Report of Projections

under the article 14th of the Regulation (EU) N.º 525/2013 of the European Parliament and the Council (Monitoring Mechanism Regulation)

Portugal

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Table of Contents

INTRODUCTION 4
ADDITIONAL INFORMATION ABOUT PROJECTIONS 4
General Information 4
Results of the Analysis of Sensitivity 5
Methodology 6

INTRODUCTION

The main purpose of this report is to meet the requirements of the article 14th of the Regulation (EU) N.º 525/2013 of the European Parliament and of the Council (MMR) of 21st of May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision n.º 28/2004/EC, which refers to the reporting of projections of Greenhouse Gases (GHG) of Portugal for 2020, 2025, 2030 and 2035.

ADDITIONAL INFORMATION ABOUT PROJECTIONS

General Information

The submitted GHG's projections data were obtained under the efforts of production of the National Program for Climate Change 2020/2030 (PNAC 2020/2030), which started in 2013 and finished in 2014. Thus for the time period of 2015-2030, the submitted data are identical of the 2015's submission under the article 14th of the MMR and for the year of 2035, we add an estimation of the data attained through the application of a linear extrapolation of the data set.

It should be noted that a new modeling exercise is under preparation, which has the year 2050 as the time horizon, and the main goals of this is to identify and analyze the several and potencial implications related with cost-effective paths to pursuit Portugal's GHG emissions neutrality by 2050 commitment, as well to identify the main vectors of decarbonisation related with the development of the Portuguese Roadmap for Low Carbon 2050 (RNBC-2050).

With regards to the projection parameters, this exercise does not present a total adhesion to those recommended by the European Commission (EC) in June 2016. However, it is clear that:

1. The carbon prices used (in euros at constant 2010/tCO_2) has the European Union Emissions Trading Scheme (EU ETS) as main data source. Nevertheless, this projection exercise differs from the 2016´s EC recommendation for 2020 and 2025 values, only converging in 2030;
2. Regarding the fuel prices (in euros at constant 2010/ boe), it should be made clear that the international values used are higher than those recommended in 2016 by the EC;
3. There is a significant difference in the population assumptions, with a slight increase in the population projections until 2030 (the 2016's EC recommended parameters specify a reduction);
4. There is a significant difference in the Gross Domestic Product (GDP) increase justified by the methodology applied, as we described below. Thus, the growth of 3% per year was considered until 2030, which diverge from a gradual decrease recommended by the EC.

Concerning the base year used in this exercise, it corresponds to the last year of the National Inventory Report (NIR) available at the time that the projections were made (year of 2011 of the 2013's NIR), for consistency purposes. For more information, please consider Table 1, which includes a brief comparison between the 2015's emission values obtained in this exercise and the inventory values submitted on January 15th of 2017.

For the Agriculture and Land Use, Land Use Change and Forestry (LULUCF), we use a set of projections made in 2011 during the production process of the RNBC-2050. For these projections we use the last available agriculture census (held in 2009).

Table 1:
Comparation of the 2015 GHG's emission values reported by the INERPA tool and projections (Mt CO_{2e})

(Mton CO_{2e})	**INERPA***	**Projections**
Total Emissions (excl. LULUCF)	68,7	70,5
Total Emissions (incl. LULUCF)	60,0	60,5
1. Energy	48,2	46,7
A. Combustion	46,9	45,5
1. Production of energy	18,3	18,2
2. Industry and Construction	7,9	7,0
3. Transportes	16,2	15, 7
4. Others sectores	4,4	4,6
B. Fugitive emissions	1,3	1,3
2. Industrial Process and other produts	7,6	6,1
3. Agriculture	6,6	8,5
4. LULUCF	-8,8	-10,0
5. Waste	6,4	9,2

* Submission of 15th of January of 2017

Within the framework of the PNAC's 2020/2030 production process, we carried out a forecast exercise of sectoral activity trajectories and their respective GHG's emissions, ie the Energy System (including production, consumption and transports), Agriculture, Waste and Waste Water and Fluorinated Gases. It was considered two socio-economic scenarios were considered (the High – *CA* - and the Low – *CB* – scenarios) and three policy scenarios with slightly different assumptions.

The results generated allow us to evaluate the potencial of reduction of the national emissions and the behaviour analysis involved several economic sectores in the political scenarios of the CA and CB socio-economic scenarios, which help us to identify some critical factors, trends and performances of the sectors in that time horizon.

So, this report should be considered as an evaluation exercise of the potential reduction over a projection of emissions in strictest sense of where Portugal may be in 2020/2030 based on current policies.

For reporting purposes the results under the CA scenarios are considered as they reflect the most straining conditions with regards to the evolution of emissions. So, the submitted values should be read as a maximum of potential emissions in the projection assumptions.

Results of the Analysis of Sensitivity

The following scenarios in the Analysis of Sensitivity should be consider as:

i) Socio-economic scenarios: High (annual increase of 3% of the GDP between 2020 and 2030) and Low (annual increase of 1% of the GDP between 2020 and 2030);
ii) Technological Evolution of the Electric Vehicles: should be assumed the optimism about technological characteristics of the electric vehicle with batteries in 2030 (will assure an equivalente mobility of the current vehicle propelled by fossil fuel);
iii) Portugal's renewables production potential for export are sustained by an increase of the interconnections which consider a maximization of the solar photovoltaic system.

The first exercise of analysis of sensitivity allow us to frame the emissions into the 2020/2030 time horizon, assuming that the national emissions will be somewhere between the identified emissions levels. The following table presents the attained global results.

Table 2

Summary of national emissions and projection results (Mt CO2e)

Mt CO_{2e}		1990	2000	2005	2010	2012	2020	2030
Total (Without LULUCF)	**High**	**61**	**84**	**88**	**71**	**69**	**59|60**	**51|54**
	Low							**44|47**
EU ETS	High	-	-	36	24	25	20|22	16|19
	Low							1#|15
Non-ETS	High	-	-	51	47	44	38	35|36
	Low							31|32

Source: National Program for Climate Change 2020/2030 (Council of Ministers Resolution n.º 56/2015 of 30th of july)

Regarding the electric mobility (vehicles):

i) The cost-effectiveness of the eletric mobility is an option limited by the costs that involve the eletric vehicles with batteries (BEV), namely the satisfaction of the long distance demand;

ii) Assuming the current outlook about electric mobility in Portugal, the main purpose is to evaluate the dimension of the barriers to insertion of the BEV (eg. the vehicle costs expectation).

iii) It was assumed that after the limitations with autonomy were overcome (offer a long distance mobility) the electric vehicle will became competitive, which introduced significant changes in the final consumption profile of the transports with an increased efficiency associated with the sector and a significant increase in the provision of mobility services by electric vehicles.

Concerning the scenario of exportation of renewable energy:

i) Once the perceived limitations are met, we can observe a substantial increase in the production of electricity by solar photovoltaic panels and the preserve of a marginal production by natural gas;

ii) Solar photovoltaic: in terms of installed capacity, the maximum allowed will be reach in 2030 and this will reflect into a decrease of the installed natural gas capacity;

iii) Onshore wind: the maximum capacity is not fully depleted, stabilising the install capacity in 2025;

iv) Concluding: an increase of electricity demand for export could be assured by the new generation of solar photovoltaic panels, a more efficient and cost effective technology (in 2030) than the current available and applied in this modelling exercise. It should be noted that the analysis of sensitivity only considers domestic demand and the results seem to prove the potential for exportation.

Methodology

The methodology for estimation of the GHG emissions from the activities are endless in the NIR document prepared by the Portuguese Environment Agency (APA).

Each activity sector has her own specific methodology for projection of their variables, properly framed by a single socio-economic scenario in order to guarantee the fully coherence of the achieved projections.

The socio-economic scenarios which support the projection exercise, in particular those relating the demand of energy services, agriculture and livestock activities plus waste, the reader should consider, until 2030, two different periods:

(i) **until 2020**: the economic development closely follows the International Monetary Fund projections, conditioned by the current national circunstamces and the short-term perspectives for the Portuguese economy, thus the generated updates to the scenarios used in the RNBC-2050;

(ii) **2020 to 2030**: the economic growth it is convergent with the RNBC-2050 and that factor ensure the consistency with this long-term exercise. So, the adopted macro economy scenario transposes to the trajectories the range (maximum and minimum) of the country's path. Are also considered the political, social or economic rupture elements that can define a structural change of the Portuguese economy. There are two national socio-economic scenarios: CA and CB, which assume two different economic (GDP growth: 3% per year and 1% per year, respectively) and social models (positive and negative population growth rates, respectively). These should be assumed as the upper and lower boundaries of the likelihood ratios of the verified results. For a more detailed description, please consult the Chapter A.3. SOCIO-ECONOMIC SCENARIOS FOR RNBC-2050[1].

It should be emphasized that the submitted projections although compliant a short-term trend of the available financial and economic information, not considering or anticipating future events but privileging long-term trends. A different degree of uncertainty is assumed throughout the time horizon, being lower for the period 2010-2020 and higher for 2020-2030.

The projection for energy services demand of the sectors (services, domestic, industry and transport) and materials (for some industries) is supported by certain variables such as sectoral Gross Value Added (GVA). For the present exercise was adopted the 2011's GVA structure.

Regarding the TIMES_PT, this is a technological model based on a linear optimization methodology which results from the application to Portugal of two items: optimization models of economy-energy and software TIMES[2].

About the structure of the TIMES model, that can be shaped to the needs of each user in order to simulate a specific energy system at different geographic scales (local, national or multi-regional). The TIMES_EN was initially developed under the NEEDS project, which integrated the pan-European TIMES model used to estimate the European total costs (including externalities) of energy production and consumption. The main purpose of this model is to meet the demand for energy services at the lowest plausible cost. To this end, options for investment and operation of certain technologies, primary energy sources, imports and exports of energy are considered simultaneously, according to the following equation [6]:

$$NPV = \sum_{r=1}^{R} \sum_{y \in YEARS} (1 + d_{r,y})^{REFYR-y} \bullet ANNCOST(r, y)$$

NPV= net updated value of total costs; *ANNCOST= annual total cost;* *d= refresh rate;* *r= geographic region;* *y= years;*	*REFYR= reference year for refresh;* *YEARS=* set of years for wich we can associate costs (the years within the modelling time horizon; the past years which we can associated costs; number of years related to a technology lifetime, if dismantling costs are considered).

For each year, the TIME's model calculate and update the sum of the total costs minus the profits. The TIMES_PT model considers all the investment, operation and maintenance (fixed and variable) costs of the several technologies of production and consumption of energy. Concerning the profits, the financial support and recovery of materials are not considered at TIMES_PT model.

The TIMES_PT represents the portuguese energy system from 2000 to 2050, including the following sectores:

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[1] http://www.apambiente.pt/_zdata/RNCB/EnergiaResiduos_10_07.pdf

[2] TIMES is an acronym for The Integrated Markal-EFOM System. Both Markal - MARKet Allocation and EFOM - Energy Flow Optimization Model are technology-based energy models developed by the IEA in the 1980s and 1970s respectively. This model was developed by the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency.

i. Primary energy offer (refining and sinthetic fuel production, endogeneous resources and importation of energy);
ii. Production of electricity;
iii. Industry (cement, glass, ceramics, steel, chemistry, paper and pulp, lime and others industries);
iv. Residential;
v. Terciary;
vi. Agriculture, forestry and fisheries (only energy consumption);
vii. Transports.

In each sector of energy, material and financial fluxes are associated several technologies related to production and consumption, including mass balances for some industrial subsectors. For a better understanding, please see the figure 1 which describe a simplified structure of the TIMES_PT model, their main inputs and outputs.

About the implementation process, this model requires a specific set of exogenous inputs, such as:

i. Energy services demand;
ii. Technical-economic characteristics of the technologies: base year and next years (eg. efficiency, input/ output ratio, availability factors, investment costs, operation, maintenance and technical update rate);
iii. Energy resources: present and future availability (potencial use of the endogeneus energy sources);
iv. Political constraints, such as: energy production purposes or emission reductions.

Founded on these elements, the TIMES_PT model generates a serie of outputs, such as:

i. Energy system associated costs;
ii. Sectoral energy fluxes;
iii. Technological options (installed capacity in eletricity production);
iv. Energy imports and exports;
v. Use of endogenous energy resources;
vi. Sectoral emissions.

In relation to the emissions, this model currently considered the emissions of GHG generated by combustion and industrial process, not including the fugitive emissions related to production, storing and distribution of fossil fuels and F-Gases.

It should be noted that the TIMES model does not consider economic interactions outside the energy sector, such as the implications for activity in other sectors of the economy (eg. the impact of wind power expansion in the metalworking sector) or the implications for the activity of national sectors dictated by changes in the international demand for its goods or service, since it is a model of partial equilibrium.

Furthermore, the TIMES_PT model don't consider the so-called irrational characteristics that could condition any investment in new and more efficient technologies (eg. preferences for aesthetics or social status that manifests itself mainly in the acquisition of end-use technologies). Thus, this model assumes that the agents have perfect knowledge of the market, present and future.

Finally, it should be stressed that technology-based models such as TIMES_PT do not accommodate market decisions based on price, but take options based on the cost of both technologies and energy resources. For this reason, the proposed solutions translate the best options in terms of cost-effectiveness and therefore competitiveness, lato sensu.

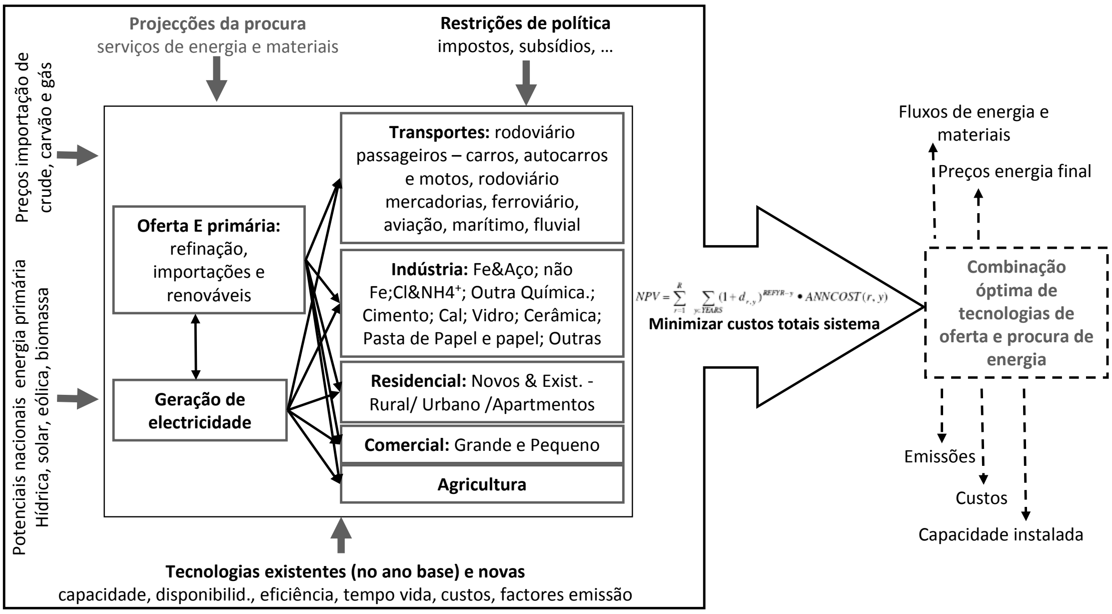

Figure 1:
Simplified structure of the TIMES_PT model

It should be noted that this model does not consider the current economic political tools, such as the Value-added Tax (IVA) and Tax on Petroleum Products (ISP), because the main purpose is to identify the cost-effectiveness technological solutions wich sustain this exercise.

Another point to note is the fact that electricity exchanges with Spain are not modelled because these are mainly based on market decisions and the TIMES_PT model is not the appropriate tool to accommodate them. So, it is assumed a zero balance with Spain from 2025 according to the National Eletric Network's (REN) outlooks.

The availability of hydroelectric plants throughout the modeling period is considered an equivalent to a mean hydraulicity (average year, eg. 2006, HPI = 0.8). Is also considered a maximum limit of 85% for the use of natural gas in the domestic and tertiary sectors, due to the limitation of access to the distribution infrastructure.