ENVIRONMENTAL SCIENCE & POLICY 50 (2015) 62–73

Available online at www.sciencedirect.com

ScienceDirect

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

Tracking development paths: Monitoring driving forces and the impact of carbon-free energy sources in Spain

Tadhg O' Mahony [a,*], Javier Dufour [a,b]

[a] Systems Analysis Unit, IMDEA Energy Institute, Av. Ramón de la Sagra 3, 28935 Móstoles, Spain
[b] Department of Chemical and Energy Technology, Rey Juan Carlos University, 28933 Móstoles, Spain

ARTICLE INFO

Article history:
Available online 26 February 2015

Keywords:
Development path
Decomposition analysis
Carbon emissions
Spain
Renewables
Nuclear

ABSTRACT

The evolution of the national development path has gravity in determining the future emissions outcomes of all nations. Deep reductions in emissions require a focus not just on energy and mitigation policy but on factors underlying this development. The Kaya identity has been recommended to track national progress with respect to sustainability and carbon emissions in the development path. This study applies an extended Kaya identity to the energy-related carbon emissions of Spain. Implemented through a divisia index decomposition annually from 1990 to 2011, it highlights the impact of factors such as affluence and energy intensity. A marked departure from previous studies is the separation of the effects of the carbon-free energy sources; both renewables and nuclear as fundamental mitigation measures. The results show that affluence and population have acted to increase emissions and energy intensity was increasing until recent years. Fuel substitution has acted to decrease emissions but while renewable energy has reduced emissions with the increasing importance of biomass, wind and solar, the decline in share of nuclear has acted to increase emissions. Implications for the development path and policy are discussed and lessons are relevant both for industrialised and industrialising nations.

1. Introduction

The Copenhagen Accord, signed under the United Nations Framework Convention on Climate Change process in 2009, responded to the scientific assessments of climate change by agreeing a goal of limiting global warming to below 2.0 °C compared to pre-industrial levels. Meeting this stabilisation objective places particular responsibilities on Annex I industrialised nations to deliver radical reductions in greenhouse gas (GHG) emissions, of the order of −80% to −95% on 1990 by 2050 to reach lower stabilisation levels (Gupta et al., 2007). Non-Annex I will also require substantial deviation from baseline. Meeting this objective is fundamentally dependent not only on mitigation policy, but also crucially on the development path[1] in all countries. This has been

* *Corresponding author*. Tel.: +34 917371153; fax: +34 917371140.
E-mail address: tadhg.omahony@imdea.org (T. O' Mahony).

[1] Sathaye et al. (2007) defined a development path as; "...as a complex array of technological, economic, social, institutional, cultural, and biophysical characteristics that determines the interactions between human and natural systems...". It consequently describes the type of underlying development that occurs with factors related to sustainability and not just the energy or climate mitigation policy implemented.

http://dx.doi.org/10.1016/j.envsci.2015.02.005
1462-9011/

highlighted by successive assessment reports of the Intergovernmental Panel on Climate Change (IPCC) as the driving forces of carbon emissions are inherently linked to the underlying wider development path (Sathaye et al., 2007). It will be extremely difficult and expensive to reach low stabilisation targets without shifting to low emission development paths. It is therefore imperative that both Annex I and non-Annex I less industrialised nations must analyse, plan for and manage this transition in development. Development paths can be directed into lower emissions outcomes but must be framed as sustainable development rather than solely as climate mitigation according to Sathaye et al. (2007) and lessons must be shared. Sustainable development[2] involves multifarious issue domains and a plethora of techniques and indicators have evolved to measure progress in development paths. A commonly applied approach to environmental impacts is the $I = PAT$ (impact = population $\times$ affluence $\times$ technology) sustainability evaluation framework of Commoner (1972) and Ehrlich and Holdren (1972). The Kaya identity (Kaya, 1990) is a specific extension of this approach that analyses development progress with respect to energy and CO_2. At the Dublin workshop of the United Nations Framework Convention on Climate Change (UNFCCC) in 2004, a marked interest was noted in the Kaya decomposition analysis reported in the in-depth review of Germany. Based on studies such as Schleich et al. (2001) on the driving forces of emissions, this technique was recommended to explain problems and success stories, allowing quantitative assessment to separate effects on emissions from improvements in energy efficiency, changes in the energy supply mix, and growth in population and GDP (UNFCCC, 2004). The IPCC fifth assessment in its report on mitigation focussed on these novel identities as the organising principle in the general analytical framework (Blanco et al., 2014) thus greatly enhancing the profile and relevance of the approach implemented here.

Similar conceptual underpinnings can be found in the field of index decomposition analysis (IDA). Initial studies during the oil crises of the 1970s focussed on processes of change in industrial energy use. As a line of research, it has since expanded substantially in both methodology and application. It is now a widely accepted analytical tool for policymaking on energy and environmental issues (Ang, 2004). According to Steenhof et al. (2006), the decomposition of a pre-defined set of factors helps to understand the progression of driving forces, the impact of major processes occurring and policy dimensions tied to these processes. The scope of application of IDA has expanded beyond industry to energy and environmental analysis across countries and sectors.

As a large industrialised economy with a high standard of living and associated GHG emissions, understanding the progression of driving forces of Spanish CO_2 emissions provides useful insights into the development path. Spain was ranked 22nd in the global league table of national CO_2 emissions and 26th in terms of GHG in 2010, according to the *Emission Database for Global Atmospheric Research* (EDGAR) (JRC/PBL, 2014). As an Annex I signatory of the Kyoto protocol, and through European decisions on effort-sharing, it is subject to an emission limitation target of +15% on 1990 in the period 2008–2012, and a reduction by −10% on 2005 levels by 2020 (in the non-emissions trading scheme sectors). Spain has since breached its target with average emissions over the Kyoto period at +24% and will require the purchase of emissions credits to meet the shortfall (EEA, 2014). Energy-related CO_2 is the dominant contributor to national GHG emissions.[3] It grew to a peak in 2008 of 336,252 Gg (Fig. 1.), 63.10% higher than in the standard base year of 1990. Growth in gross domestic product (GDP) over this period was high, increasing by 68.12% to its peak in 2008 before the country entered recession (UNSD, 2013). The growing total primary energy requirement (TPER) accompanying this period of economic growth can clearly be seen in Fig. 2, as are accompanying changes in fuel shares.

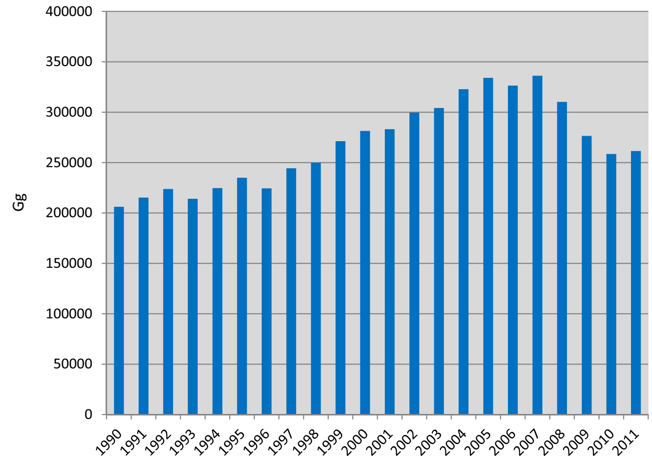

Fig. 1 – Total energy-related carbon emissions in Spain from 1990 to 2011 in Gg.
***Data source:* MAGRAMA (2013a).**

Apart from its economic growth path, Spain has a number of interesting characteristics in its energy profile. There is virtually no domestic production of oil and gas and indigenous refineries rely on imports. It is currently a large producer of wind energy, has an important hydro generation capacity, and has a nuclear programme stretching back to first commercial production in 1968. Subsidised domestic coal production has also played an important part, predominantly in power generation. Government subsidies were being phased out, but a renewal in 2011 and preferential access granted to the power market,[4] saw an increase in coal consumption that is evident in Fig. 2. The increases in Spanish carbon emissions observable over the analysis period will be a challenge to future emissions reduction objectives.

[2] With environmental, economic and social dimensions and includes both cultural and political change.

[3] Energy-related carbon emissions accounted for 77.5% of total GHG emissions in Spain in 2011 (MAGRAMA, 2013b).

[4] The Spanish government introduced domestic coal production subsidies and gave preferential access to the wholesale power market to coal-powered generators in an attempt to reduce dependence on imported coal.