices for energy commodity trade with the rest of the world are based on TIAM endogenous trade prices for its CSA region.

2.2. GHG emissions and storage in T-ALyC

The emission structure in CSA-C is quite different from the rest of the world. Brazil's national emission inventory reported, in 2016, GHG emissions from the energy sector that amounted to only 29% of total national emissions for 2010 (MCTI, 2016). By comparison, energy emissions for the European Union at the same date accounted for 80% of total emissions[3] (European Commission, 2014). This is mainly due

[3] Excluding AFOLU which is actually a sink rather than a source of CO_2 emissions in Europe.