

## Chapter 8

# Modeling the Influences of Heating Fuel Consumption in Gaseous Emissions and Solid Waste Generation

**Robert Baťa**

*University of Pardubice, Czech Republic*

**Ticiano Costa Jordão**

*University of Pardubice, Czech Republic*

### ABSTRACT

*The chapter deals with the modeling of materials and energy flows associated with different types of heating fuels used in the household sector in the Czech Republic in order to assess the material flow balance from heating energy consumption by all dwellings in the Czech Republic. Statistical data on heating fuel consumption was gathered and Petri net models were used to quantify the variety and amount of resulting air pollutant emissions and solid waste generated. The results indicate that a particular net with a type Place-Color is the appropriate for modeling these processes, because the model is optically identical to the schematic representation of modeled flows.*

### INTRODUCTION

In 2008, the world primary energy consumption – including oil, natural gas, coal, nuclear and hydro power – grew by 1.4%, the slowest growth since 2001. The production growth exceeded that of

consumption for all fossil fuels, particularly later in the year. This evidence is related to the high price of energy combined with the global recession observed in the past few years and peaked in July and September 2008, respectively. Over the whole 2008, average prices for all forms of primary energy increased significantly, with annual oil prices rising for a seventh consecutive year. The

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Asia-Pacific region leaded by China accounted for 87% of the world's energy consumption growth. The primary energy consumption by Non-OECD countries exceeded OECD countries consumption for the first time (British Petroleum, 2009, pp.1-2).

It is well known that energy consumption, particularly of fossil fuels, can have a significant impact on the environment such as air pollution (e.g., photochemical smog caused by increase in ground level ozone), ecosystem acidification, eutrophication in aquatic habitat, and global warming, all followed by severe impacts to flora and fauna species. The most important emissions generated by fossil fuel energy consumption are particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), sulfur oxides (SO<sub>x</sub>) and volatile organic compounds (VOC). Among the environmental impacts aforementioned, the global warming caused mainly by CO<sub>2</sub> emissions imposes the strongest pressure on government authorities worldwide due to possible harmful associated global climate change. For this reason, a growing concern over reducing the greenhouse gas emissions by replacing fossil fuel with renewable energy sources (RES) and energy efficiency measures have grown. Such a concern has been translated into the Kyoto Protocol signed in 1997 and entered into force in 2005 with the objective to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (United Nations Framework Convention on Climate Change, 1992, article 2).

According to Kyoto Protocol, signatory industrialized countries listed in Annex I commit themselves to reduce collectively the greenhouse gas (GHG) emissions by at least 5% below 1990 levels in the commitment period 2008 to 2012. The gases are: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons and perfluorocarbons (United Nations, 1998). In the time the Kyoto Protocol was signed, the European Union (EU) had only 15 member countries.

These countries have established a joint commitment to reduce their collective GHG emissions in the period 2008-2012 to 8% below the levels in a chosen base year (1990 in most cases). This collective commitment has been translated into differentiated national emission targets for each EU-15 member state which are binding under EU law. There is no collective target for EU-27 emissions. Ten of the twelve member states which joined the EU in 2004 and 2007 have individual commitments under the Protocol to reduce their emissions to 6% or 8% below base year levels by 2008-2012. Only Cyprus and Malta have no emission target.

The European Union has taken a leading position on the global transition to a low-carbon economy in various sectors. On March 2007, the European Council (EC) endorsed an integrated climate change and energy package with an agreed target to reduce GHG emissions by 20% by 2020 (or 30%, if other developed countries join a global post-2012 climate change agreement), increase the EU contribution from renewable energy to 20% of the total final energy consumption and a target to increase energy efficiency by 20% against the baseline year 2005 (European Commission, 2007). The EC proposed a series of legislative measures on January 2008 to implement the energy package (EC, 2008a).

The residential sector is one of the sectors with the highest potential for energy efficiency, mainly through measures to reduce the heating/cooling demand in buildings. Notwithstanding the significant potential for cost effective savings, energy consumption in the household sector has been increasing. In Europe, the residential sector represented 26.6% of the final energy consumption in 2005. When considered altogether, the current 27 Member States of European Union (EU-27) have registered an average annual increase of 1.0% in the absolute level of final household energy consumption during the period between 1990 and 2005. On the other hand, the final energy consumption of households per m<sup>2</sup> decreased annu-

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