How Could GHG Reduction Targets Beyond 2012 Influence Investments in Electricity Generation in Belgium

By Danielle Devogelaer and Dominique Gusbin*

Abstract

This article discusses the influence a specific (determined ex ante) target to reduce energy related CO_2 emissions in the period after 2012 initiates on the Belgian power generation system. In a first step, a baseline is defined in which current policy and ongoing trends and structural changes are supposed to continue. Over the period 2000-2030, the average electricity and steam production cost rise 36% and sector specific investments between 2006 and 2030 amount up to € 17 billion (expressed in €2000), covering the replacement of obsolete plants and the additional capacity needed to cope with surging demand (on average +1.0% per annum). In terms of energy CO_2, the most dominant greenhouse gas, the baseline foresees a growth by 32% compared to 1990, the base year of the Kyoto Protocol. In order to combat climate change, the energy scene depicted in the baseline is obviously not sustainable. The article then changes scope and sets a -15% target in comparison with 1990 on energy CO_2 emissions on Belgian soil to be reached by the year 2030. In order to accomplish this goal, three energy policy frameworks are examined. These frameworks are in fact different combinations of (the lack of) two energy technologies, namely nuclear power plants and carbon capture and storage (CCS). The impact of this -15% objective on the production of electricity and steam and more specifically on investments in the sector is scrutinized.

Introduction

The results presented in this article are based on quantitative analyses realised with the aid of the model PRIMES (NTUA, 2007). PRIMES is a partial equilibrium model that integrates energy supply and demand on a national or European level. Since it is a partial equilibrium model solely, the energy system is modelled and not the rest of the economy. It is principally conceived to build energy projections for the long term (up to 2030), to analyse scenarios and to study the impact of policies and measures that potentially can influence the energy system. Although numerous aspects of the energy system can be analysed with PRIMES[1], this article only focuses on the Belgian electricity sector through the examination of the capacity, capacity extension, average production costs, investments and CO_2 emissions.

As a starting point, a baseline or reference scenario is run. The reference scenario that is used for this analysis is the same as the one published in May 2006 by dg tren of the European Commission (CE, 2006). In the PRIMES baseline, energy developments are simulated on the basis of assumptions concerning, e.g., economic and social development, world energy markets and implemented policies. Starting from these assumptions, developments are driven by market forces so that efficient energy solutions are chosen whenever this is economic, taking into account significant discount rates including risk premiums.

In PRIMES, the indicators on CO_2 or the share of RES are modelling results that inform the policy process about the effects of policies or their absence. This approach enables the baseline to illustrate the gap between policy ambitions and what is already underway for delivering on these policy aspirations. This approach allows the baseline to be a valid reference case for the subsequent evaluation of the effects of energy and climate policies and measures. Such measures are modelled in the policy scenarios irrespective of their state of implementation (answering “what if” questions).

The policy scenarios chosen in this study are scenarios in which an energy CO_2 emission reduction target in Belgium is fixed and the effect of different energy policy options is investigated. In PRIMES, the installation of a constraint on emissions is equivalent with the introduction of a variable that reflects the economic cost imposed by this constraint. This variable is the marginal abatement cost (also called *carbon value*) associated with this constraint; it represents the cost to reduce the last unit of emissions that needs to be eliminated in order to reach the set emission target. The marginal abatement cost can also be seen as the emission permits’ price determined on a perfect market and of which the quantity corresponds to the constraint. The carbon value by hypothesis is unique for all sectors; it initiates changes in the relative prices of the different energy forms, reflecting by this the differences in the carbon content of fuels. These changes induce technological modifications/innovations and behavioural

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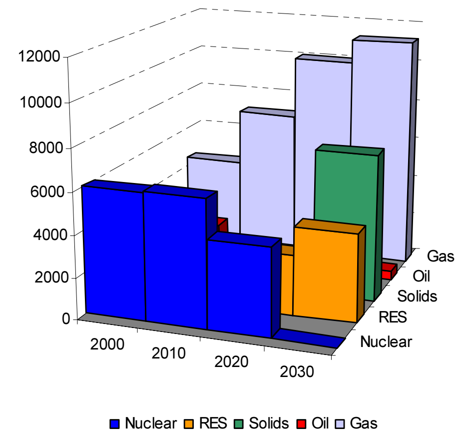
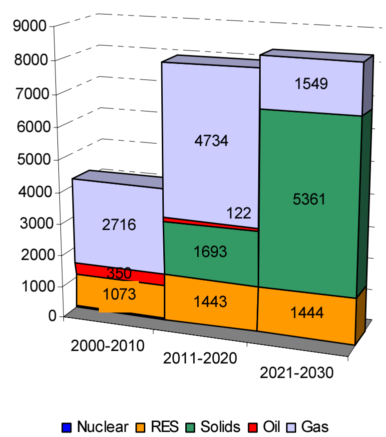


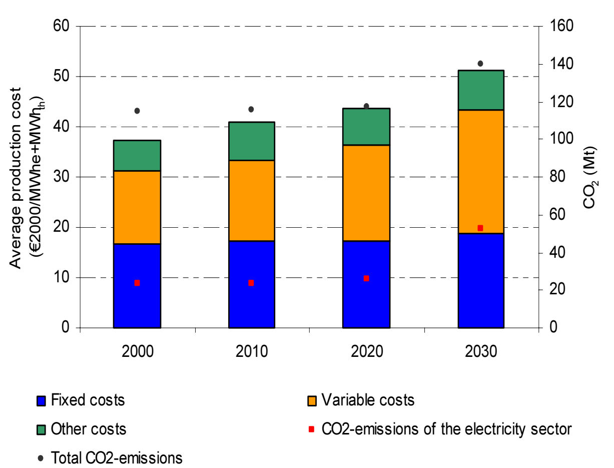
Source : PRIMES, FPB 2006b.
RES = renewable energy sources.

Figure 1
Installed Capacity for Electricity Generation, baseline (MW_e)



Source : PRIMES, FPB 2006b.
RES = renewable energy sources.

Figure 2
Electricity generation capacity expansion, baseline (MW_e)



Source : PRIMES, FPB 2006b

Figure 3 Average Power and Heat Production Cost vs. CO_2 Emissions, Evolution, baseline

adaptations of producers and consumers of energy.

Impact on the Belgian Electricity System of a CO_2 Reduction Objective

Starting from a projection of the Belgian energy system under unchanged policy (baseline), a Belgian defined objective to reduce energy CO_2 emissions in 2030 and different energy policy options, an evaluation of the impact of the realisation of this objective on the Belgian electricity sector is described.

Evolution of the Belgian Electricity System under Unchanged Policy

In order to analyse the Belgian electricity sector, a selection of indicators is chosen and subsequently discussed: the capacity (extension), the average electricity and steam production cost, investments and sectoral emissions. With the aid of graphical material, key messages are underlined.

Figure 1 shows the installed capacity allocated per energy form for the entire projection period (2000-2030). Under baseline assumptions, the nuclear installed capacity is gradually being phased out to have completely vanished by the year 2025, following the Belgian law of 2003 on the nuclear phase out[2]. The installed capacity of renewable energy sources (RES) shoots, partly because RES become competitive when fossil fuel prices increase, and partly because its intermittency dictates a strong capacity expansion in order to reach a certain production level, this level resulting from policies dedicated to the development of RES for the production of electricity. The installed capacity of solid (mainly hard coal) and gas fired plants also rises, essentially because the phased out nuclear baseload power plants have to be replaced. In 2030 the largest capacity is taken in by gas fired power plants.

Figure 2 depicts the capacity extension over the projection period: it immediately becomes clear that until 2020, mainly gas fired plants are built, whilst after 2020, the rise of supercritical coal becomes undeniable.

When it comes to the average production cost, an increase of 36% during the period 2000-2030 can be seen. This boils down to an annual growth of slightly more than 1% per year. Especially the last decade gives rise to an expansion of average production costs. This remarkable rise is due to, on the one hand, the huge investments in new power capacity in order to compensate for the deprivation of the fully amortised nuclear power capacity, and on the other hand, the strong increase in international energy prices (natural gas, coal). In 2030, the variable costs (amongst which fuel) make up more than half of the total average cost. Together with the rise in average costs, CO_2 emissions of the electricity and heat sector soar, leading to an overall increase in total CO_2 emissions.

Over the period 2006-2030, the investment expenses of the electricity sector[3] (combined heat and power included) reach approximately € 17 billion (expressed in €2000). These expenses cover at the same time the replacement of existing but obsolete plants and the additional production capacity necessary to meet the growing electricity demand.

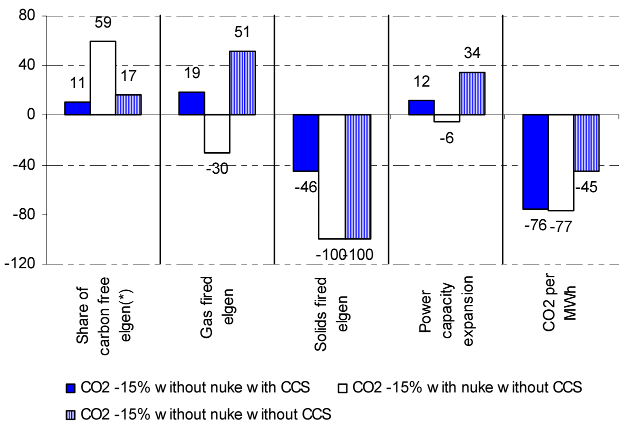
A Belgian Reduction Target in 2030

Figure 3 also showed that total CO_2 emissions in 2030 are 22% higher than in 2000 (and 32% higher than in 1990, the base year for the Kyoto Protocol). Since this is not reconcilable with the line of thinking as stated by the European Council on March 8 and 9 (20% reduction of all greenhouse gases in 2020 on a European level), we now place a constraint on the most dominant greenhouse gas, namely CO_2 emissions, and deduct its impact on the Belgian electricity system. Therefore, in what follows, it is assumed that Belgium fixes an objective to reduce its energy CO_2 emissions on its territory by 15% in 2030 compared to 1990. This choice is arbitrary in the sense that it does not result from a specific criterion to determine the Belgian share in the European burden sharing effort. Nevertheless, this objective can be imaginable if one compares it to the Belgian objective of -7,5% over the period 2008-2012[4] and if one takes into account the urge to intensify the reduction efforts at a longer time horizon. Three different energy policy orientations to reach the set objective of -15% of energy CO_2 are examined. These policy orientations are based on the (non) existence of 2 energy technologies: nuclear power plants and carbon capture and storage (CCS).

The first orientation takes into account the termination of nuclear power based electricity to conform with the calendar stipulated in the Belgian law on the nuclear phase out and assumes that CCS is not a feasible option in Belgium for the horizon 2030 (*scenario CO_2 -15% without nuke without CCS*). The second orientation also places itself in the framework of the nuclear shut down but leaves the possibility open to have CCS available in big (>300 MW) power plants burning coal or natural gas (*scenario CO_2 -15% without nuke with CCS*). Finally, the third option supposes that nuclear is allowed in Belgium for the entire period of projection, but that CCS is not available during that time horizon (*scenario CO_2 -15% with nuke without CCS*).

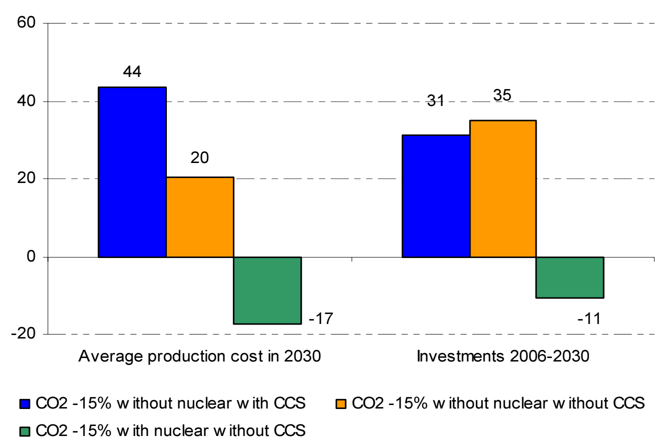
Turning to the impact this objective has on the Belgian power sector, we see a significant effect in all three scenarios. This effect results from the additional costs brought on by the carbon value (the cost of the last reduced ton of CO_2 through which the -15% reduction objective can be reached in 2030). The carbon value is a measure of the degree of ease or difficulty to fulfill the constraint and depends, amongst others, on the energy policy orientation. It is estimated to be 524 €/t CO_2 in the *CO_2 -15% without nuke without CCS* scenario, 123 €/t CO_2 in the *CO_2 -15% without nuke with CCS* scenario and 105 €/t CO_2 in the *CO_2 -15% with nuke without CCS* scenario. According to the carbon value and, underlying, the chosen policy options, the effect can vary strongly. Figure 4 illustrates this effect as a percentage (point) difference relative to the baseline.

The key messages are that the share of carbon free electricity generation is considerably higher in the *CO_2 -15% with nuke without CCS* scenario because nuclear energy is categorized as a non CO_2 emitting energy source. In the two scenarios in which CCS is not available, coal completely vanishes from the power picture because it has the highest carbon content which is severely punished by installing a carbon value. The capacity expansion in the non-nuclear scenarios is profoundly higher than in the baseline, essentially because of the strong representation of RES in these scenarios (the share of RES in power generation is 11 percentage points higher in the *CO_2 -15% without nuke with CCS* scenario and 17 percentage points higher in the *CO_2 -15% without nuke without CCS* scenario compared to the baseline). CO_2 emissions per MWh decrease considerably compared to the baseline, although the decline in the



Source : PRIMES, FPB 2006b.
(*) expressed in percentage points.

Figure 4
Some Electricity Production Related Indicators, Belgian Reduction Target for CO_2 Emissions, Year 2030, Difference with



Source : PRIMES, FPB 2006b.

Figure 5 Average Power and Heat Production Costs in 2030 and Sectoral Investments in the Period 2006-2030, Belgian Reduction Target for CO_2 Emissions, Difference with the Baseline (%)

CO_2 -15% without nuke without CCS scenario is somewhat lower because of the restricted reduction options in the power sector (this also means that reductions are relatively more important in the other sectors).

Figure 5 then summarizes the change in average production costs and investment expenses in the reduction scenarios relative to the baseline. The average production costs are depicted for the last year of the projection period, whilst the investments cover the period 2006-2030.

When a constraint is put on the energy CO_2 emissions in Belgium, the average production costs rise considerably, except when nuclear energy is part of the picture. In the non-nuclear scenarios, this cost increase can be explained by the cost of having to use specific technologies or having to switch to other fuels with lower carbon content but at a higher price.

In the scenario *CO_2 -15% without nuke without CCS,* average production costs in 2030 are 20% higher than in the baseline (64% higher than in 2000), while at the same time the power sector diminishes its CO_2 emissions by 48% relative to the baseline. The cost increase is the result of the following factors: the replacement of coal by more expensive natural gas, a larger production park in terms of installed capacity to take the intermittency of some RES into account and an electricity production level that is lower than the baseline's.

The *CO_2 -15% without nuke with CCS* scenario shows an even bigger increase in average production costs (+44% relative to the baseline, +96% relative to 2000), but on the other hand, emission reductions are also bigger than in the previous scenario (-76% in 2030 compared to the level in the baseline, against -48% in the previous scenario). This time, the costs brought about by the CCS technology are at the origin of the significant cost increase.

In the last scenario (*CO_2 -15% with nuke without CCS*), the average production costs also mount compared to 2000 (+13%), but stay below the level of the baseline and the non-nuke scenarios. Not surprisingly, this scenario can rely on the existing, fully amortised nuclear power plants to fill in large parts of its electricity generation (40%). Production costs of nuclear units are much lower than those of any new plant; this gap more than counterbalances elements that push up average costs, e.g., higher natural gas prices and extended use of intermittent RES.

Finally, between 2006 and 2030 investments in the reduction scenarios without nuclear energy are approximately one third above the level attained in the baseline. The scenario *CO_2 -15% without nuke with CCS* contains the CCS specific investments that can be considerable, in the scenario *CO_2 -15% without nuke without CCS* the RES share is significantly higher (in 2030 it reaches 45% of the installed capacity) and the total installed capacity is the highest of all scenarios (+30% compared to the baseline, +18% compared to the *CO_2 -15% without nuke with CCS* scenario and +7.5% compared to the *CO_2 -15% with nuke without CCS* in 2030). The option to keep the nuclear power plants into operation until the end of the projection period (the scenario *CO_2 -15% with nuke without CCS*) scales the investments down by 10% compared to the baseline.

Conclusion

In a nutshell, this article describes a Belgian baseline up to the year 2030 in which current policy and ongoing trends and structural changes endure, without any specific efforts or additional policies to constrain damaging greenhouse gases other than those already implemented by the end of 2004. In terms of power generation, the installed capacity will change dramatically: phase out of nuclear power plants, surge in gas fired plants, appearance of supercritical coal fired plants and a growing share of RES. Average production costs rise 36% and sector specific investments between 2006 and 2030 amount to € 17 billion.

In a second step, a CO_2 emissions constraint of -15% in 2030 relative to 1990 on Belgian soil is scrutinized for its impact on the Belgian power system. Three energy policy frameworks are examined, differing in the (lack of) utilization of two energy technologies, e.g., nuclear energy and CCS. According to the chosen energy policy, the power sector undergoes big changes (e.g., absence of coal in the non-CCS scenarios, way more gas fired plants in the non-nuke scenarios, …). Impact on average production costs and investments also depends on the adopted policy angle: compared to the baseline, costs and investments are higher when nuclear power is being phased out, lower otherwise. Investments are highest (+35% relative to the baseline) when neither energy technology is allowed.

Footnotes

[1] Interested readers are referred to Devogleaer and Gusbin (2007) and both 2006 studies of the Federal Planning Bureau for an overview on long term projections on all aspects of the Belgian energy system for a multitude of (policy) scenarios.

[2] Belgian Monitor, February 28, 2003, pp. 9879-9880.

[3] The investment expenses comprise all new CHP plants, but not the investments in transmission and distribution grids.

[4] For all greenhouse gases and compared with 1990 (1995 for the fluorinated gases).

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