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Impact evaluation of biomass used in small combustion activities sector on air emissions

Analyses of emissions from Alpine, Adriatic-Ionian and Danube EU macro-regions by using the EDGAR emissions inventory

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Abstract

The emissions from small stationary combustion activities sector, in particular from the energy needs for residential buildings, have significant shares in total emissions of EU28. Therefore, measures to mitigate the emissions from this less regulated sector related to implementation checking are needed. In this study, we analysed the changes in fuel mix for this sector over 1990-2012 period, the emissions and their distribution over the areas covered by European Union Strategy for Alpine macro-region (EUSALP), European Union Strategy for Adriatic and Ionian macro-region (EUSAIR) and European Union Strategy for Danube macro-region (EUSDR). The emissions gridmaps of fine particulate matter (PM2.5), black carbon (BC) and benzo(a)pyren (BaP) are presented for the year 2010; in specific circumstances, these pollutants are known to produce negative effects on health. For this research, we used the data and information of the Emissions Database for Global Atmospheric Research (EDGAR) versions v4.3.2 and v4.tox3.

Accurate emissions estimates are important to evaluate the impacts of fuel combustion in small stationary combustion activities sector on air quality, human health and crops. Inventories of GHGs, air pollutants and toxic pollutants included in EDGAR are developed by using, as input, fuel consumption from IEA (2014) and emissions factors from scientific literature and official guidebooks such as EMEP/EEA (2013). Working together with emissions inventory experts from selected countries in these macro-regions, the effects of improvements of fuel consumption statistics, biomass in particular, on emissions in the latest years have been quantified by comparing EDGAR data with national data.

Besides sectorial emissions estimation, the emissions distribution is also important in the inventory development process. In order to distribute emissions consistently for all countries included in Alpine, Adriatic-Ionian and Danube macro-regions, the EDGAR team upgraded the WEB-based gridding tool with a module for small stationary combustion activities. Emissions estimation and distribution are key elements in preparing a complete input for chemical transport models and further evaluate the impacts of these emissions on air quality, health and crops.

This report aims to provide the policy makers and scientists insights on the representativeness and uncertainty of local emissions from the residential sector that play an important role on air quality. These datasets can be used as input for the atmospheric chemical transport models for air pollutants and can illustrate the importance of emission inventory uncertainties and discrepancies.

1 Introduction

The small combustion activities sector, which is less regulated compared to large combustion plants sector, includes combustion units with thermal capacities: less than 50 kWth, between 50 kWth and 1 MWth and between 1 MWth and 50 MWth. These ranges cover stationary combustion activities in residential, commercial and agriculture subsectors. Appliances used in this sector are fireplaces, stoves, small boilers and medium-size boilers (EMEP/EEA, 2013).

Substantial quantities of pollutants such as particulate matter (PM10, PM2.5), CO, polychlorinated dibenzo-p-dioxins (PCDDs)/ polychlorinated dibenzofurans (PCDFs), black carbon (BC), organic carbon (OC) and polycyclic aromatic hydrocarbons (PAHs) are emitted due to incomplete combustion of solid fuels in small combustion installations. Besides technology, the combustion control measures, i.e., fuel quality, temperature control and air distribution could contribute to emissions mitigation; important elements are also operational practices and maintenance.

According to EEA (2016), in 2014, the shares of emissions from small combustion activities sector in total emissions of EU28 were 50% for PM2.5, 35% for PM10, 38% for CO, 36% for PCDDs/PCDFs, and 52% for total PAHs. PAH group includes: benzo[a]pyrene (BaP), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF) and Indeno[1,2,3-cd]pyrene (IcdP)); BaP, an indicator for carcinogenic effects of PAHs, accounted for about 70% in total BaP emissions of EU28 (EEA, 2016). Outdoor and indoor exposure to these pollutants lead to negative health effects such as lung cancer. However, the risks to health associated to the emissions from small combustion activities depend on the level of exposure, at what age the person is exposed and how long and how often a person is exposed.

The EU Directives on air quality provide the air quality standards for the protection of health, e.g. for calendar year, the limit values are 40 µg/m3 for PM10, 25 µg/m3 for PM2.5, 40 µg/m3 for NOx and 1 ng/m3 for BaP. Furthermore, the WHO provides the reference levels of 20 µg/m3 for PM10, 10 µg/m3 for PM2.5, 40 µg/m3 for NOx and 0.12 ng/m3 for BaP, which are lower than the limits values provided by EU Directives for most of the pollutants (EEA, 2017a). Regarding PAHs and other Persistent Organic Pollutants (POPs), measures to protect human health and environment worldwide are included in the Protocol on Persistent Organic Pollutants (UNECE, 1998) of the Convention on Long-range Transboundary Air Pollution (UNECE, 1979) and the Stockholm Convention on Persistent Organic Pollutants (UNEP, 2001).

This study, which is developed in the framework of the MARREF project/Connectivity workpackage, focuses on the impact of fuel used in small stationary combustion activities (named here after "small combustion") on air emissions. The areas covered by this analysis are those included in Alpine, Adriatic-Ionian and Danube macro-regions as they are defined in European Union Strategy for the Alpine Region (EUSALP), European Union Strategy for the Adriatic and Ionian Region (EUSAIR) and European Union Strategy for the Danube Region (EUSDR). In section 2, we provide the definitions of EU macro-regions and in section 3, we describe the EDGAR methodology used for emissions estimation and distribution. The results of the analyses of fuel mix changes by country, technology and emissions factors, and emissions levels and gridmaps, including a comprehensive comparison of EDGAR emissions with national emissions from some countries, are provided in section 4. Section 5 describes the EDGAR.grid2 Web-based gridding tool, module for emissions distribution from small combustion activities and in section 6 are presented the conclusions and main findings of this study.

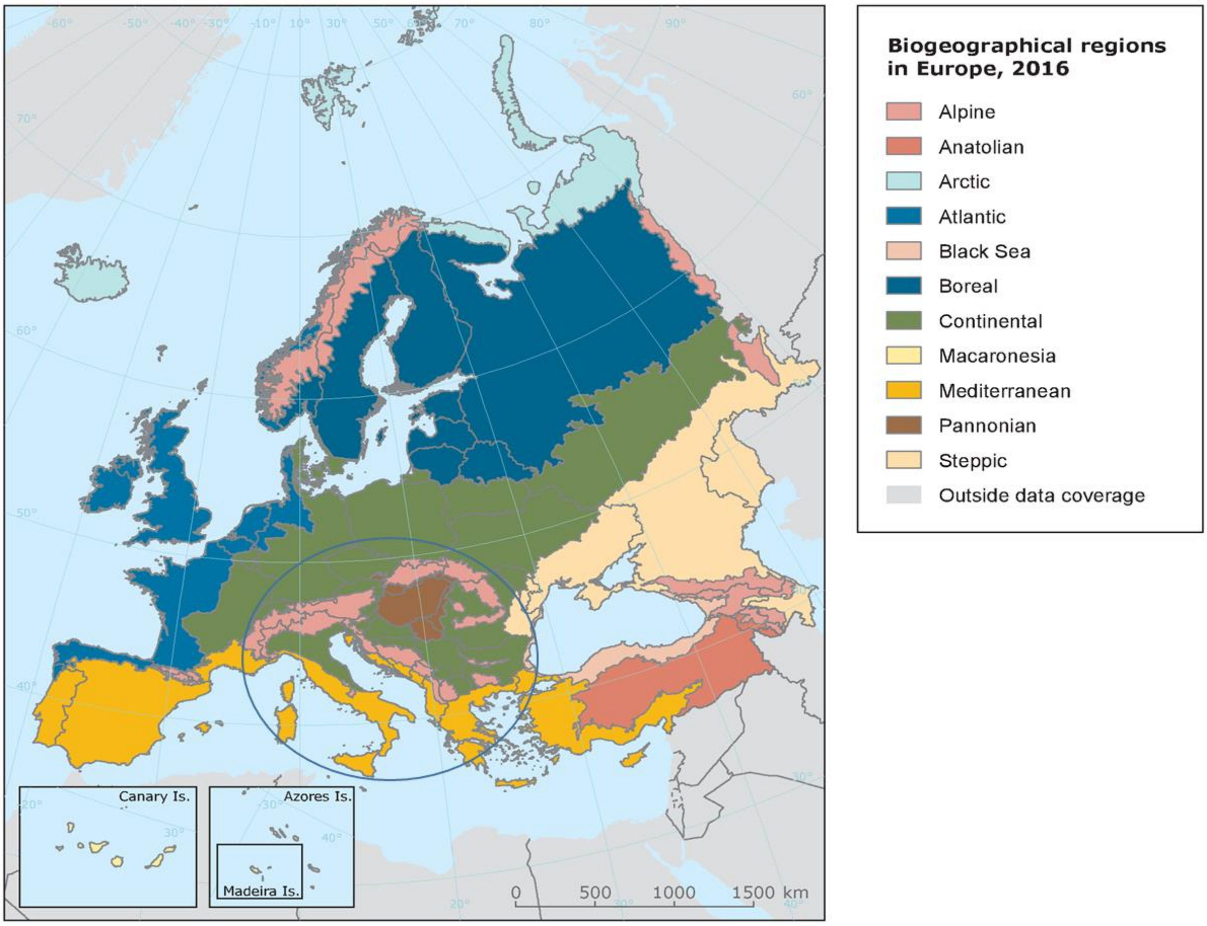
2 Alpine, Adriatic-Ionian and Danube EU macro-regions: definition

As defined by European Commission (EC, 2014), a macro-regional strategy is an integrated framework endorsed by the European Council, which may be supported by the European Structural and Investment Funds among others. The aim is to address common challenges faced by a defined geographical area relating to Member States and third countries located in the same geographical area, which thereby benefit from strengthened cooperation contributing to achievement of economic, social and territorial cohesion.

Four European Union macro-regional strategies have been adopted; the EU Strategy for the Baltic Sea Region in 2009, the EU Strategy for the Danube Region (EUSDR) in 2010, the EU Strategy for the Adriatic and Ionian Region (EUSAIR) in 2014 and the EU Strategy for the Alpine Region (EUSALP) in 2015. These strategies include different policies that are of interest for these macro-regions targeting also issues related to sustainable development focusing on approaches that integrate different aspects such as economy-environment-mobility.

In this study, we focus on the Alpine, Adriatic-Ionian and Danube macro-regions only. They are characterized by economic, social and cultural diversity, and are important natural areas in Europe with flora and fauna richness (see Figure 1).

Figure 1. Status of the Biogeographical Regions in Europe, 2016



Source: (EEA, 2017b; http://www.eea.europa.eu/legal/copyright).

These three macro-regions, for which the maps are provided in annex I) include EU and non-EU countries as following:

- EUSALP covers Slovenia, Austria, Switzerland and Liechtenstein as full countries and some regions from Italy, Germany and France. Part of EUSALP are provinces from north Italy: Liguria, Piemonte, Valle D'Aosta, Lombardia, Veneto, Trento, Bolzano and Friuli-Venezia Giulia, from south Germany: Freiburg, Tubingen, Schwaben, Oberbayern, and from east France: Alsace, Franche-Comte, Rhone-Alpes and Provence-Alpes-Cote D'Azur (see Figure 35 in annex I).
- EUSAIR covers Slovenia, Croatia, Serbia, Bosnia and Herzegovina, Montenegro, Albania and Greece as full countries and part of Italy with the following provinces: Bolzano, Trento, Friuli-Venezia Giulia, Lombardia, Veneto, Emilia-Romagna, Marche, Umbria, Abruzzo, Molise, Puglia, Basilicata, Calabria and Sicilia (see Figure 36 in annex I).
- EUSDR covers Slovenia, Croatia, Serbia, Bosnia Herzegovina, Montenegro, Austria, Bulgaria, Czech Republic, Hungary, Slovakia, Moldova and Romania as full countries and the following provinces from Germany: Freiburg, Tubingen, Schwaben, Oberbayern, Niederbayern, Oberpfalz, Oberfranken, Unterfranken, Stuttgart and Karlsruhe provinces and from Ukraine: Zakarpats'ka, Ivano-frankivs'ka, Chernivets'ka and Odes'ka (see Figure 37 in annex I).

As the increase use of renewables and ensure access to affordable and clean energy (while considering sustainability criteria) are on the policy makers agenda not only in Europe but also worldwide (e.g. SDG 7 of the UN), the impact of these changes should be investigated. In this study, we analysed the emissions by fuel type from small combustion activities, residential subsector in particular, and their spatial distribution focusing on areas covered by these three macro-regions.

3 EDGAR methodology

3.1 Emissions estimation for small combustion activities

The Emissions Database for Global Atmospheric Research (EDGAR) includes emissions of greenhouse gases (GHGs), air pollutants (APs) and toxic pollutants such as mercury (Hg) and persistent organic pollutants (POPs) for all world countries. The activity data from international statistics and emissions factors from scientific literature and official guidebooks are used as input to estimate these emissions in the EDGAR database; full description of the methodology is provided in Janssens-Maenhout et al. (2017) and Muntean et al. (2014).

In this study, we analysed emissions of fine particulate matter (PM2.5) and black carbon (BC) of EDGARv.4.3.2, and benzo [a] pyrene (BaP) of EDGARv4.tox3 from small combustion activities in Alpine, Adriatic-Ionian and Danube EU macro-regions. These pollutants, which are specific to household heating, are known for their adverse impacts on human health. The following equation 1 is used to estimate these emissions; activity data (AD) are from IEA (2014) and emissions factors (EF) from EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2013); extended equation is provided in Janssens-Maenhout et al. (2017).

$$EM_i = AD * EF_i \quad (1)$$

Where:

- EM_i is emission of pollutant i,
- AD is the fuel used in this sector associated to a certain technology,
- EF_i is the technology-specific and fuel-specific emission factor for pollutant i.

The technologies and emissions factors used in EDGAR to estimate emissions for this sector are described in section 4.2.

3.2 Emissions distribution for small combustion activities

Besides sectorial emissions as totals by country, EDGAR provides also emissions gridmaps of 0.1x0.1 degree resolution; the methodology for spatial distribution is described in Janssens-Maenhout et al. (2012, 2017). Important to be mentioned is the fact that the EDGAR grid is bottom left corner type, therefore, the emission assigned to the (lat_i, lon_i) point is the emission distributed in the cell assigned to this point. Further, 1) if a cell belongs to many countries, a percentage will be assigned to each of those countries. 2) if sea area, international waters, is part of the cell the entire emission in the cell will be allocated to the country(s), except for coastal fishing fuel combustion, where the maritime boundaries are considered.

Here, we provide a brief description of the methodology used for emissions distribution from small combustion activities (1.A.4 in EMEP/EEA guidebook classification).

For emissions distribution, three main source categories are considered: point, line and area sources. As for all area sources in EDGAR, the emissions from small combustion activities are distributed using equation 2.

$$EM_{cell,pi} = (EM_{country,pi}) * {}^{PROXY_{cell\_pi}}\!/_{PROXY_{country\_pi}} \quad (2)$$

Where:

- $PROXY_{cell\_Pi}$ is proxy associated to the pollutant pi, inside the cell (e.g. population), $PROXY_{country\_Pi}$ is proxy associated to the pollutant pi, as total by country,
- $EM_{cell,pi}$ is pollutant pi, emission inside the cell
- $EM_{country,pi}$ is pollutant pi, emission as total by country.

For small combustion activities (1.A.4), EDGARv4 uses the following proxy to distribute emissions from small combustion activities sector:

- Population from CIESIN (http://sedac.ciesin.columbia.edu/); datasets of CIESIN from 1990 until 2015 with a time step of 5 years: Global Rural-Urban Mapping Projec (GRUMP) v3 with a grid map of 30 seconds resolution.
- In house EDGARv4 proxy: 1) Urban population, 2) Rural population and 3) Fishing. The emissions generated by fuel combustion in fishing activities (EDGAR code RCO.FSH, IEA code FISHING) are distributed in EDGAR considering both inland waterways and sea fishing areas. The latest proxy is derived from Bathymetry map and Maritime Boundaries Geodatabase.

In Table 1 are presented the proxy data (right column) associated to the EDGAR codes (left column) for small combustion activities sector. The coupling matrix between EDGAR codes and the description of the subsectors in EMEP/EEA (2013) is provided in Table 2.

Table 1. Proxy associated to EDGAR codes.

EDGAR codes	Proxy data
RCO.FSH (all fuels(1))	Fishing
RCO.AGR (all fuels)	Rural population
RCO.COM: dung, municipal waste non-renewable, peat, vegetal waste, primary solid biomass	Rural population
RCO.COM: natural gas	Urban population
RCO.COM: rest of the fuels	Total population
RCO.RES: dung, municipal waste non-renewable, peat, vegetal waste	Rural population
RCO.RES: natural gas	Urban population
RCO.RES: rest of the fuels and primary solid biomass	Total population
RCO.OTH: dung, municipal waste non-renewable, peat, vegetal waste	Rural population
RCO.OTH: natural gas	Urban population
RCO.OTH: rest of the fuels and primary solid biomass	Total population

(1) 58 fuel types are defined and used in EDGAR for emissions calculations (see Table 7).

Source: EDGARv4.3.2.

Table 2. Coupling matrix: EDGAR vs EMEP/EEA codes

EMEP/EEA		EDGAR codes
Small combustion	1.A.4.i	RCO
Commercial/Institutional	1.A.4.a.i	RCO.COM
Residential	1.A.4.b.i	RCO.RES
Agriculture/Forestry/*Aquaculture*	1.A.4.c.i	RCO.AGR and *RCO.FSH*
Other (stationary combustion)	1.A.5.a	RCO.OTH

Source: EDGARv4.3.2 and EMEP/EEA (2013).

4 Results: activity data, emissions factors and emissions

The fuel mix for each country belonging to the Alpine, Adriatic-Ionian and Danube macro-regions is described in this section. Further, we explained the relevance of fuel type and technology used in small combustion units for emissions estimation. Finally, the emissions of PM2.5, BC and BaP from small combustion activity sector, the emissions gridmaps of 0.1°x0.1° resolution, including emissions gridmaps by fuel and emissions per capita are discussed for the countries and provinces covered by the EUSALP, EUSAIR and EUSDR.

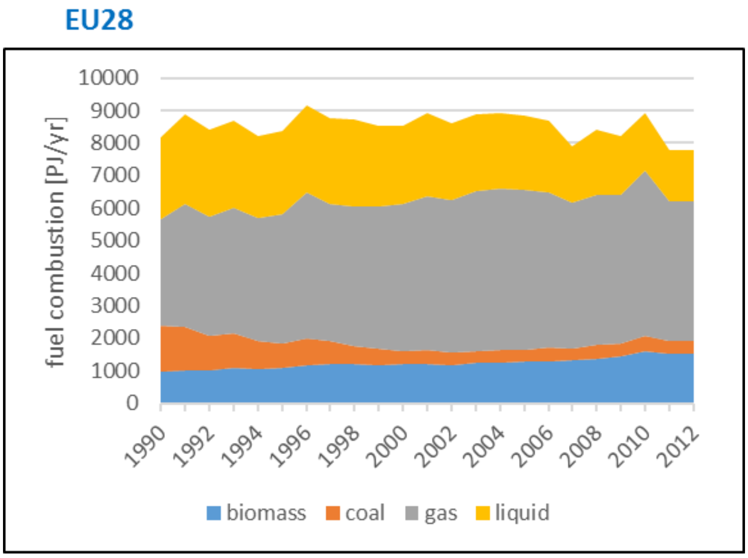
4.1 Activity data

Fuel used in combustion units represent the activity data (AD) for small combustion activity sector. In order to emphasize better the contribution of biomass in fuel mix of a specific country, here we analyse the fuel mix for residential subsector only; the appliances used in household heating and cooking such as fireplaces, stoves and small boilers are less efficient than the medium-size boilers that are more used in commercial and agriculture subsectors. This analysis focuses on EU28, OECD Europe and Central Europe, and provides details for each country in Alpine, Adriatic-Ionian and Danube macro-regions that is also included one of these world regions.

As mentioned, the data on fuel consumption in residential subsector are from International Energy Agency (IEA, 2014). For this analysis, the fuels used in EDGAR (58 types) were aggregated in 4 classes: "biomass", "coal", "gas" and "liquid", In order to separate fossil fuel from renewable fuel, the "solid" fuel from which most of the air pollutants are emitted was split in "coal" and "biomass"; the latter is considered a renewable energy source. For example, the consumptions of charcoal, dung, industrial waste, municipal waste renewable, primary solid biomass, vegetable waste and wood are aggregated under "biomass"; for details regarding the rest of the fuels and classes see Table 7.

In the EU28, the energy demand in residential decreased 5% in 2012 compared to 1990. Regarding fuel mix, for the same period, it changed to more gas and biomass; the gas increased by 30% and biomass by 57% whereas coal decreased by 72% and liquid fuel by 38% as illustrated in Figure 2.

Figure 2. Fuel mix in residential subsector: EU28

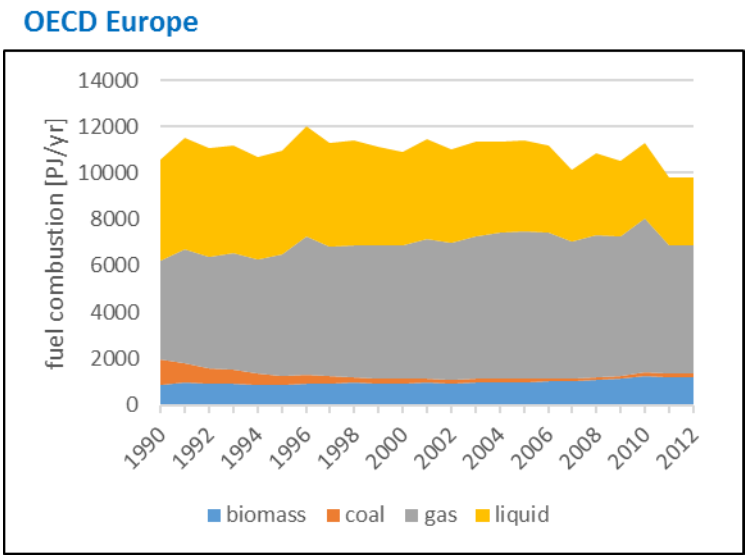


Source: EDGARv4.3.2 (IEA, 2014).

Fuel mix in residential subsector for both OECD Europe and Central Europe world regions, as they are defined in the IMAGE model (full description of the 24 world regions is provided in Bouwman et al., 2006), are illustrated in Figures 3 and 4.

For OECD Europe countries (all together, see footnote 1 at page 11), the energy demand in 2012 compared to 1990 decreased by 8%. The gas consumption in residential subsector increased by 31% and had shares in fuel mix of 40% in 1990 and of 57% in 2012. The biomass increased 37% and changed its share in total fuel combustion in residential subsector from 8% in 1990 to 12% in 2012. Instead, coal decreased 85% and its share in total fuel consumption in this subsector changed from 10% in 1990 to only 2% in 2012 (see Figure 3).

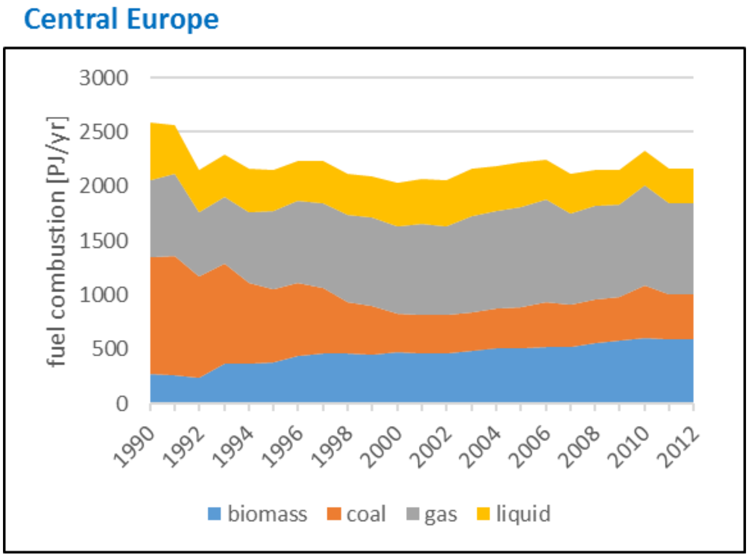
Figure 3. Fuel mix in residential subsector: OECD Europe



Source: EDGARv4.3.2 (IEA, 2014).

For countries in Central Europe (all together, all together, see footnote 2 at page 14), the energy demand in residential subsector decreased by 17% in 2012 compared to 1990. Biomass consumption significantly increased (113%) shifting from a share in total fuel consumption in household of 11% in 1990 to a share of 27% in 2012. Gas increased 19% reaching the greatest share of 39% in 2012. Coal and liquid fuels decreased by 61% and 40% respectively and their shares changed from 42% to 19% and from 20% to 15% for the same years.

Figure 4. Fuel mix in residential subsector: Central Europe



Source: EDGARv4.3.2 (IEA, 2014).

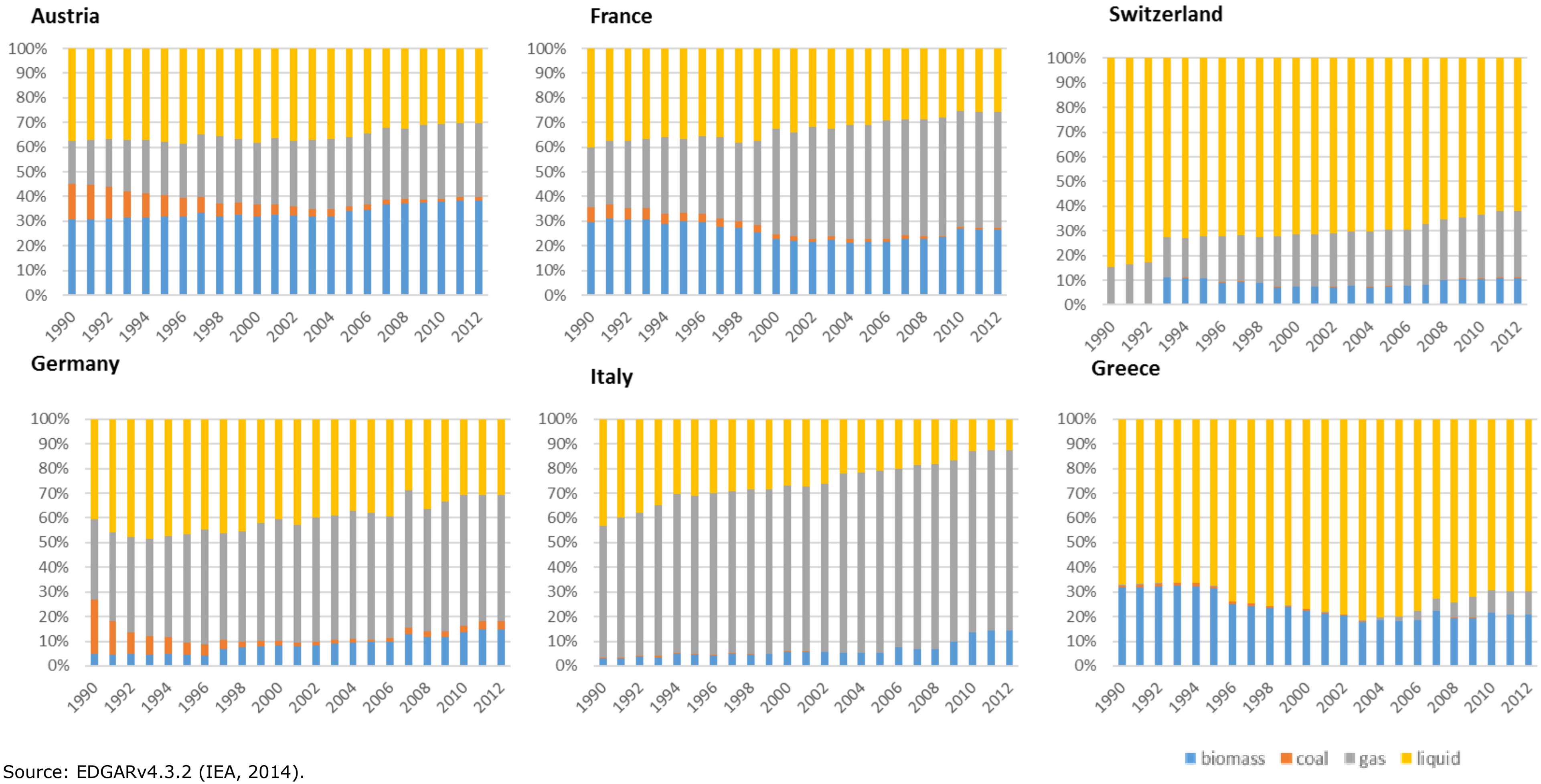
At country level, the situation is different. For example, in the countries covered by the EUSALP, EUSAIR and EUSDR and part of the OECD Europe world region, the energy demand decreased in 2012 compared to 1990 in Austria, Switzerland, Germany and France by 13%, 8%, 11% and 12% respectively and increased in Greece and Italy by 67% and 14% (see Figure 5).

The share of biomass in total fuel consumption for residential subsector is significant and changed in Austria from 31% in 1990 to 38% in 2012. Over 1990-2012 period, coal consumption decreased by 93% and liquid fuel consumption by 30%, instead gas consumption increased by 53%; in 2012, the shares of coal, liquid and gas fuels in total fuel consumption in household were 1%, 30% and 30%. According to IEA (2014), in Switzerland small quantity of coal is used for heating in residential and starting from 1993 biomass was introduced and reached a share of 11% in total fuel used in this subsector in 2012. Over 1990-2012 period, gas increased 63% and liquid fuel consumption decreased 32%; their shares in total fuel used in household changed from 15% and 85% in 1990 to 27% and 62% in 2012. In Germany, biomass consumption increased by 166% changing its share in fuel mix from 5% in 1990 to 15% in 2012. Gas consumption increased 39% while coal and liquid fuel consumption decreased for the same period by 87% and 33% respectively; in 2012, the shares in total fuel used in household heating were 51% for gas, 3% for coal and 31% for liquid fuel. In France although the biomass consumption decreased 21% between 1990 and 2012, it still has a significant share in fuel mix, which was 27% in 2012 compared to 30% in 1990. Small quantities of coal are used in residential subsector in France; its contribution to fuel mix were 6% in 1990 and 1% in 2012 and the consumption decreased 90% over this period. The liquid fuel, with the greatest share of 40% in the fuel mix in 1990, decreased 43% and had a share of 26% in total fuel consumption in household heating 2012. Over 1990-2012, in France, fuel mix shifted to more gas; this fuel that had a share of 24% in 1990 increased 71% and in 2012 its share in total fuel consumption in residential subsector almost doubled reaching 47%.

Greece and Italy show an increasing trend in energy demand. Small quantity of coal is used in Greece and its contribution to fuel mix is less than 1%. Gas used in household heating is also small; according to IEA (2014), it started to be used from 2003 onward reaching a 9% share in total fuel consumption in residential subsector in 2012. Liquid fuel is an important player in Greece; the consumption increased by 74% in 2012 compared to 1990 and the shares in fuel mix were 67% in 1990 and 70% in 2012. Although biomass increased only 9%, the share in total fuel consumption in household was 21% in 2012 compared to 32% in 1990. In Italy we see a significant increase of 478% in biomass used in residential in 2012 compared to 1990; its share in fuel mix were 3% 1990 and 14% in 2012. Gas consumption, which was important in the past with a share in fuel mix of 53% in 1990, increased by 56% and its share in 2012 was 73%. Coal is used in small quantities in residential heating.

As illustrated in Figure 5, the proportion of each fuel in the fuel mix is country specific and the fuel shift over the years is policy and market driven. From OECD Europe countries belonging to Alpine, Adriatic-Ionian and Danube regions, Austria relies on biomass, gas and liquid fuels for its household heating needs. In Germany, France and Italy the gas fuel is the most important whereas in Switzerland and Greece liquid fuel has the greatest share in total fuel consumption in residential subsector. As a main characteristic of fuel mix pattern change from 1990 to 2012 for these countries is the fact that coal had a low share in fuel mix in 1990, except Austria (14%) and Germany (22%), decreased abruptly to shares of less than 3% in Germany and 1% for the rest of the countries. The biomass consumption increased in all these countries except France; countries with shares of biomass in total fuel consumption in residential subsector in 2012 greater that biomass share in OECD Europe world region (12%) are Austria (38%), France (27%), Greece (21%), Germany (15%) and Italy (14).

Figure 5. Fuel mix in residential subsector: countries in EUSALP, EUSAIR and EUSDR part of OECD Europe[1] world region



Source: EDGARv4.3.2 (IEA, 2014).

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[1] OECD_Europe - Andorra, **Austria**, Belgium, **Switzerland**, **Germany**, Denmark, Spain, Finland, **France**, Faroe Islands, United Kingdom, Guernsey, Gibraltar, **Greece**, Greenland, Isle of Man, Ireland, Iceland, **Italy**, Jersey, Liechtenstein, Luxembourg, Monaco, Netherlands, Norway, Portugal, Svalbard and Jan Mayen, San Marino, Sweden, Holy See (Vatican City State).

As illustrated in Figure 6, in the countries covered by the EUSALP, EUSAIR and EUSDR and part of the Central Europe world region, the energy demand decreased in 2012 compared to 1990 in Slovakia, Albania, Czech Republic and Hungary by 19%, 47%, 46% and 22% respectively. It increased in Romania, Serbia and Montenegro, Slovenia, Bulgaria, Bosnia and Herzegovina and Croatia by 52%, 17%, 18%, 16%, 23% and 30% respectively (see Figure 6). In Moldova and Ukraine, which are part of the Ukraine+ world region the energy demand increased by 85% and decreased by 9% respectively.

Albania depends on biomass for its household heating, which decreased 53% over 1990-2012 period and had shares in total fuel combustion of 78% in 1990 and 69% in 2012. The second important fuel with a share of 20% in 1990 and 31% in 2012 is liquid fuel; coal and gas fuels are not used in Albania in residential subsector.

In Bosnia Herzegovina, biomass used in residential subsector that had a share of 60% in 1990 and 53% in 2012 increased by 9% over the same period. Although the share of gas remained almost constant (13%), its consumption over 1990-2012 period increased 36%. Big changes are observed for coal and liquid fuels; in 1990 their shares were 0% and 28% and in 2012 34% and 0% respectively.

For Czech Republic, gas had the greatest share of 55% in 2012 compared to 16% in 1990 increasing its consumption by 86% over this period. Biomass consumption in household heating increased by 37%, moving from a share in total fuel consumption in this subsector of 12% in 1990 to 31% in 2012. Coal combustion, which decreased by 89%, changed its share from 70% in 1990 to 14% in 2012. In this country, liquid fuel is used in small quantities for residential heating.

In Bulgaria, small quantities of liquid and gas are used; in 2012, these fuels had shares of 5% and 3% in total fuel consumption in residential subsector. Biomass increased 333% reaching a share of 70% in total fuel consumption in 2012 compared to 19% in 1990. The coal consumption decreased 65% and its share changed from 75% in 1990 to 22% in 2012.

Coal, which decreased 96% over 1990-2012 period is less used in Croatia; its share in total fuel consumption was 12% in 1990 and in 2012 was less than 0.5%. Liquid fuel consumption decreased 27% and its share changed from 33% in 1990 to 19% in 2012. The biomass with shares of almost 35% in 1990 and 2012 increased by 25% over this period. Big change is observed for gas consumption, which moved from a share of 20% in 1990 to 47% in 2012 and increased 202% over this period.

In Hungary, gas consumption increased 81% moving from a share in total fuel consumption from 32% in 1990 to 75% in 2012. Biomass increased by 22% and its share changed from 12% in 1990 to 18% in 2012. Coal and liquid fuels consumption decreased by 90% each, changing their shares in total fuel used in household heating from 33% to 4% and from 23% to 3% respectively.

Biomass and gas had large shares in total fuel used in residential subsector in Romania; biomass increased 447% in 1990-2012 period, changing its share from 15% in 1990 to 55% in 2012 while gas increased only 3% changing its share from 60% in 1990 to 41% in 2012. Coal, which decreased 97% over this period, had a share of 16% in 1990 and less than 0.5% in 2012. Liquid fuel, which is used in small amount in household heating, had shares of 9% and 4% in 1990 and 2012 respectively and decreased 31%.

Slovakia depends on gas for its household heating. This fuel had shares in total fuel consumption in this subsector of 70% in 1990 and 92% in 2012 and increased 7% over this period. Liquid and biomass are less used; in 2012, their shares in total fuel consumption had shares of 1% and 3% respectively. Coal decreased 89% changing its share in total fuel used from 28% in 1990 to 4% in 2012.

In Serbia and Montenegro, biomass increased 15% for the period 1990-2012 and its share in total fuel combustion was 69% in 1990 and 2012. Coal decreased 32% moving from a share in total fuel consumption of 28% in 1990 to a share of 16% in 2012. Gas and liquid fuels had shares of 11% and 5% in 2012.

In Slovenia, biomass increased 176% changing its share in total fuel consumption in residential subsector from 23% in 1990 to 53% in 2012 and gas increased by 308% changing its share from 4% in 1990 to 15% in 2012. Coal, which had a share of 16% in total fuel consumption in 1990, it is not used in household heating since 2005. Although liquid decreased 33%, its share of 32% in total fuel used in household heating remained significant; in 1990, the share was 57%.

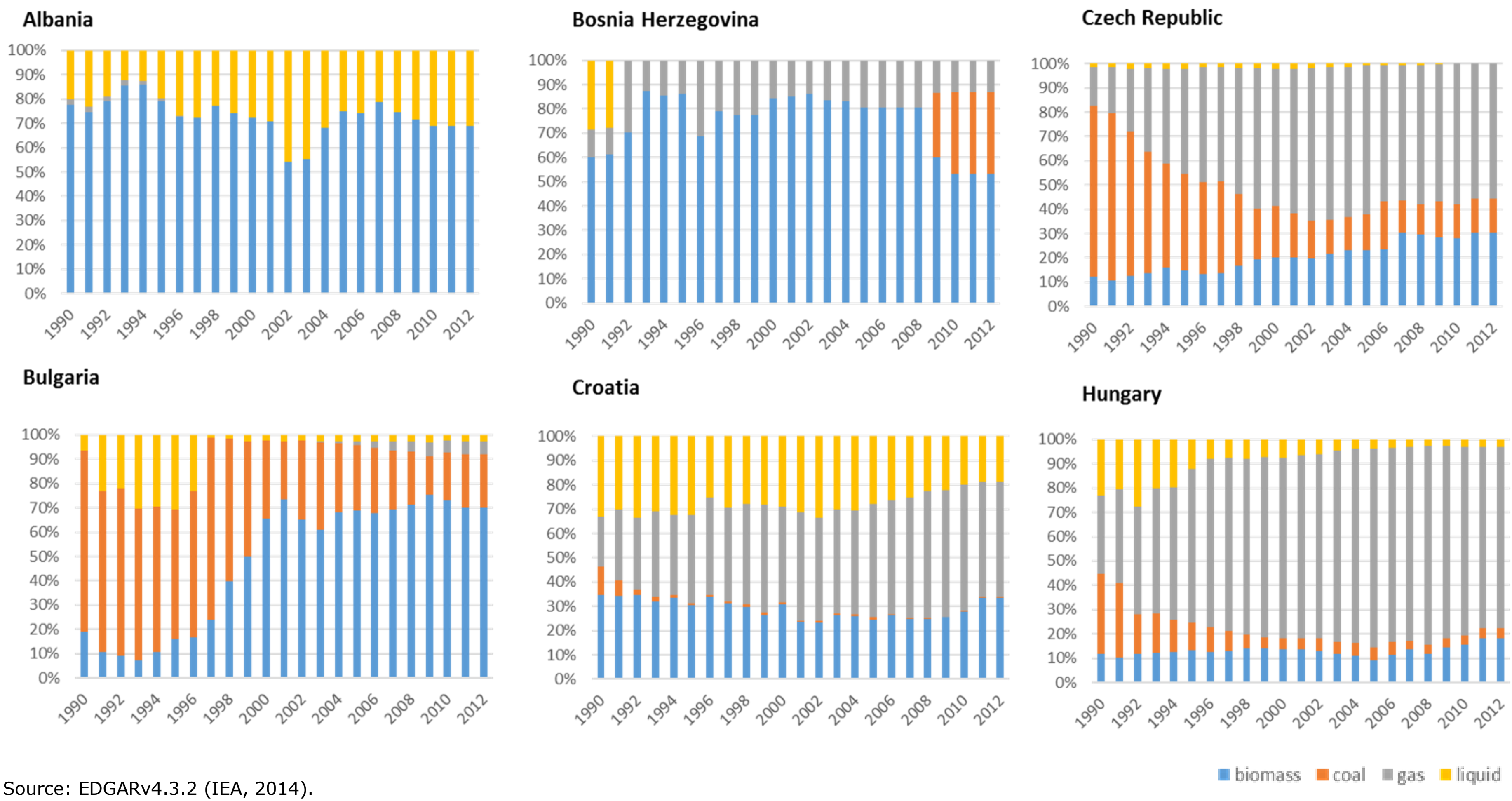
In Moldova, liquid had the greatest share of 49% in 2012 followed by gas with a share of 38%, and biomass and coal that represented 11% and 3% respectively in total fuel used in residential subsector.

In Ukraine, gas, coal and liquid fuels had shares of 50%, 32% and 18% respectively in 1990, which changed in 2012 to 89%, 4% and 0.3% respectively. Small quantities of biomass were used in household heating in 1990's; biomass consumption increased reaching 6% in fuel mix in 2012.

As illustrated in Figure 6, the proportion of each fuel in the fuel mix is country specific and varies over the years. From Central Europe countries belonging to Alpine, Adriatic-Ionian and Danube macro-regions, Czech Republic, Romania, Slovenia and Croatia rely on biomass and gas fuels for their household heating needs. In Bosnia Herzegovina, biomass is the most important fuel followed by gas, whereas in Moldova liquid fuel has the greatest share in total fuel consumption in residential subsector followed by gas fuel. Bulgaria, Serbia and Montenegro, and Albania depend on biomass, whereas Hungary, Slovakia and Ukraine use more gas in household heating. A notable achievement of Hungary, Croatia, Romania, Slovenia, Slovakia and Ukraine is the reduction of coal used in household heating to less than 4% and some of them eliminated this fuel from their fuel mix in residential subsector, instead Bosnia Herzegovina increased the share of coal in its fuel mix to 34% in 2012. Efforts have been made to reduce coal consumption in Bulgaria, Serbia and Montenegro, and Czech Republic but the share of coal in their total fuel used in residential subsector of 22%, 16% and 14% respectively remained significant in 2012. On the other hand, the biomass consumption increased in all these countries except Albania; countries with shares of biomass in total fuel consumption in residential subsector in 2012 greater that biomass share in Central Europe region (27%) are Albania (69%), Bulgaria (70%), Bosnia Herzegovina (53%), Czech Republic (31%), Croatia (34%), Romania (55%), Serbia and Montenegro (68%) and Slovenia (53%).

This analysis is based on the data and information reported by these countries to IEA. However, our comparison presented in section 4.4.1 for Croatia and in section 4.4.2 for Slovakia shows that there is a large uncertainty in the evaluation of fuel used in residential subsector, biomass in particular. Croatia in its new submissions to Eurostat provides values that are 3.7 times higher than the values reported before revision. Slovakia uses a specific approach to evaluate biomass consumption in residential subsector, which in the future is expected to contribute to the improvement of national statistics in this country. Approaches and the ongoing improvements of the evaluation of fuel used in the residential subsector focussing on biomass will be further documented in Muntean et al. (2018, in preparation) in detailed case studies for some countries in the Danube region and global aspects will be discussed in Janssens-Maenhout et al. (2018, in preparation).

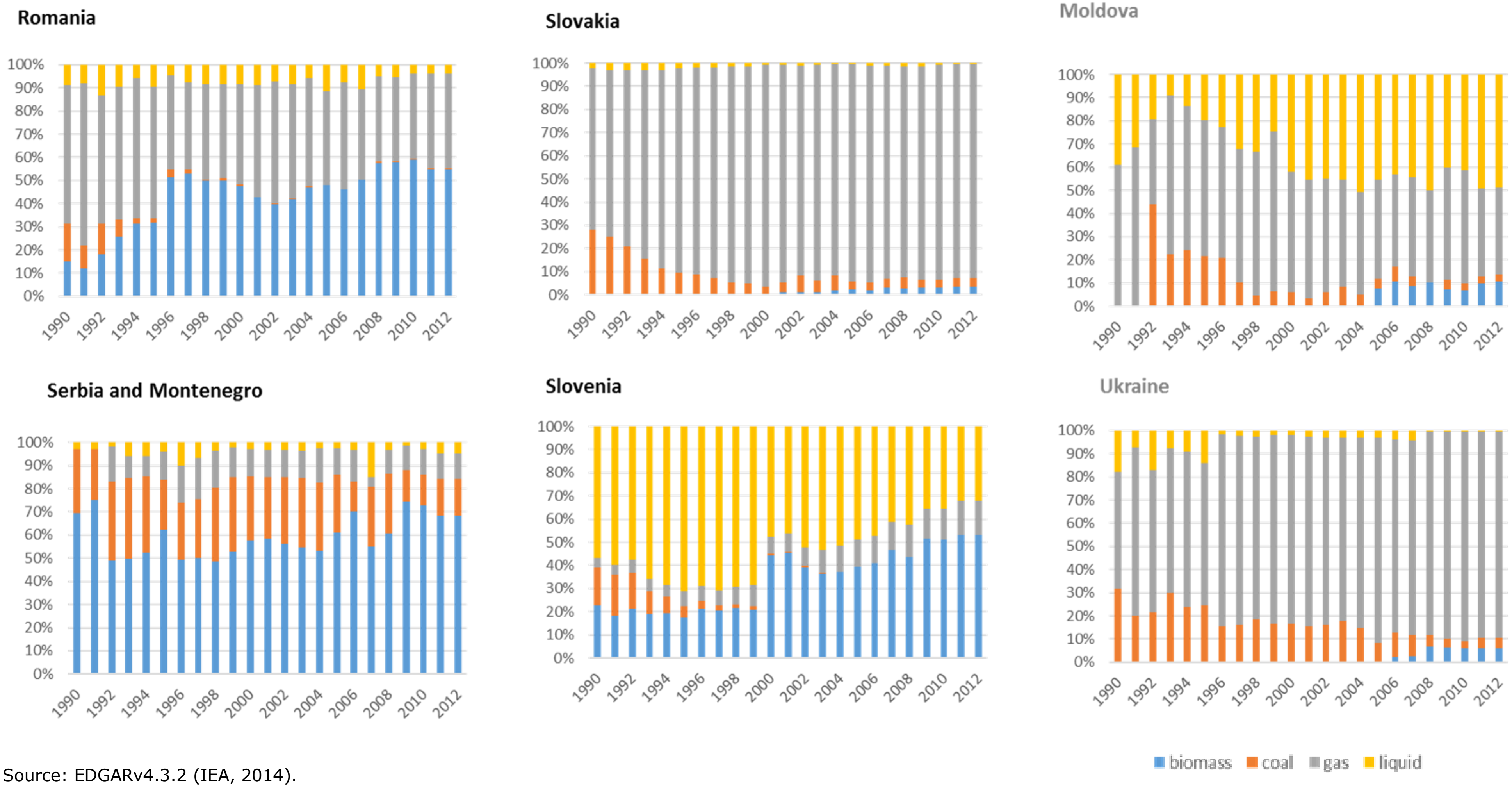
Figure 6. Fuel mix in residential subsector: countries in EUSALP, EUSAIR and EUSDR part of Central Europe[2] world region



Source: EDGARv4.3.2 (IEA, 2014).

[2] Cental Europe - **Albania, Bulgaria, Bosnia and Herzegovina**, Cyprus, **Czech Republic**, Estonia, **Croatia, Hungary**, Lithuania, Latvia, the former Yugoslav Republic of Macedonia, Malta, Poland, **Romania, Serbia and Montenegro, Slovakia, Slovenia**. Please note that **Moldova** and **Ukraine** are from Ukraine+ region.

Figure 6 (continued). Fuel mix in residential subsector: countries in EUSALP, EUSAIR and EUSDR in Central Europe[2]



Source: EDGARv4.3.2 (IEA, 2014).

4.2 Technology and emissions factors

The levels of emissions from small combustion activity sector in a specific country depend on technology used for fuel burning, and on both fuel type and fuel quantity. For each country in the Alpine, Adriatic-Ionian and Danube macro-regions, we discussed and analysed the changes in fuel mix from 1990 until 2012 (see section 4.1). Further, the technologies and the fuel-specific and technology-specific emissions factors used to estimate emissions from small combustion activities are described in this section.

In EDGAR, the following technologies are assigned to small combustion activities sector: fireplaces, medium size boilers, small boilers and conventional stoves. As an example, in Table 3 are indicated the technologies (%) that are allocated to different fuels for the years 1970 and 2000 for OECD Europe and for the World regions.

Table 3. Technology distribution in EDGAR associated to small combustion activities (example).

Region	Fuel	Technology	1970	2000
OECD Europe	other bituminous coal	Fireplaces	0%	2%
		Medium size boilers	60%	85%
		Small boilers	10%	10%
		Conventional stoves	30%	3%
	wood	Fireplaces	5%	5%
		Medium size boilers	20%	20%
		Small boilers	25%	25%
		Conventional stoves	50%	50%
World	solid biomass	Fireplaces	0%	0%
		Medium size boilers	0%	0%
		Small boilers	0%	0%
		Conventional stoves	0%	0%
		Non-specified	100%	100%

Source: EDGARv4.3.2

The quantity of pollutants emitted per unit of energy consumed (EFs) are strongly related to the combustion efficiency of a specific technology (appliance). As mentioned, for emissions estimation in EDGAR were used the EFs from EMEP/EEA (2013); in Table 4 are presented the EFs for PM2.5 (as an example) by fuel type for different appliances and capacities.

Significant differences are between technology-specific EFs for coal, biomass, liquid and gas fuels: EF for conventional boiler burning wood is 2.3 times higher than the EF for conventional boiler burning solid fuel (except biomass). The EF for a medium size boiler burning coal is 2 times higher than the EF for a medium size boiler burning wood and 57 times higher than the EF for a medium size boiler burning liquid fuel and 378 times higher one burning gas.

Regarding stoves, the modern stoves are more efficient and generate less emission: for wood combustion, the EF factor for a conventional stove is 2 times higher than the EF of an energy efficient stove, 8 times higher than the EF for an ecolabelled stove and 26 times higher than a pellet stove.

Table 4. Emissions factors for different types of appliances and fuels.

Appliance/fuel type	**EF PM2.5**
	Unit: g/GJ
Boiler burning wood	
conventional boilers (<50 kWth)	470
manual boilers, commercial	140
automatic boilers, commercial	33
medium sized (>50KWth to ≤ 1 MWth), commercial	86.5
medium sized (>1 MWth to ≤ 50 MWth), commercial	33
Boiler burning coal	
small boiler (<50 kWth)	201
medium size (>50 kWth to <=1 MWth), commercial	170
medium-size (>1 MWth to ≤50 MWth), commercial	72
Boiler burning liquid fuel	
medium sized (>1 MWth to ≤50 MWth), commercial	30
medium-sized (>50 kWth to ≤1 MWth), commercial	3
boilers burning liquid fuels	1.5
Boiler burning gas	
medium-sized (>50 kWth to ≤1 MWth), commercial	0.45
small boiler (<50 kWth)	0.2
Stove burning wood	
conventional stoves	740
energy efficient stoves	370
advanced/ecolabelled stoves and boilers	93
pellet stoves and boilers	29
Stoves burning coal	
conventional stoves	450
advanced stoves	220
Stoves burning liquid fuel	2.2
Fireplace burning wood	820
Fireplace burning coal	330
Fireplace burning gas	2.2

Source: EMEP/EEA, 2013.

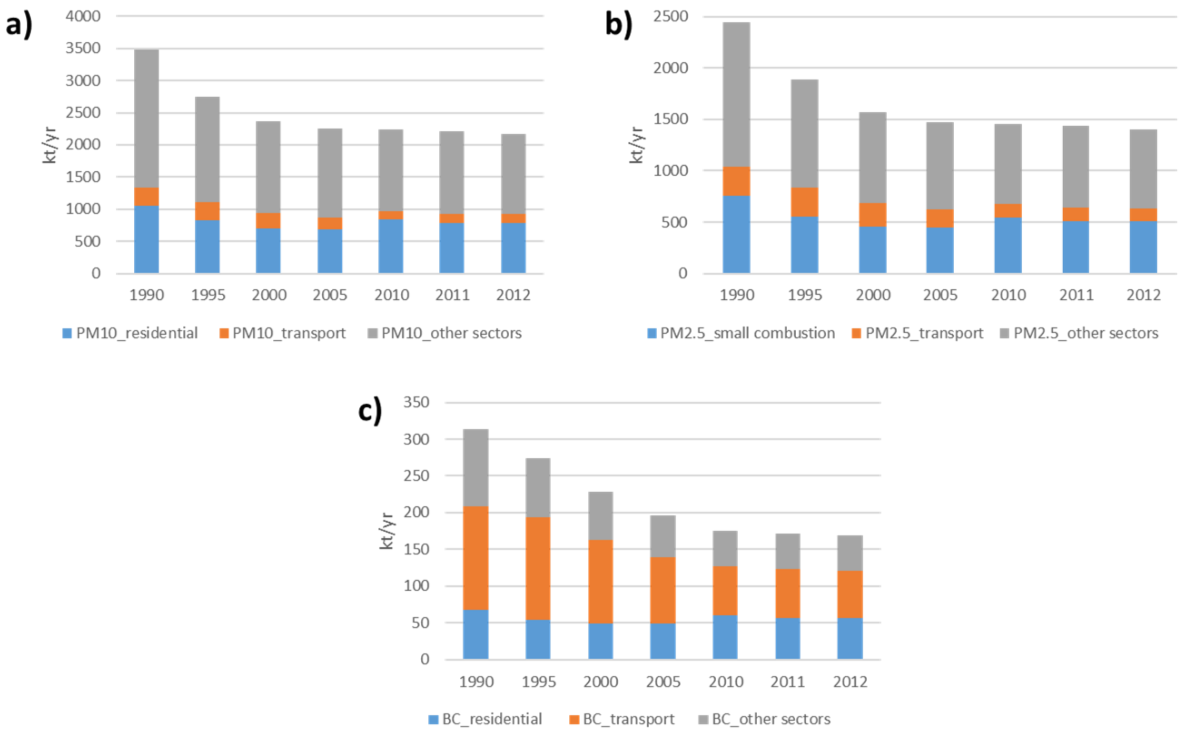
The impact of technology penetration on emissions will be further documented in Muntean et al. (2018, in preparation); in this study, it is discussed in section 4.4.1 for the particular case of Croatia.

4.3 Small combustion activities: emissions levels and gridmaps

For small combustion activities sector, in the EDGARv4.3.2 and tox3 versions, there are emissions estimations for GHGs, air pollutants and toxic pollutants for all world countries.

Anthropogenic emissions in EU28 are decreasing for most of the pollutants. Figures 7a, 7b and 7c illustrate the trends of PM10, PM2.5 and BC in EU28 for the period 1990-2012, all sources included. Important to be mentioned is the fact that the shares of small combustion activities sector (in blue) are significant in the latest years. In 2012, the contributions of this sector to the EU28 total emissions of PM10 and PM2.5 was 36% each, and of BC was 34% respectively.

Figure 7. Emissions from all sources in EU28: a) PM10, b) PM2.5 and c) BC. Note: the shares of different sectors are represented as follows: small combustion activities in blue, transport in orange and the rest of the sectors in grey.



Source: EDGARv4.3.2.

Further, we focus on emissions from small combustion activities sector and their distribution in the three EU macro-regions: Alpine (section 4.3.1), Adriatic-Ionian (section 4.3.2) and Danube (section 4.3.3); the PM2.5, BC and BaP emissions will be analysed and discussed for the year 2010.

In EDGAR, the first step in building an inventory is to estimate sectorial emissions as country totals for all human activities. After, these emissions are distributed using proxy data on gridmaps at the places where they are emitted. The proxies used to distribute emissions from fuel combustion in small combustion activities sector are mainly urban and rural population and other EDGAR in-house proxy as described in section 3.2.

In order to derive emissions for the areas covered by EUSALP, EUSAIR and EUSDR, firstly, we considered the emissions and the gridmaps for all full countries included in the Alpine, Adriatic-Ionian and Danube macro-regions as EDGAR provides them. Secondly, we estimated the emissions only for those provinces belonging to a macro-region e.g. for a country that is not entirely included in a macro-region by extracting the emissions of these provinces from the gridmaps of this country using an appropriate mask, in which only the provinces part of a macro-region belonging to that specific country are included. We developed this methodology to calculate emissions for the areas included in Alpine, Adriatic-Ionian and Danube macro-regions, which are not full countries but only parts of these countries; although, the uncertainty is important this is the best approach we could use to estimate emissions for these areas. In order to increase accuracy in emissions evaluation for a macro-region it is recommended to develop emissions inventory at province level and to distribute them by using refined proxy that can better indicate the emissions hotspots and establish mitigation measures accordingly.

The gridmaps presented in sections 4.3.1, 4.3.2 and 4.3.3 represent the PM2.5, BC and BaP emissions for three macro-regions in 2010; in this analysis we included also PM2.5 emissions per capita, BC, and BaP emissions that are disaggregated by fuel showing the importance of fuel mix composition in each country.

4.3.1 Emissions gridmaps: Alpine macro-region

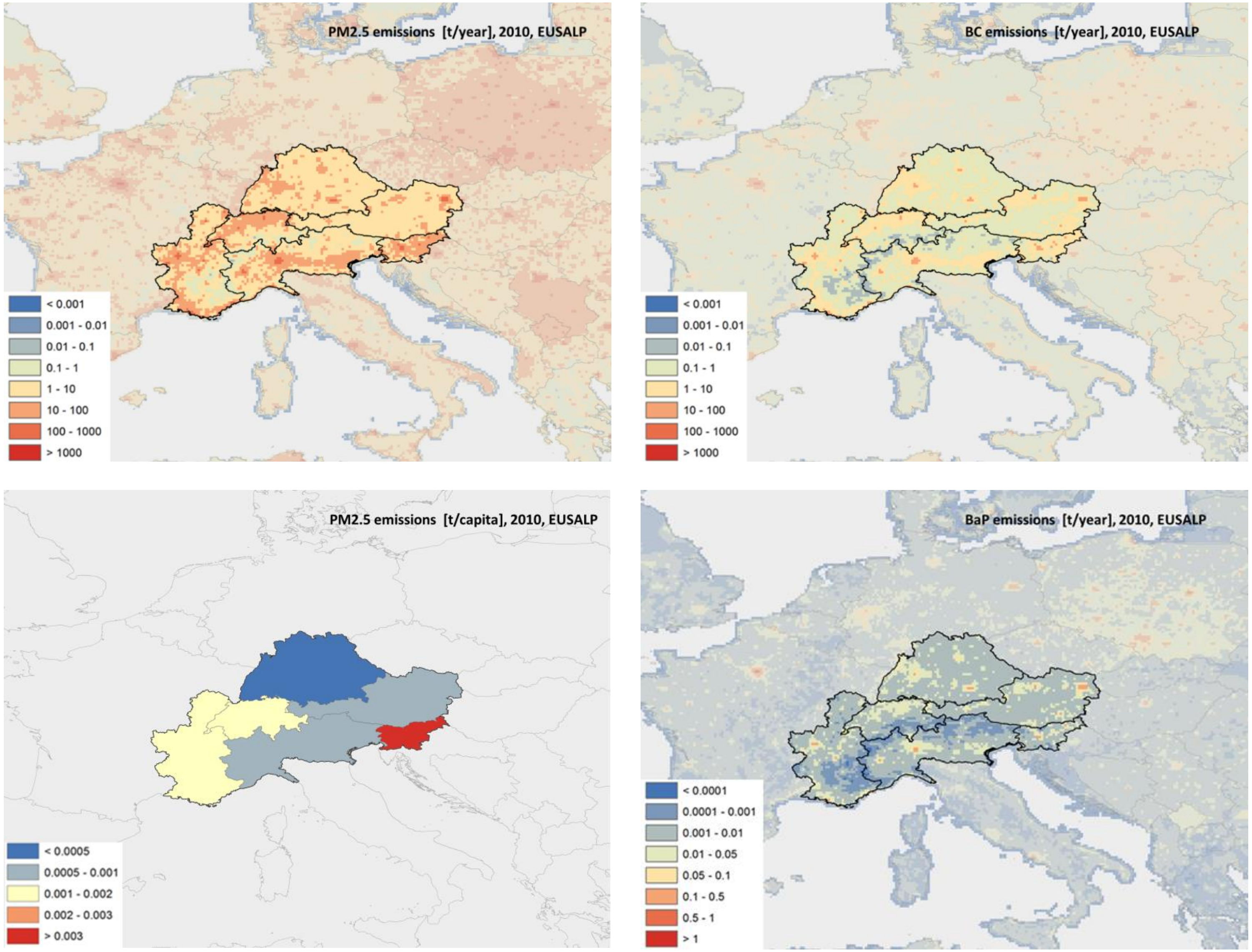


Figure 8. Alpine macro-region: PM2.5 emissions gridmap and emissions per capita (left panels) and BC, BaP emissions gridmaps (right panels), 2010

France (27%) is the largest contributor to PM2.5 emissions in Alpine macro-region; it is followed by Italy, Germany, Switzerland, Austria and Slovenia. The later had the highest PM2.5 per capita emissions in 2010.

For BC, the countries with the larger shares are Germany and France with 21% each.

Germany contributes 26% to BaP emissions and Austria 24%.

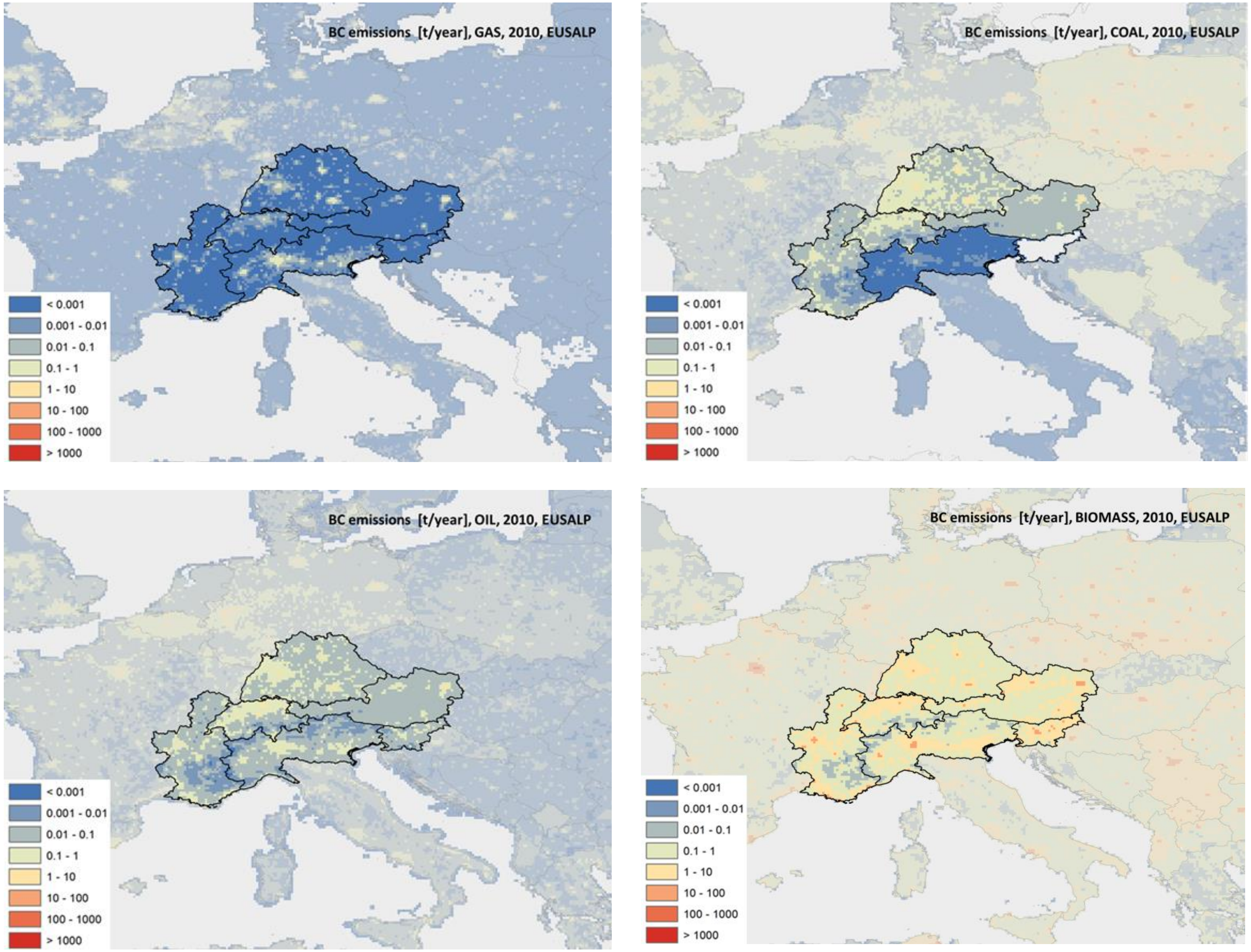


Figure 9. Alpine macro-region, BC emissions gridmaps disaggregated by fuel: gas and oil (left panels), and coal and biomass (right panels), 2010

Slovenia, although contributes only 5% to the total BaP emissions in Alpine macro-region, is the second country after Austria in the ranking of BaP emissions per capita (see annex 2).

Figure 8 illustrates the areas with elevated PM2.5, BC and BaP emissions in Alpine macro-region; PM2.5 emissions per capita are also presented.

The breakdown of total emissions from small combustion activities sector to emissions by fuel is provided in Figure 9 for BC and in Figure 10 for BaP.

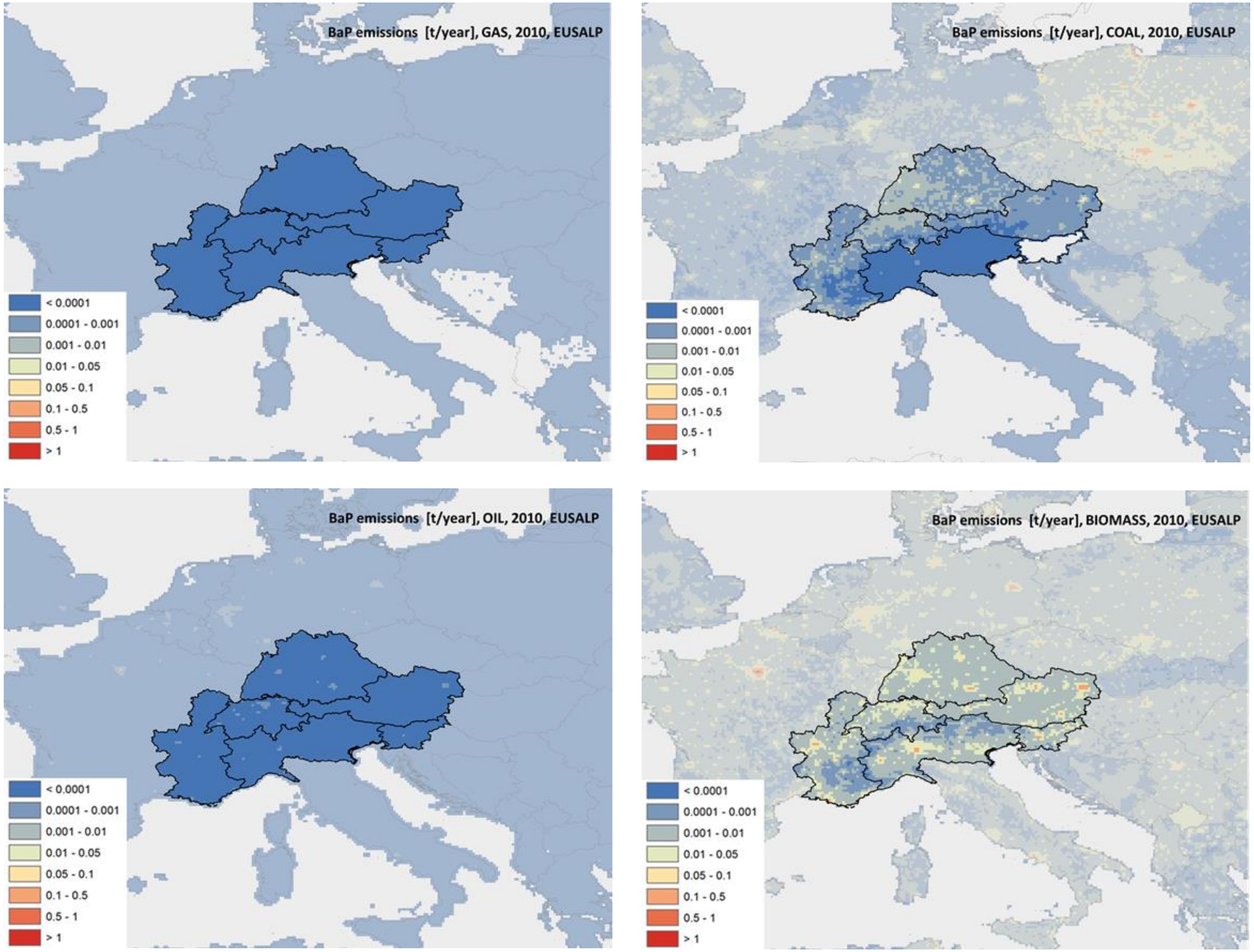


Figure 10. Alpine macro-region, BaP emissions gridmaps disaggregated by fuel: gas and oil (left panels), and coal and biomass (right panels), 2010

In 2010, higher BC and BaP emissions are observed in the countries that used more solid fuel such as coal and biomass.

For example in Italy, the shares in total fuel used in 2010 for household heating were 73% for gas, 13% for liquid fuel, 13% for biomass and 0.02% for coal (see Figure 5 in section 4,1). Because of that, the emissions of BC and BaP from coal are low for the part of Italy belonging to Alpine macro-region, (see Figures 9 and 10). In Slovenia there is no coal consumption 2010, therefore the emissions are zero.

4.3.2 Emission gridmaps: Adriatic and Ionian macro-region

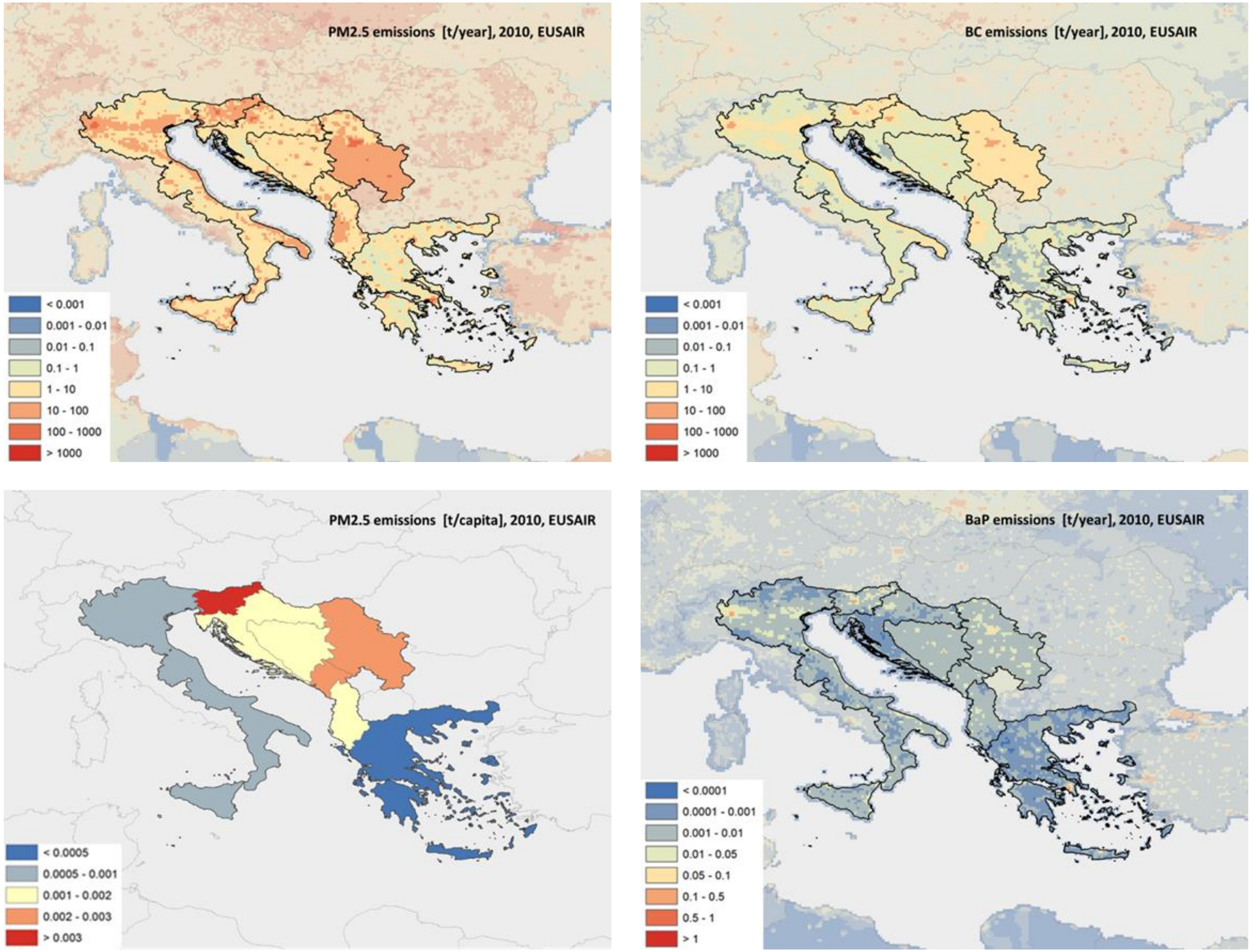


Figure 11. Adriatic and Ionian macro-region: PM2.5 emissions gridmap and emissions per capita (left panels) and BC, BaP emissions gridmaps (right panels), 2010

Italy (32%) is the largest contributor to PM2.5 emissions in Adriatic and Ionian macro-region, and the next in the range is Serbia (28%), which is followed by Slovenia, Greece, Croatia, Bosnia Herzegovina, Albania and Montenegro; Slovenia has the highest emissions per capita and Serbia is the second in the ranking.

For BC, the countries with the larger shares are Serbia (30%) and Italy (29%).

Italy contributes 37% to BaP emissions and Serbia 26%. Slovenia is the largest contributor to the BaP

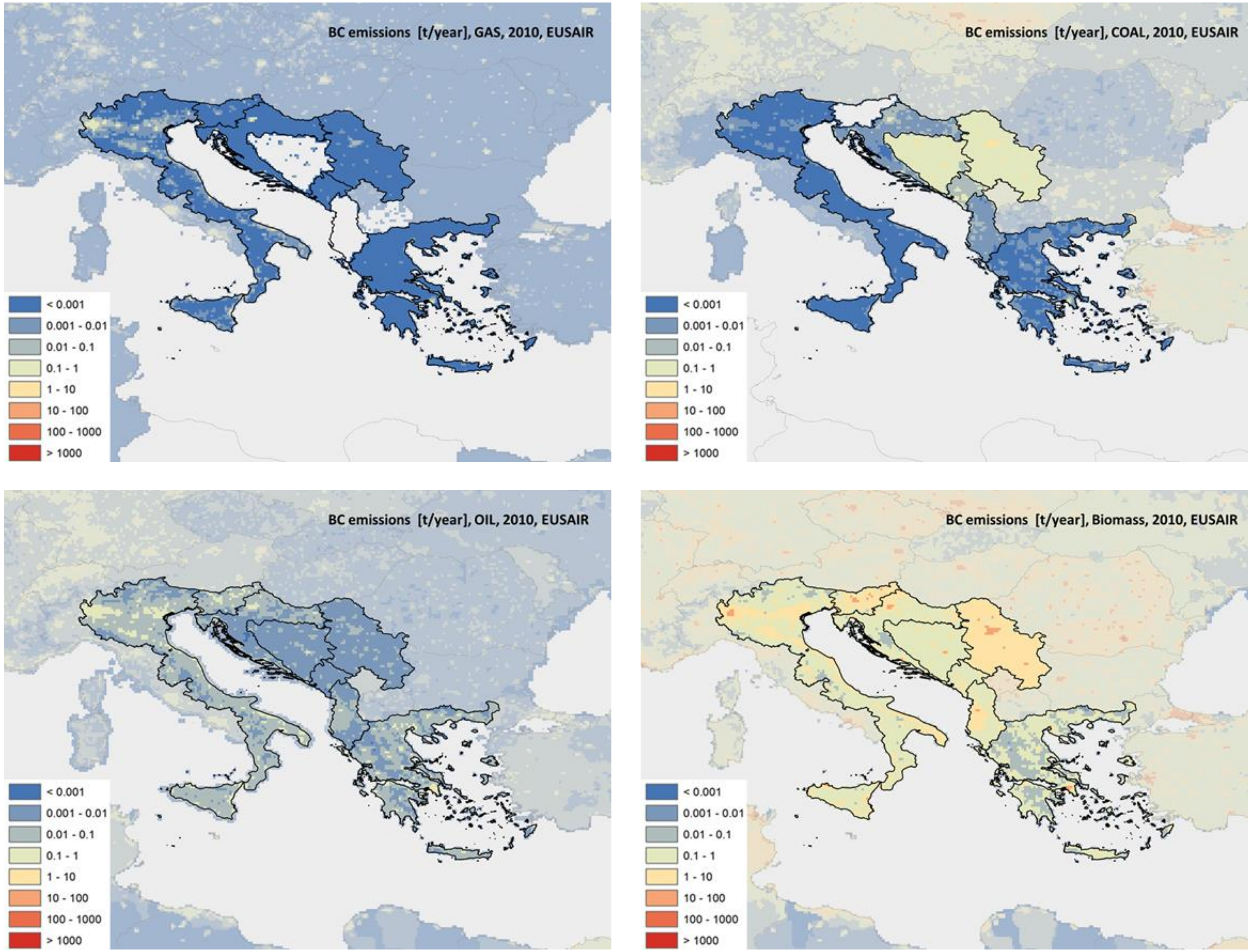


Figure 12. Adriatic and Ionian macro-region, BC emissions gridmaps disaggregated by fuel: gas and oil (left panels), and coal and biomass (right panels), 2010

emissions per capita, although it contributes only 8% to the total BaP emissions in Adriatic and Ionian macro-region (see annex 2).

Figure 11 illustrates the areas with elevated PM2.5, BC and BaP emissions in Adriatic and Ionian macro-region; PM2.5 emissions per capita are also presented.

The breakdown of total emissions from small combustion activities sector to emissions by fuel is represented in Figure 12 for BC and in Figure 13 for BaP.

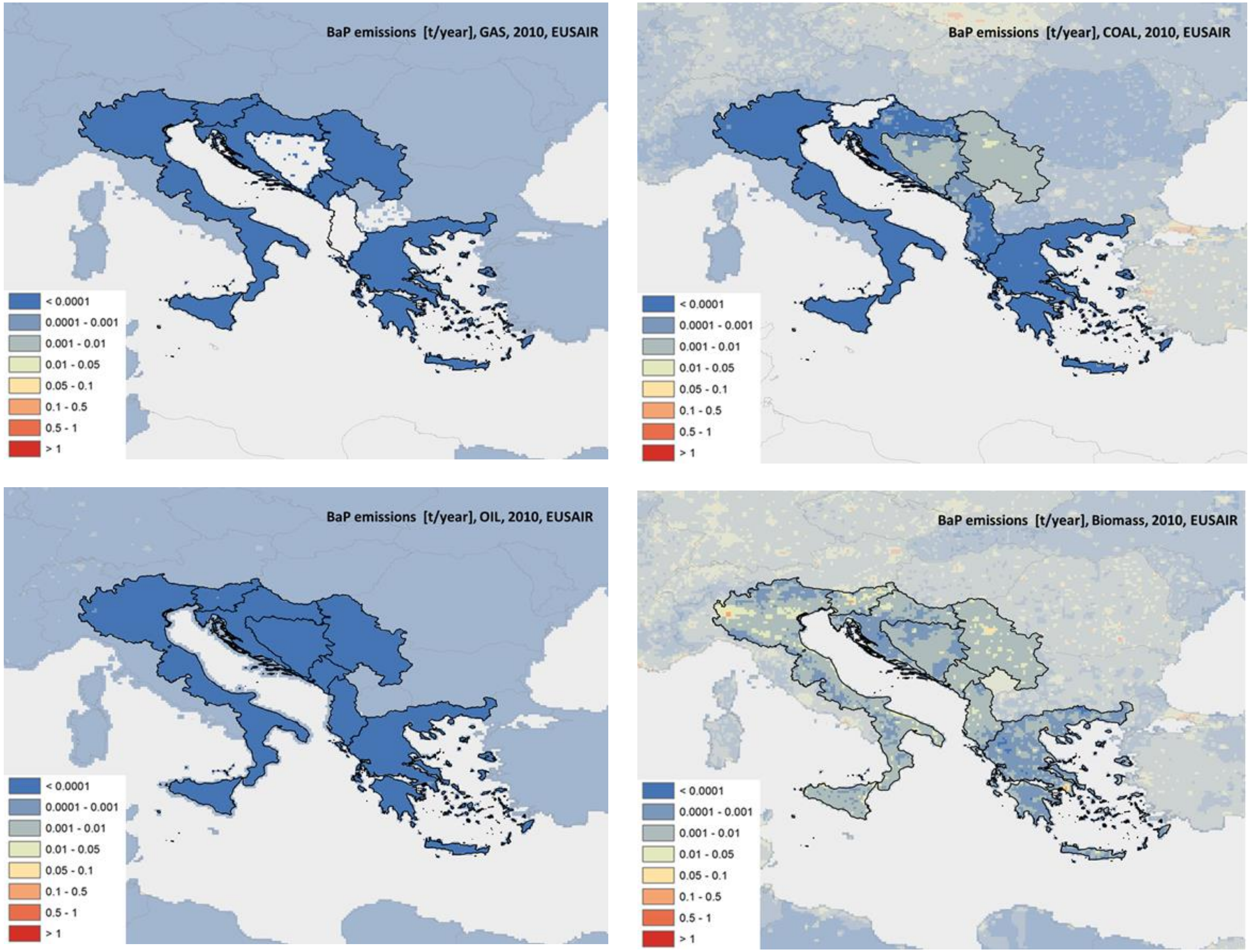


Figure 13. Adriatic and Ionian macro-region, BaP emissions gridmaps disaggregated by fuel: gas and oil (left panels), and coal and biomass (right panels), 2010

Countries using more coal and biomass for their heating needs in residential contribute most to BC and BaP emissions in Adriatic and Ionian macro-region.

For example, in Bosnia Herzegovina, the share of coal in total fuel used in household heating is 34% and in Serbia and Montenegro is 13% in 2010 (see Figure 6 in section 4,1). As illustrated in Figures 12 and 13, the emissions of BC and BaP from coal are significant for these countries.

4.3.3 Emission gridmaps: Danube macro-region

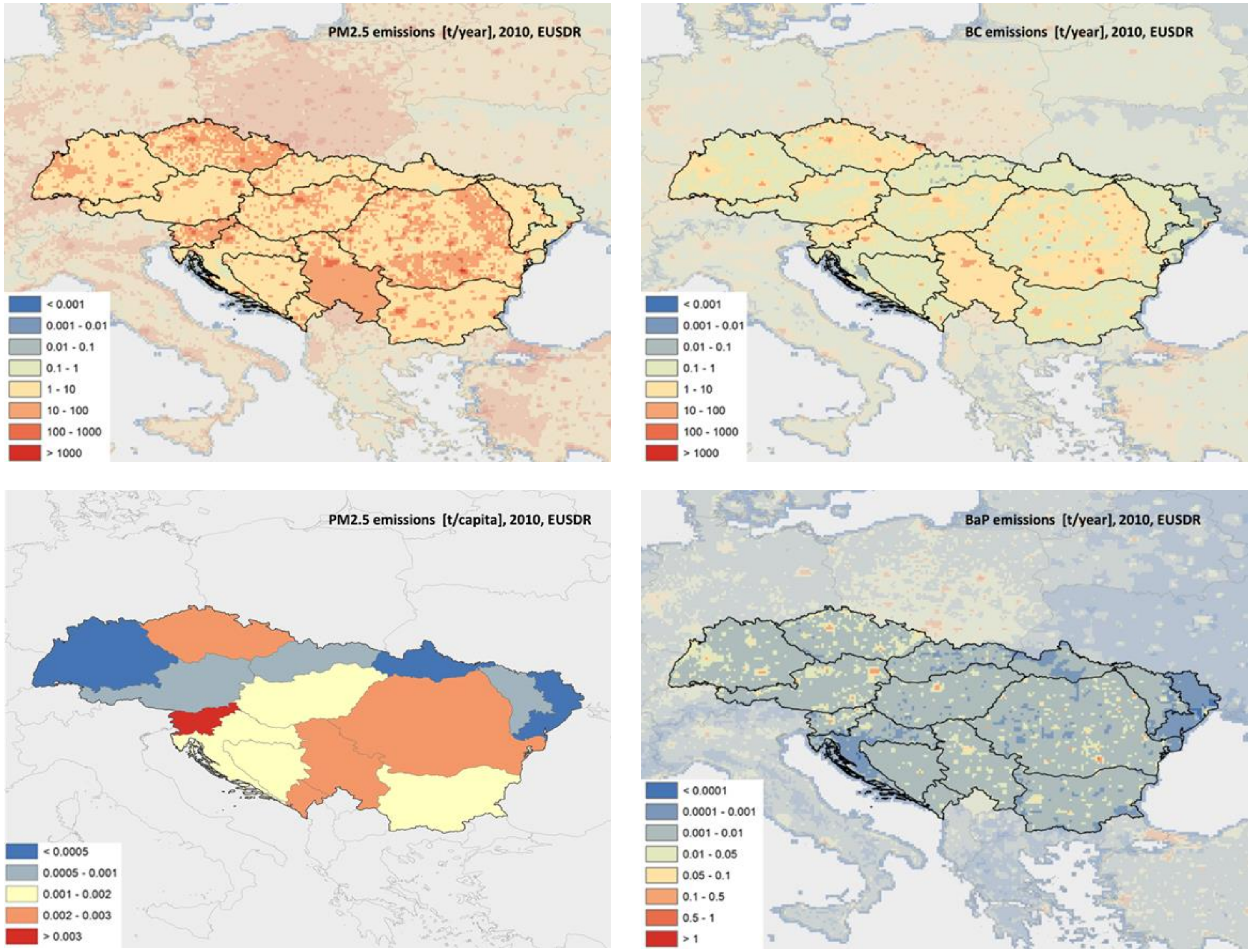


Figure 14. Danube macro-region: PM2.5 emissions gridmap and emissions per capita (left panels) and BC, BaP emissions gridmaps (right panels), 2010

In 2010, significant shares in PM2.5 and BC emissions had Romania (33%), Czech Republic (14%) and Serbia (11%); the rest of the countries in the Danube region had shares less than 8% in total PM2.5 and BC emissions from small combustion activities. The contribution of Slovenia is only 4%, but it had the largest emissions per capita.

Romania contributes 24% to BaP emissions, Germany 14% and Austria and Czech Republic contribute 13% each.

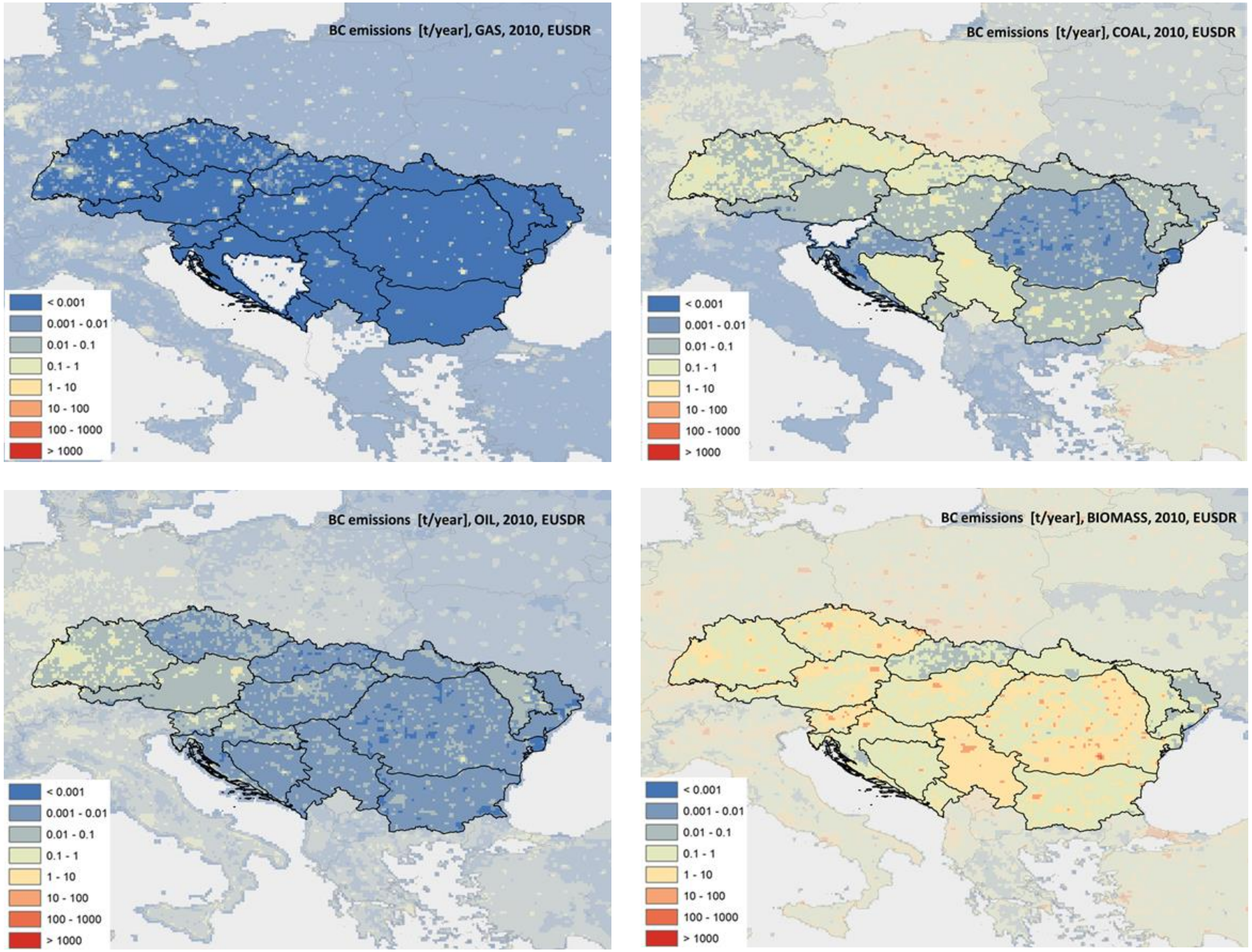


Figure 15. Danube macro-region, BC emissions gridmaps disaggregated by fuel: gas and oil (left panels), and coal and biomass (right panels), 2010

Figure 14 illustrates the areas with elevated PM2.5, BC and BaP emissions in Danube macro-region including PM2.5 emissions per capita.

The breakdown of total emissions from small combustion activities sector to emissions by fuel is represented in Figure 15 for BC and in Figure 16 for BaP.

BC and BaP emissions are higher for the countries that used more solid fuel compared to those that use more gas and liquid fuels.

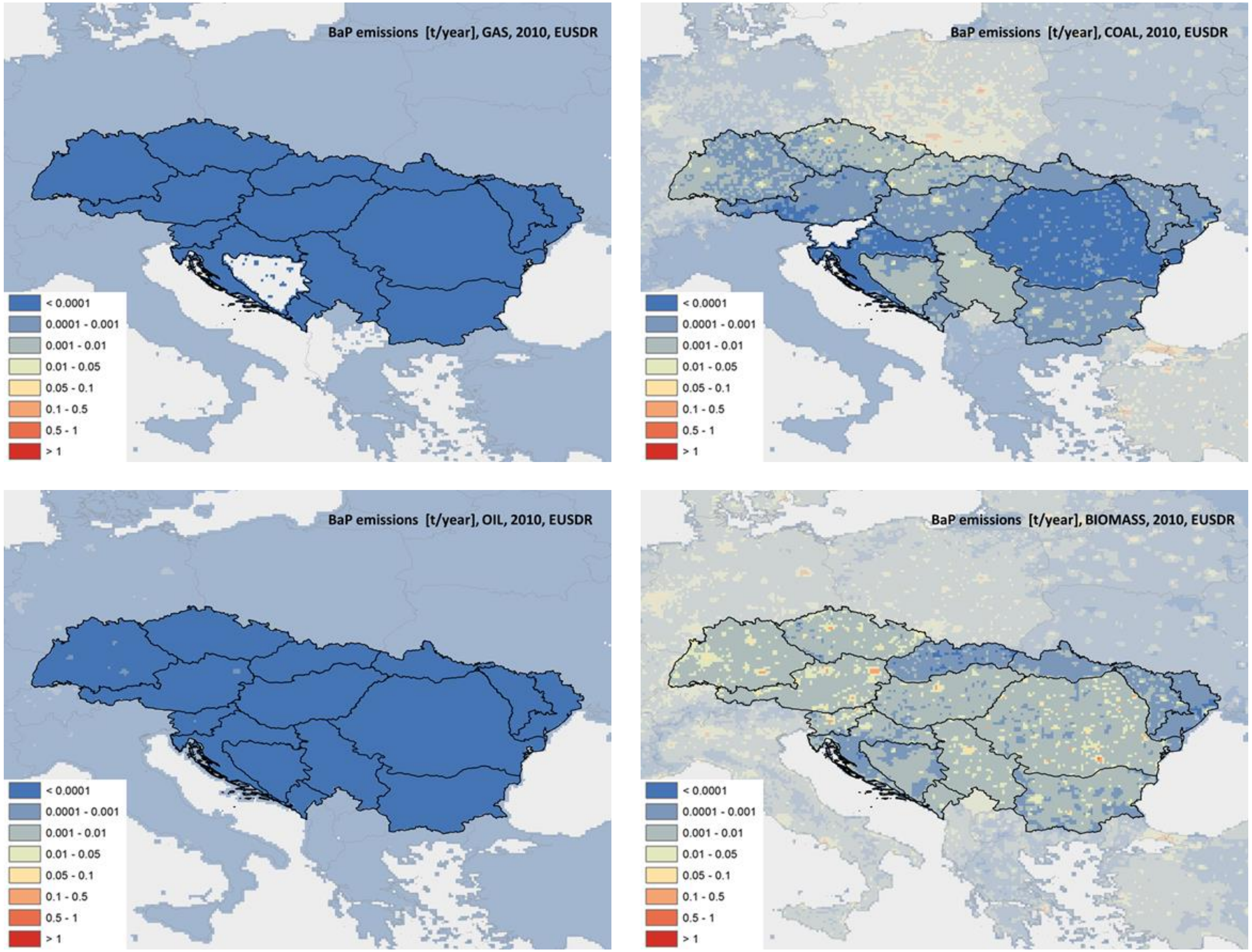


Figure 16. Danube macro-region, BaP emissions gridmaps disaggregated by fuel: gas and oil (left panels), and coal and biomass (right panels), 2010

For example, in Slovakia, the shares in total fuel used in 2010 for household heating were 92% for gas, 1% for liquid fuel, 3% for biomass and 4% for coal (see Figure 6 in section 4.1). On emissions gridmaps for BaP and BC emitted from biomass fuel (see Figures 15 and 16), could be observed that these emissions are low compared to the emissions from other countries in the Danube macro-region, which in 2010 had greater shares of biomass in their fuel mix such as Romania (59%) and Austria (28%).

4.4 Emissions comparison: EDGAR vs National Emissions Inventories (NE)

In this chapter, we presented the results of the comparison: EDGAR emissions vs national emissions inventories (NE) of Croatia, Slovakia, Romania and Slovenia. Due to missing data and for consistency, we compared the emissions only for residential subsector (see also section 4.1).

Under the small combustion activity sector 1.A.4, according to the EMEP/EEA Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2013) named hereafter GB2013, the following sub-categories are included:

- Small combustion (NFR 1.A.4.i)
  - Commercial/Institutional (NFR 1.A.4.a.i),
  - Residential (NFR 1.A.4.b.i),
  - Agriculture/Forestry (NFR 1.A.4.c.i)
- Non-road mobile sources and machinery (NFR 1.A.4.ii)
  - Residential (NFR 1.A.4.b.ii),
  - Agriculture/Forestry (NFR 1.A.4.c.ii).

Official NEs are compiled by country experts, who generally use the methodology described in GB2013. Full description of the national emissions inventories presented in this section is provided in the Informative Inventory Reports (EMEP/CEIP, 2017); the metadata are included in annex 3 of this report. Since the 1.A.4.b.i subsector (residential) is a key source of emissions in these four countries and because of data missing for other subsectors in some countries, we compared here only the emissions from this subsector; Metadata for NEs are presented in annex 3.

4.4.1 Croatia

Croatia reports to the Convention on Long-range Transboundary Air Pollution (CLRTAP, 1983) and National Emission Ceilings Directive (NECD 2016/2284/EU) emissions for all sub-categories of the 1.A.4 sector.

Methodology, emission factors, activity data for emissions calculation for small combustion (NFR 1.A.4.i). Small combustion covers installations with thermal capacity ≤ 50 MW_{th}. Small combustion activities are commercial and institutional heating, residential heating and cooking, agriculture/forestry and other stationary combustion (including military). Residential heating includes fireplaces, stoves, cookers, small boilers (< 50 kW) while institutional/commercial/agricultural/other heating include heating boilers, space-heaters (> 50 kW), and smaller-scale combined heat and power generation (CHP).

Commercial/Institutional (NFR 1.A.4.a). Methodology for emission calculation is Tier 1 of GB2013 performed by multiplying total fuel sold (disaggregated by fuel type) with emission factors. In Croatia, the sector 1.A.4.a Commercial/Institutional is not a key source. Emission factors are expressed as the quantity of emissions of pollutants per GJ fuel consumed. All emission factors are default Tier 1 from GB2013.

Residential (NFR 1.A.4.b.i). Within small combustion source category only 1.A.4.b.i Residential is a key source in Croatia, so Tier 2 GB2013 methodology was applied for emission calculation. The application of Tier 2 methodology implies knowledge of the structure and combustion techniques applied in residential since 1990 onwards. Emissions calculation algorithm considers for solid fuel and biomass: different type of technology installed, different time of entering into usage, life time of the appliances. For biomass combustion, five types of technology were assumed: heating stoves, fireplaces, single house boilers (<50 kW), advanced/ecolabelled stoves and boilers and pellet stoves and boilers. For the coal combustion, two types of technology were assumed: heating stoves and single house boilers (<50 kW). For liquid and gaseous fuels, it is assumed that the technologies defined in the GB2013 are represented in equal proportions, i.e., heating stoves and single house boilers (<50 kW) for liquid fuel, and fireplaces and single house boilers (<50 kW) for gaseous fuel. Emission factors are expressed as the quantity of emissions of pollutants per GJ fuel consumed. Emission factors by fuel types are default Tier 2 from GB2013 except for SO2.

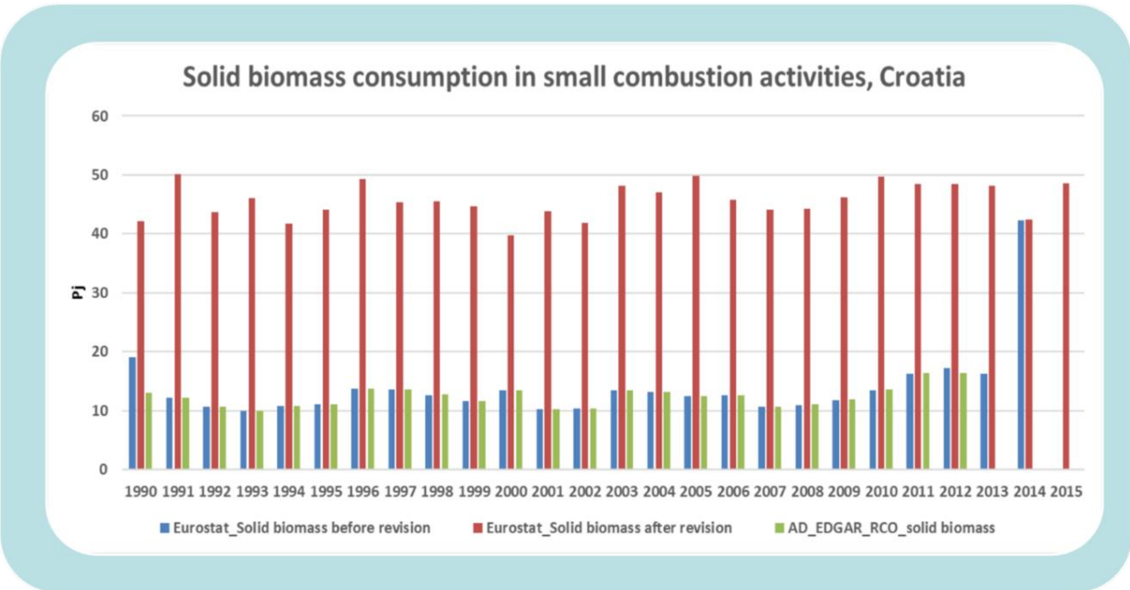
For SO2 emission calculation, national emission factor were used. National SO2 emission factor assumed two type of solid fuel use in Croatia lignite and sub-bituminous coal with net calorific value of 12.25 GJ/t and 18.2 GJ/t respectively, with their average value of sulphur content of 1.67%, and sulphur ash retention factor of 0.1. Emission factors for 2015 by NFR sectors can be found in Appendix 4 of the Croatian IIR 2017 (EMEP/CEIP, 2017).

Agriculture/Forestry (NFR 1.A.4.c.i). Methodology for emission calculation is Tier 1 GB2013, performed by multiplying total fuel sold (disaggregated by fuel type) with emission factors. Sector NFR 1.A.4.c.i Agriculture/Forestry is not a key source. Emission factors are expressed as the quantity of emissions of pollutants per GJ fuel consumed. All emission factors are default Tier 1 from GB2013, and are presented by NFR sectors can be found in Appendix 4 of the Croatian IIR 2017 (EMEP/CEIP, 2017).

Non-road mobile sources and machinery (NFR 1.A.4.ii). Non-road mobile sources and machinery source category covers a mixture of 'other' equipment. Types of equipment used in Agriculture/Forestry include: Two-Wheel Tractors, Agricultural tractors, Harvesters/combiners, Others (e.g. sprayers, manure distributors, mowers, balers, tillers, swatchers), Professional chain saws/clearing saws, Professional chain saws/clearing saws, Forest tractors/harvesters/skidders, Others (tree processors, haulers, fellers, forestry cultivators, shredders and log cultivators). Types of equipment used in Residential (Household and gardening) include: Trimmers/edgers/brush cutters, Lawn mowers, Hobby chain saws, Snow mobiles/skidoos, Other household and gardening equipment, Other household and gardening vehicles (all-terrain vehicles, off-road motor cycles, golf carts, etc.). For all types of equipment, the emissions originate from the combustion of fuel to power the equipment. The source category 1.A.4.ii Non-road mobile sources and machinery is a key source in Croatian inventory and Tier 2 technology-dependent advance method proposed in GB2013 is used.

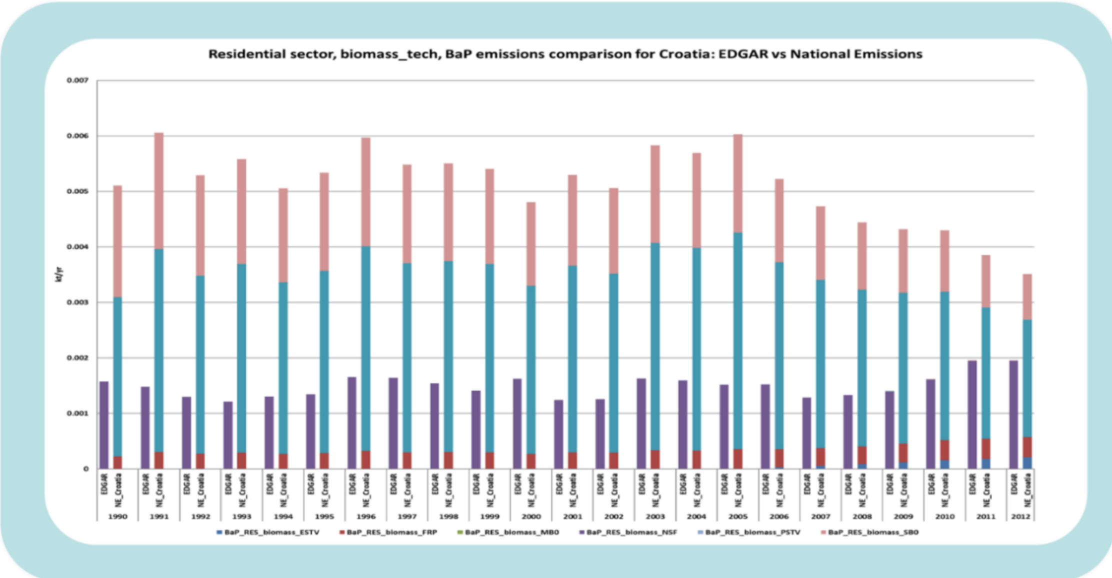
For the emissions comparison presented in this report, we focus on residential subsector only.

Figure 17. Croatia, biomass used in small combustion activities



Regarding biomass used in small combustion activities sector, Croatia substantially improved the activity data. This is illustrated in Figure 17; on average for the period 1990-2012, the biomass used in small combustion activities is 3.7 times higher after revision compared to the values reported before revision. The IEA (2014) data used as input to EDGARv4.3.2 does not include the revised values of biomass used in residential subsector of Croatia. Therefore, the emissions in EDGARv4 are expected to be lower than those in the NE of Croatia in which the revised AD for biomass was used as input to compile NE emissions inventory.

Figure 18. Croatia, BaP emissions from biomass used in residential subsector

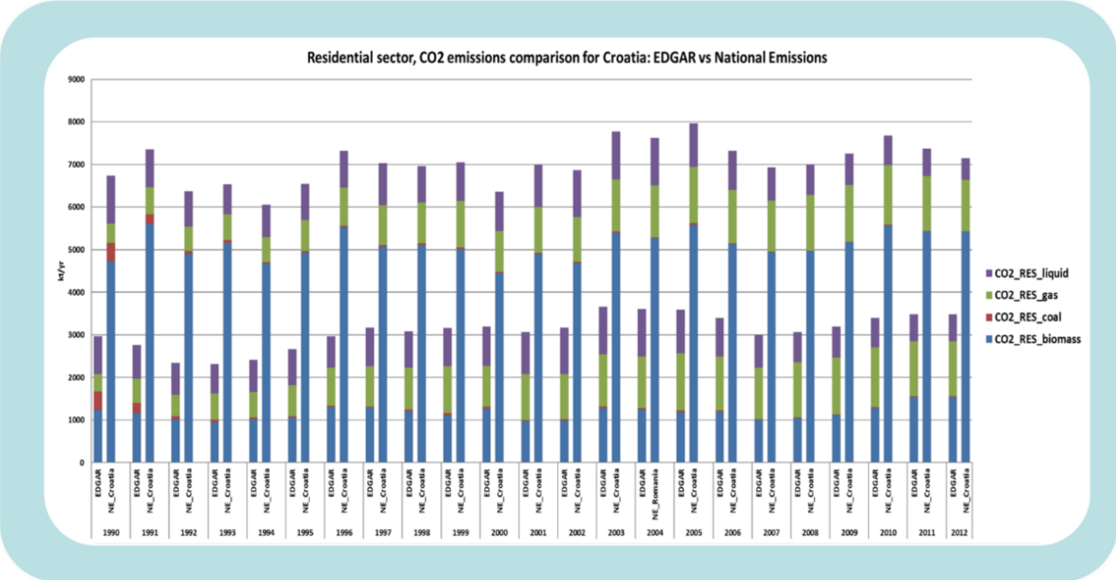


Source: NE Croatia (WG, 2017), EDGARv4.tox3.

Croatia uses Tier 2 methodology of the GB2013 to estimate emissions from residential subsector taking into account the effects of different technologies used for biomass combustion e.g. fireplace (FRP), medium size boiler (MB0), small size boiler (SB0) and stove (STV). Figure 18 illustrates the decreases in BaP emissions in the latest years due to introduction of modern stoves, i.e., pellet stoves (PSTV) and eco-labelled (ESTV) since 2004 and 2006 respectively.

[3]http://ec.europa.eu/eurostat/web/products-statistical-books/-/KS-EN-17-001; http://ec.europa.eu/eurostat/documents/38154/4956218/ENERGY-BALANCES-June2017edition.zip/85e86130-6a52-42aa-848f-d6d2012c9024

Figure 19. Croatia, CO2 emissions from fuel used in residential sub-sector

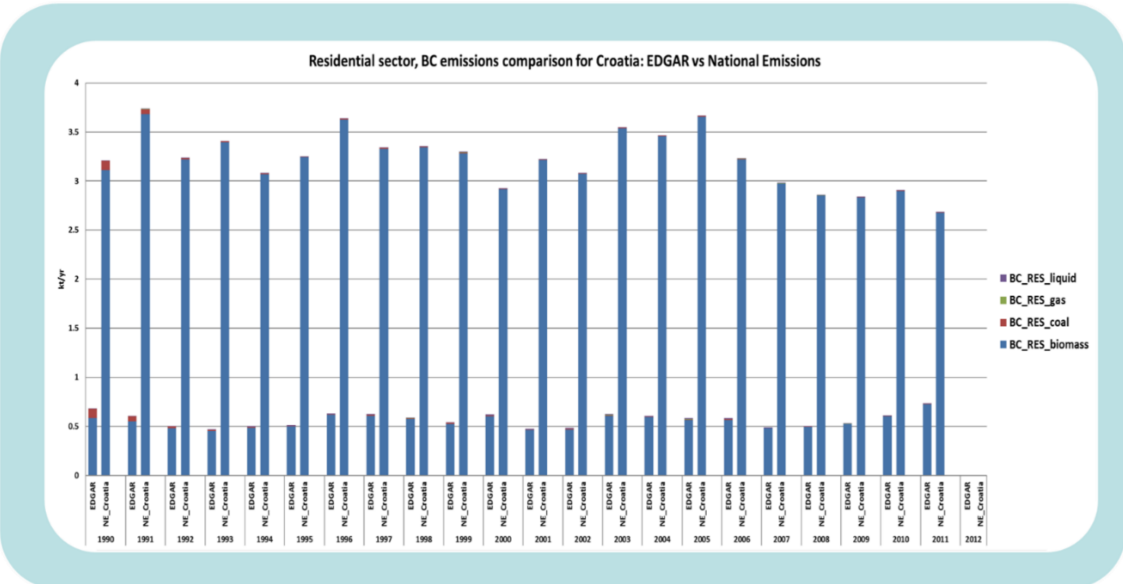


Source: NE Croatia (WG, 2017), EDGARv4.3.2.

Due to scarce information on technology used for fuel combustion in residential sub-sector, EDGARv4 does not include information on technology; therefore, the code associated to EDGARv4 emissions is "NSF". As mentioned, details on other methodologies to improve the activity data related to fuel combustion in residential subsector, biomass consumption in particular, and info on technology used in some countries will be provided in Muntean et al. (2018, in preparation).

CO2 emissions trends by fuel type confirm the improvement of AD for biomass used in NE; the fuels used in residential subsector were aggregated in four groups: biomass, coal, gas and liquid. On average, the CO2 emissions from biomass in NE are 4 times higher than in EDGARv4.3.2 whereas emissions from the other fuels are comparable (see Figure 20).

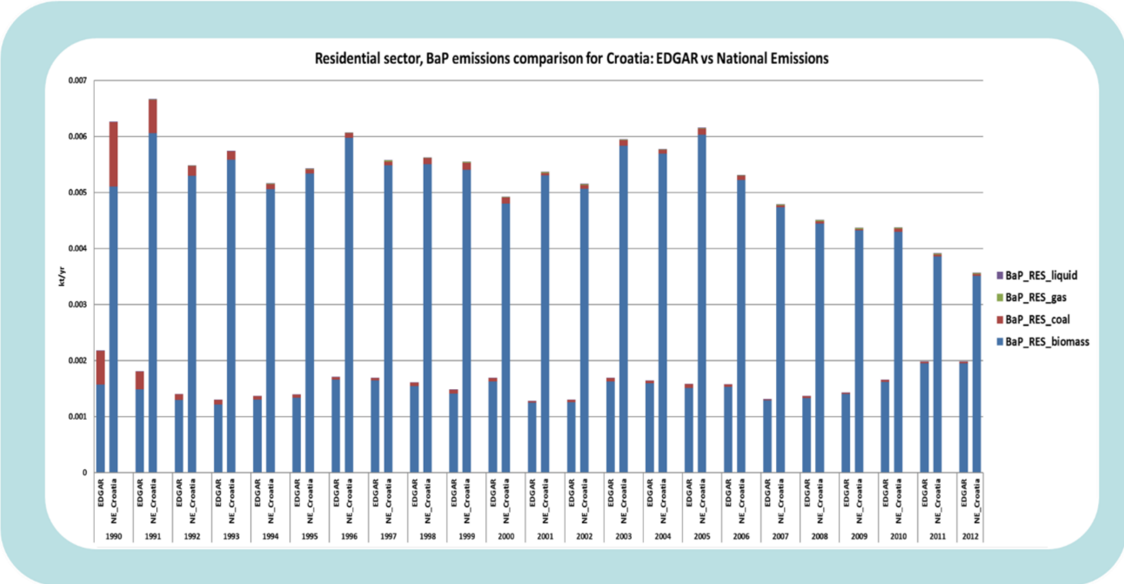
Figure 20. Croatia, BC emissions from fuel used in residential sub-sector



Source: NE Croatia (WG, 2017), EDGARv4.3.2.

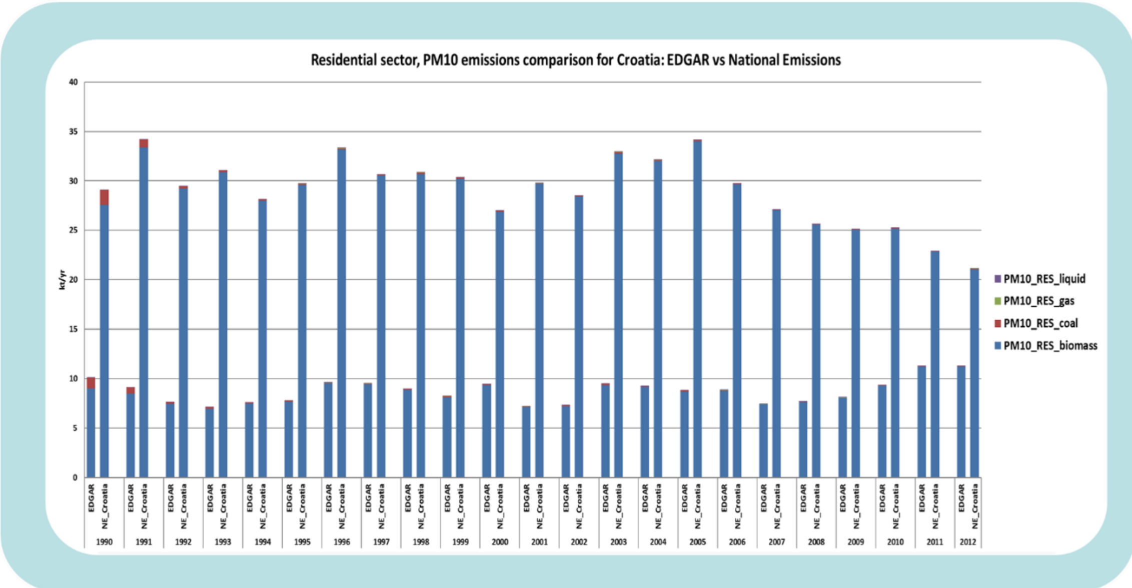
As illustrated in Figures 21, 22 and 23, in Croatia, BC, BaP and PM10 are emitted primarily from biomass combustion (in blue). In NE emissions decreased in the latest years due to implementation of modern appliances in residential subsector.

Figure 21. Croatia, BaP emissions from fuel used in residential subsector



Source: NE Croatia (WG, 2017), EDGARv4.tox3.

Figure 22. Croatia, PM10 emissions from fuel used in residential sub-sector



Source: NE Croatia (WG, 2017), EDGARv4.3.2.

The emissions of NE Croatia presented in this study are calculated using the revised activity data for biomass consumption in this sector (see Figure 17) whereas the emissions in EDGAR are estimated based on IEA (2014) data that includes fuel consumption reported before this revision, which explain the differences between NE Croatia and EDGAR emissions.

4.4.2 Slovakia

The CO2 emissions used for this comparison are from GHGs inventory reported under Greenhouse gas Monitoring Mechanism Regulation (MMR); emissions are split by categories and by fuels (solid, liquid, gaseous and biomass). Complete GHG emissions data are available at http://ghg-inventory.shmu.sk/documents.php?download=556 or http://cdr.eionet.europa.eu/sk/eu/mmr/art07_inventory/ghg_inventory/.

Air pollutant emissions calculation is based on the data from official emissions inventory reported to the NEC Directive and CLRTAP. Complete air emissions data are available at http://cdr.eionet.europa.eu/sk/eu/nec_revised/inventories/envwmmbxa/.

Air pollutant emissions from categories commercial and public services and agriculture/forestry are based on the emissions data from National emission information system (NEIS). These emissions were calculated within the system and it is very difficult to split them by fuels. The NEIS system contains more than 13 thousands emission sources aggregated in different categories including above mentioned categories.

Emissions from the category residential were estimated based on: a) the total energy demand in residential subsector, b) natural gas inputs from supplier, c) inputs from NEIS, i.e., detailed data from regional fuels sellers (hard coal (HC), brown coal (BC), brown coal briquettes (BCB) and coke (Ck)).

Since the availability of data for biomass consumption in residential is poor, calculation of biomass used in this subsector is based on Total Energy Demand of households (TED), consumption of Natural gas (NG) and other solid fuels from NEIS using the formula:

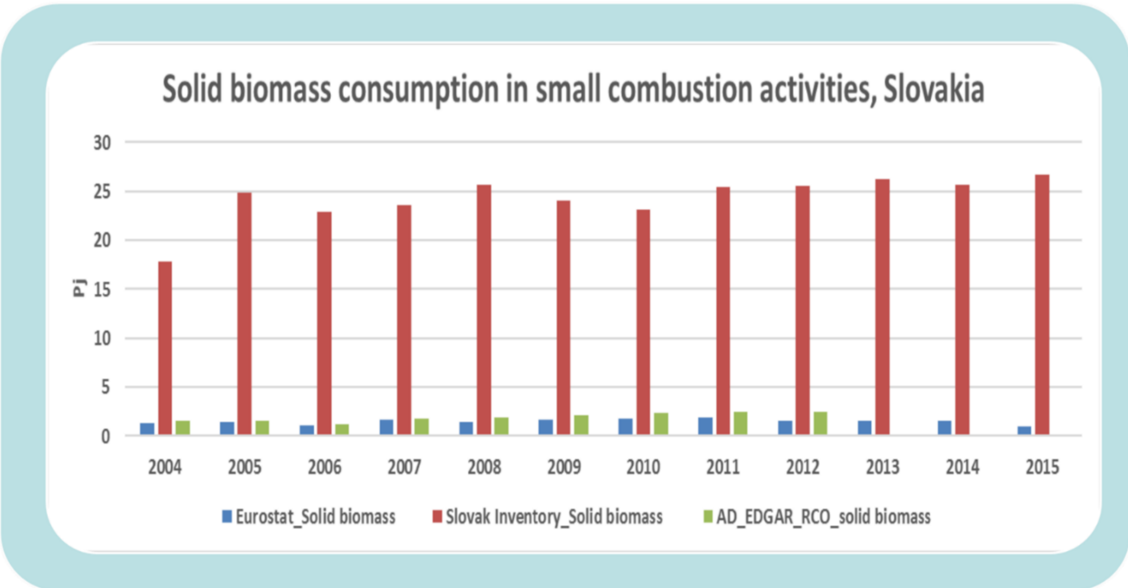
$$BM_E = TED - NG_E - HC_E - BC_E - BCB_E - Ck_E$$

Where: index E is "energy from fuel". Assuming that the effectivity of energy production is 72% and net calorific value is 14,27 MJ/kg the resulting biomass combustion is $BM_{amount} = BM_E/0{,}72$.

This methodology to estimate the biomass combustion in residential subsector is under development in Slovakia. In the future, based on these findings also the official statistics it is expected to be improved.

Important to be mentioned is the fact that the quantity of biomass used as input to compile the national emissions inventory (NE) are different than those reported to EUROSTAT and to IEA by Slovakia. Figure 23 shows this difference; the values for biomass combustion in residential subsector used as input for the NE are 16.8 times higher than values included in the reporting to Eurostat and IEA.

Figure 23. Slovakia, biomass used in small combustion activities



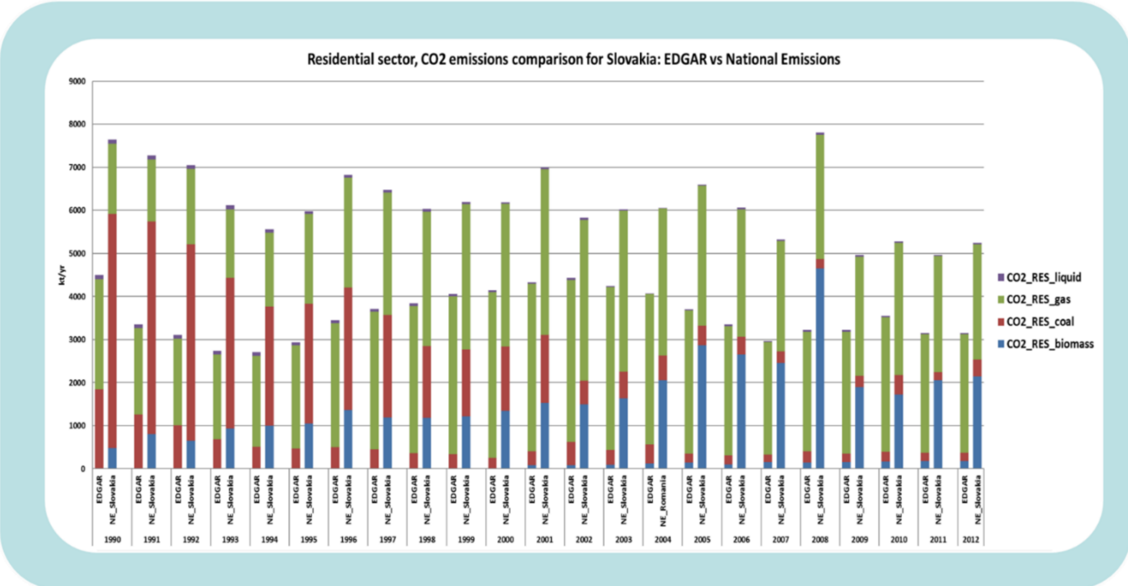
Source: Eurostat[4], Slovak Inventory[5],

[4] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_107a&lang=en

EDGARv4.3.2 (from IEA, 2015).

The differences between CO_2 emissions calculated in NE and EDGARv4.3.2 are illustrated in Figure 24. The CO_2 emissions from biomass combustion in NE, which are based on an improved evaluation of biomass used in residential subsector, are e.g. 17.6 times higher on average for the period 2004-2012 than those estimated in EDGARv4.3.2. This effort to improve the activity data for biomass combustion increased the accuracy of the emissions estimation.

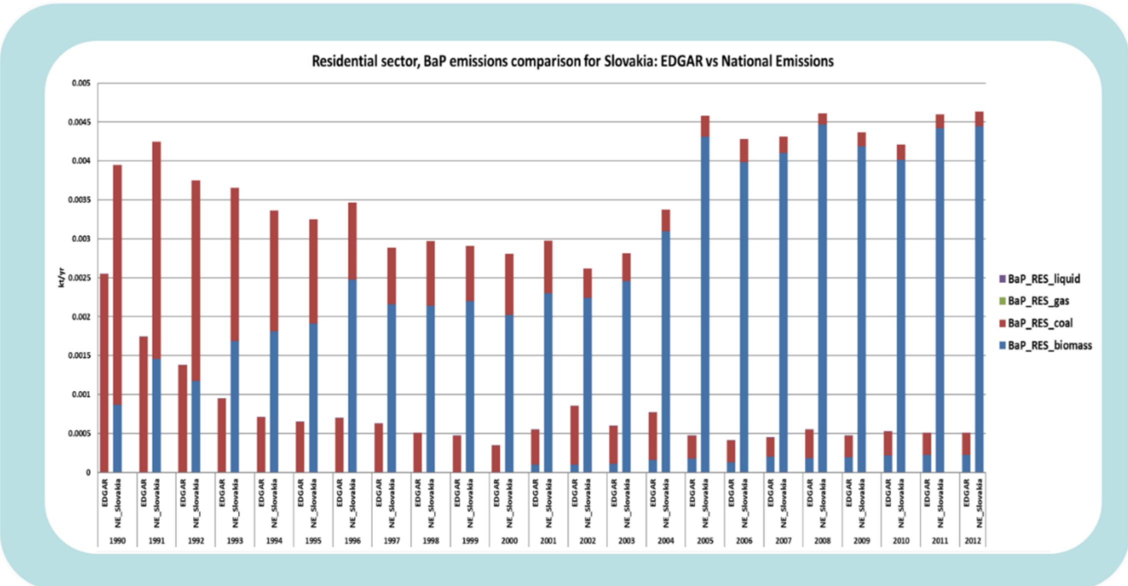
Figure 24. Slovakia, CO2 emissions from fuel used in residential sub-sector



Source: NE Slovakia (WG, 2017), EDGARv4.3.2.

In residential subsector, the BaP and PM10 are emitted primarily from coal and biomass combustion. The differences in quantities of biomass used for emissions calculation in the two inventories resulted in differences in emissions levels.

Figure 25. Slovakia, BaP emissions from fuel used in residential subsector

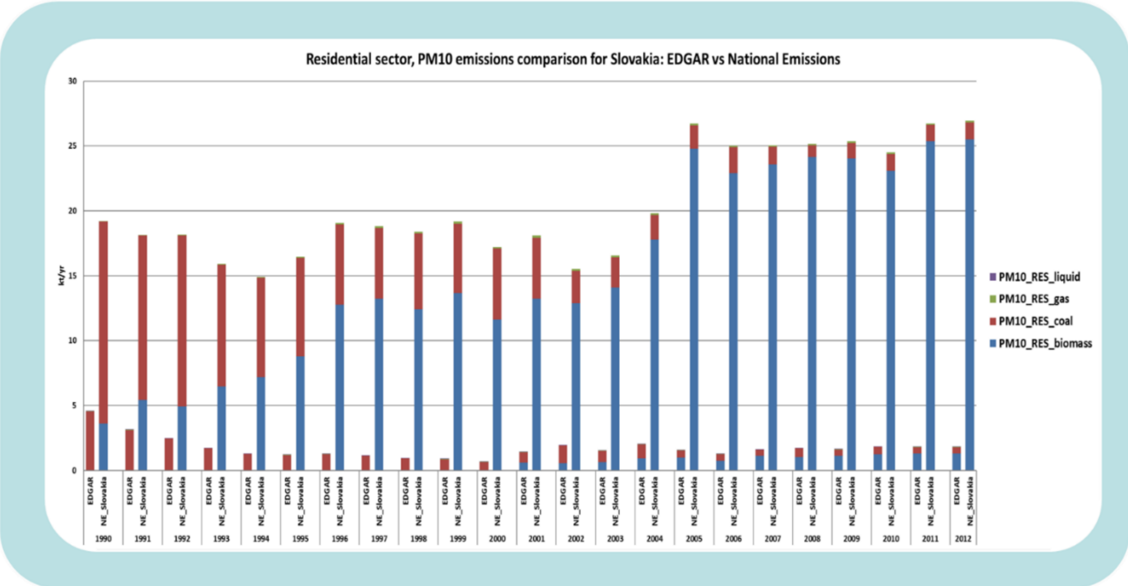


Source: NE Slovakia (WG, 2017), EDGARv4.tox3.

[5] http://cdr.eionet.europa.eu/sk/eu/nec_revised/inventories/envwmmbxa/

Compared to EDGARv4.3.2 and EDGARv4.tox2, both pollutants have higher values in NE (see Figures 25 and 26). Fuel combustion in residential subsector emits significant quantities of pollutants, which damage human health. The results of this analysis show that the official national statistics based on selling records of biomass for household heating are incomplete. Emissions from the real quantity of biomass used in residential subsector are substantially higher and the impacts on health are increasing accordingly. In addition to fuel sold information, countries with biomass share in fuel mix shall use an appropriate methodology to estimate biomass consumption in residential subsector and consequently to lower the uncertainty in emissions estimation.

Figure 26. Slovakia, PM10 emissions from fuel used in residential subsector



Source: NE Slovakia (WG, 2017), EDGARv4.3.2.

As described in this section, the emissions in NE Slovakia used in this analysis are calculated using a methodology based on the total energy demand in residential subsector whereas the emissions in EDGAR are estimated based on IEA (2014) data, which explain the differences between NE Slovakia and EDGAR emissions.

4.4.3 Romania

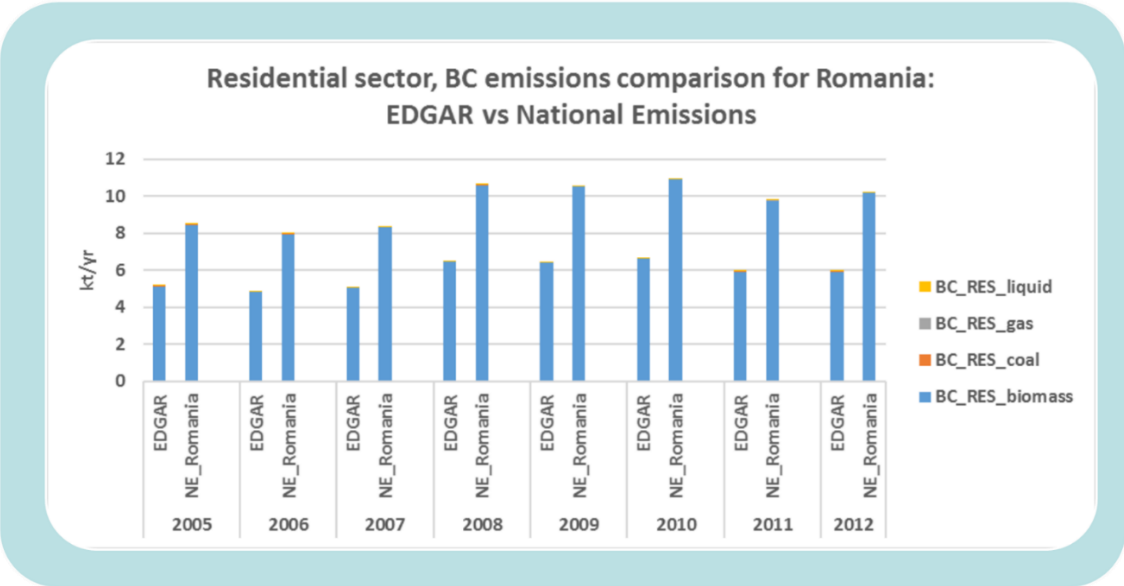
For this comparison, the inventories officially submitted to CLRTAP for the reference years 2005-2012 were used as main data source. Pollutants considered here are: BC, PM10 and BaP. Air emissions from stationary combustion in the Commercial/Institutional, Residential, Agriculture/Forestry/Fishing subsectors were calculated based on fuel consumption in each subsector and Tier 1 emissions factors from GB2013. The National Institute for Statistics provided activity data for emissions calculation in the domestic Energy Balance yearly books. The activity data are those available at the time of inventory compilation (not revised).

The activity data, as fuel consumption, were aggregated in four groups: liquid, solid, gas and biomass. To these activity data, Tier 1 emission factors provided in GB2013 for the fuel groups, liquid, solid, gas and biomass were applied in order to calculate the official national emissions.

For Romania, the comparison is presented for the period 2005-2012. The quantities of fuel consumption in residential subsector officially reported to Eurostat and IEA were used as input for emissions estimation in NE.

Figure 27 illustrates the comparison NE vs EDGARv4.3.2 for BC. According to the methodology presented in GB2013, BC has different shares in PM2.5 emissions; the fraction of BC in PM2.5 depends on the technology and fuel used in residential subsector. The choice of EFs for biomass combustion in the two emissions inventories led to differences in emissions; the BC emissions in NE are, on average, 1.7 higher than in EDGARv4.3.2.

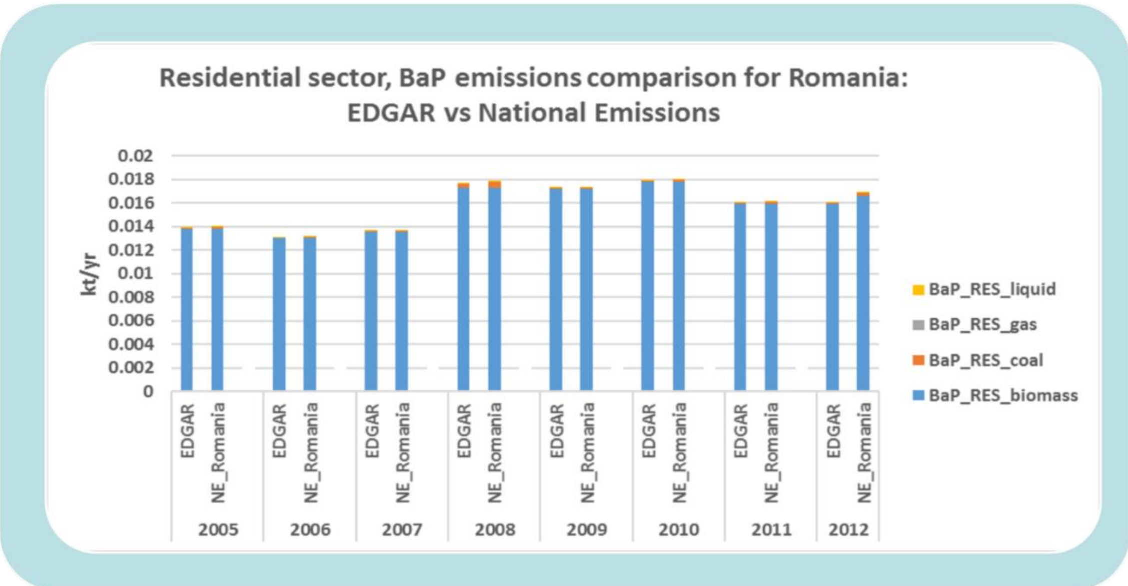
Figure 27. Romania, BC emissions from fuel used in residential subsector



Source: NE Romania (WG, 2017), EDGARv4.3.2.

The comparison provided in Figure 28 shows consistency between NE and EDGARv4.tox3 for both activity data and emission factor; in the NE and EDGARv4.tox3, the BaP emissions from biomass combustion are equal for each year.

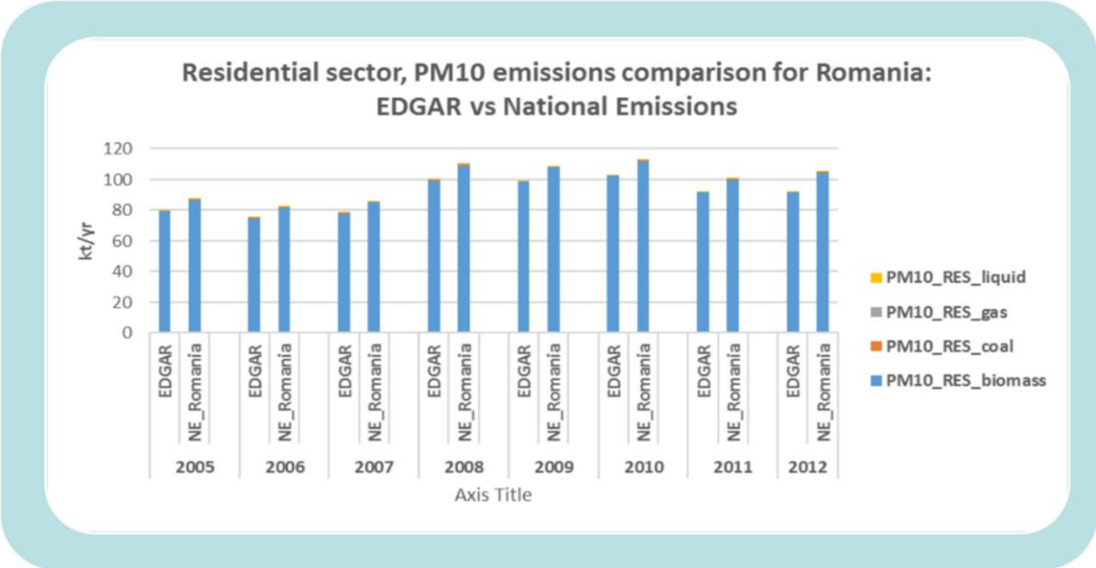
Figure 28. Romania, BaP emissions from fuel used in residential subsector



Source: NE Romania (WG, 2017), EDGARv4.tox3.

In Romania, PM10 is emitted primarily from biomass combustion. These emissions are presented in Figure 29 for both NE and EDGARv4.3.2. On average NE emissions are 10% higher than those in EDGARv4.3.2. This shows that the emissions factors used for emissions calculation are slightly different in the two emissions inventories.

Figure 29. Romania, PM10 emissions from fuel used in residential subsector



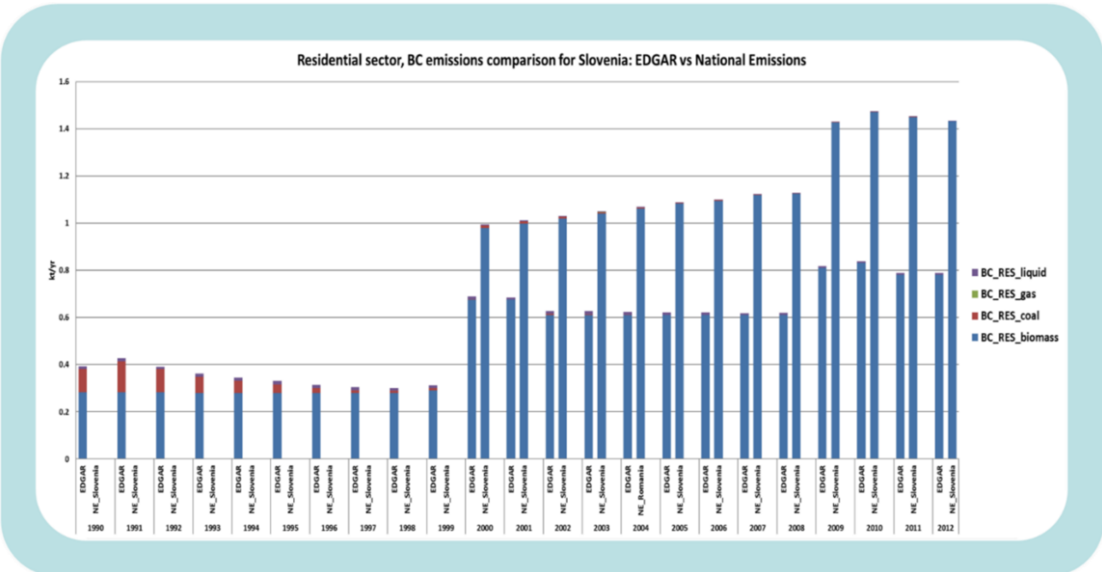
Source: NE Romania (WG, 2017), EDGARv4.3.2.

For fuels used in residential subsector, the GB2013 provides technology-based EFs. The analysis of the results of this emissions comparison for Romania shows the impacts on emissions levels of an appropriate choice of EFs.

4.4.4 Slovenia

As for the other countries, the GB2013 methodology is used to estimate emissions in Slovenia. In the last official reporting, the emission time series have been recalculated for BaP from 1990 to 2014 and for BC and PM10 from 2000 to 2014 by using improved activity data, including also small corrections applied to the biomass used in residential subsector. Market drivers, price in particular, and the state measures to promote renewable energy source led to increasing use of biomass. Full description of the NE emissions inventory is provided in the "Informative Inventory Report Slovenia 2017" of Slovenian Environment Agency (EMEP/CEIP, 2017).

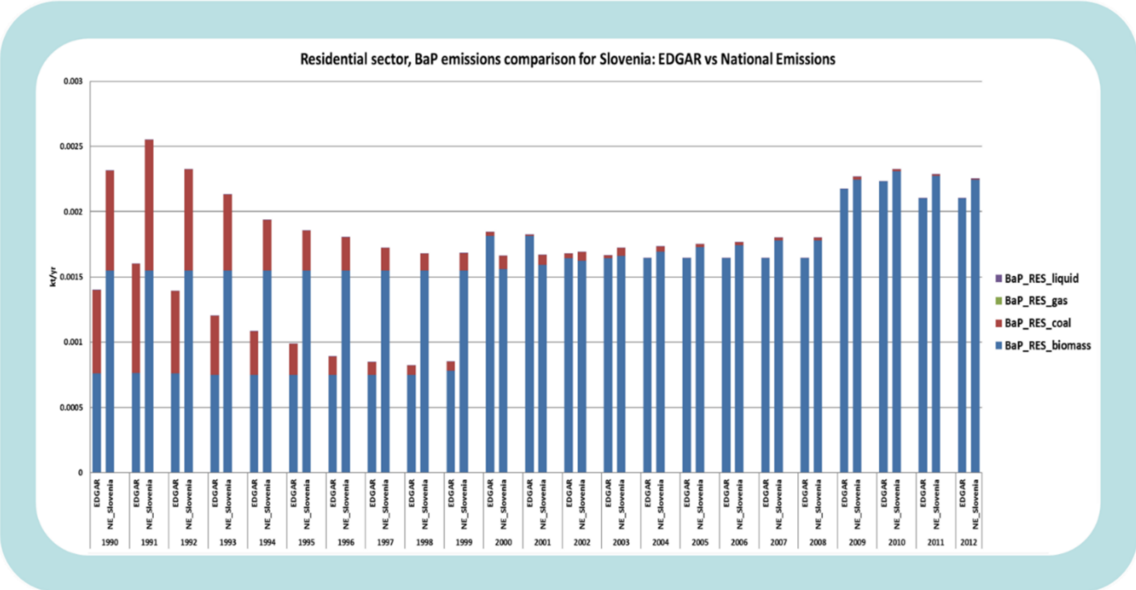
Figure 30. Slovenia, BC emissions from fuel used in residential subsector



Source: NE Slovenia (WG, 2017), EDGARv4.3.2.

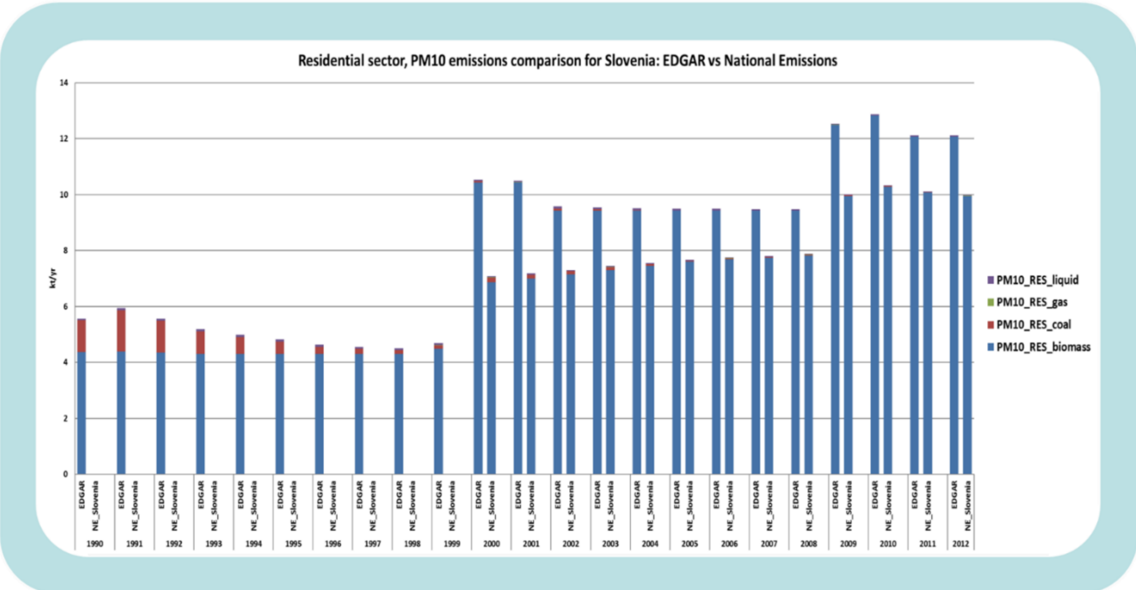
The results of emissions recalculation are illustrated on the Figures 30, 31, and 32 for BC, BaP and PM10 respectively. BC and PM10 emissions in NE are estimated from 2000 onwards only.

Figure 31. Slovenia, BaP emissions from fuel used in residential subsector



Source: NE Slovenia (WG, 2017), EDGARv4.tox3.

Figure 32. Slovenia, PM10 emissions from fuel used in residential subsector



Source: NE Slovenia (WG, 2017), EDGARv4.3.2.

The jump in EDGARv4.3.2 and EDGARv4.tox3 emissions with an increase of 132% from 1999 to 2000 lead to the conclusion that the biomass used in residential subsector was revised and improved from 2000 onwards and included in the official reporting to the IEA (2014).

5 EDGAR.grid2 Web-based gridding tool: module for emissions distribution from small combustion activities

The EDGAR.grid2 was developed in the framework of EC/JRC scientific support to macro-regional strategies, EUSDR in particular, at the request of emissions country experts members of the TFEIP. This gridding tool contains two modules: 1) gridding tool for distribution of emissions from road transport and 2) gridding tool for distribution of emissions from small combustion activities

Full description of the module for emissions distribution from road transport is provided in in "The impact of a modal shift [trucks/ships] in transport on emissions to the atmosphere: Methodology development for the best use of the available information and expertise in the Danube Region." report by Muntean et al., 2015.

This gridding tool is an important support to emission country experts with less experience in emissions distribution; it can be freely used by countries for a first gridding of their emissions or to compare the gridmaps produced with this tool with their gridded emissions. As recommended by the TFEIP this tool "is useful for countries that don't have the capacity or knowledge to perform the spatial distribution themselves and can help to improve reporting of gridded data at 0.1ºx0.1º under the Convention and the NEC Directive" (TFEIP, 2017). With this tool, the emission country experts can distribute their national emissions for road transport (1.A.3.b) and small combustion activities (1.A.4).

Scientists, regional institutions and authorities can use this tool to distribute emissions from road transport and small stationary combustion activity sectors in a consistent manner over an area that covers many countries such as a macro-region.

The methodology for spatial distribution and proxy data used in the EDGAR.grid2 module for emissions distribution from small combustion activities sector are described in section 3.2.

The module of the EDGAR.grid2 Web-based gridding tool for emissions distribution from small combustion activities, which is described in this section and in annex 4, has the same structure as the module dedicated to road transport.

The information and steps on how to navigate into the EDGARv4.grid2 tool are provided in annex 4 of this report. The tool is available upon request at http://edgar.jrc.ec.europa.eu/eolo_new/index.php/webtool; the potential users can send an e-mail at "jrc-edgar@ec.europa.eu" to ask for user name and password.

The input for EDGAR.grid2 has to be prepared by using the Template provided in the Table 5. This template has to be filled in with information and data:

- the name of pollutant,
- process code,
- ISO A3 country code,
- emissions of the pollutants for the years for which the user would like to run the EDGAR.grid2 tool and crate gridmaps.

An example of the emissions input file (part of it) is provided in Table 6 with PM10 emissions from small combustion activities (1.A.4) in Croatia.

Table 5. Template to prepare the emissions input for EDGAR.grid2 tool.

Dataset	dataset_name									
Process code	RCO									
IPCC code	1A4									
Unit	Ktons									
Year from	2005									
Year to	2012									
Substance	Process code	Country_ISO_A3	2005	2006	2007	2008	2009	2010	2011	2012

Source: EDGAR.grid2.

Where: 1) Substance is e.g. CO2, NOx, SO2, BC, PM10, PM2.5, PAH_BaP etc., 2) Process code is e.g. RCO.RES.LGN.SB0; RCO stands for "small combustion activities", RES "residential subsector", and LGN "Lignite/Brown Coal" as fuel used in SB0 "small boiler appliance". 3) Country_ISO_A3 is e.g. ROU, HRV, SVK, SVN for Romania, Croatia, Slovakia and Slovenia respectively.

The EDGAR codes for fuels and technologies are presented and described in Table 7.

Table 6. Emissions input for EDGAR.grod2 tool - example

Dataset	EDGAR RCO EMISSIONS						
Process code	RCO						
IPCC code	1A4						
unit	Ktons						
Year from	2008						
Year to	2012						
Substance	Process code	Country_ISO_A3	2008	2009	2010	2011	2012
PM10	RCO.AGR.DIE.NSF	HRV	0.026166	0.024431	0.023643	0.023484	0.023484
PM10	RCO.AGR.GGS.NSF	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.AGR.HFO.NSF	HRV	0.00074	0.00074	0.000592	0.00074	0.00074
PM10	RCO.AGR.LPG.NSF	HRV	0.000511	0.000511	0.000511	0.000511	0.000511
PM10	RCO.AGR.MOG.NSF	HRV	0.001465	0.001302	0.001302	0.001302	0.001302
PM10	RCO.AGR.NGS.NSF	HRV	0.00035	0.000333	0.000378	0.000366	0.000366
PM10	RCO.AGR.OKE.NSF	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.COM.BKB.MB0	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.COM.BKB.SB0	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.COM.BKB.STV	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.COM.CHA.MB0	HRV	NULL	0.00293	0.00293	0.00293	0.00293
PM10	RCO.COM.CHA.SB0	HRV	NULL	0.001507	0.001507	0.001507	0.001507
PM10	RCO.COM.CHA.STV	HRV	NULL	0.003232	0.003232	0.003232	0.003232
PM10	RCO.COM.DIE.NSF	HRV	0.013712	0.012295	0.011662	0.010245	0.010245
PM10	RCO.COM.GGS.NSF	HRV	0.000024	0.000029	2.45E-05	2.15E-05	2.15E-05
PM10	RCO.COM.HFO.NSF	HRV	0.000444	0.001036	0.001184	0.00148	0.00148
PM10	RCO.COM.LGN.MB0	HRV	0.004845	0.009263	0.007125	0.011685	0.011685
PM10	RCO.COM.LGN.SB0	HRV	0.001292	0.00247	0.0019	0.003116	0.003116
PM10	RCO.COM.LGN.STV	HRV	0.002295	0.004388	0.003375	0.005535	0.005535
PM10	RCO.COM.LPG.NSF	HRV	0.001702	0.002042	0.002213	0.002383	0.002383
PM10	RCO.COM.MOG.NSF	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.COM.NGS.NSF	HRV	0.002699	0.002762	0.003275	0.002949	0.002949
PM10	RCO.COM.OKE.NSF	HRV	NULL	NULL	NULL	NULL	NULL
PM10	RCO.COM.SBI.NSF	HRV	0.056295	0.07784	0.068805	0.09035	0.09035

Source: EDGAR.grid2/EDGARv4.3.2 (WG, 2017).

Table 7. EDGAR codes for fuels and technologies

EDGAR fuels

BIOMASS FUELS	
Charcoal	CHA
Dung	DNG
Industrial Waste	IWS
Municipal Waste (Renew)	MWR
Primary Solid Biomass (non-specified)	SBI
Vegetal waste	VWS
Wood	WOD
Biodiesel	BDS
Biogasoline	BGL
Bagasse	BGS
Black Liquor	BLI
Liquid Biomass	LBI
Other Liquid Biofuels	OLB
Biogas	GBI
Non-specified Combust. Renew.+Wastes (if no detail)	NSF

GASEOUS FOSSIL FUELS	
Natural Gas (if no detail)	NGS
Blast Furnace Gas	BFG
Gas Works Gas	GGS
Output from Non-spec. Manuf. Gases	MNG
Coke Oven Gas	OGS
Refinery Gas	RGS
Oxygen Steel Furnace Gas	SGS

FOSSIL OIL AND OIL PRODUCTS	
Bitumen	BIT
Crude/NGL/Feedstocks	CNF
Crude Oil	CRU
Gas/Diesel Oil (if no detail)	DIE
Residual Fuel Oil	HFO
Lubricants	LUB
Other Hydrocarbons	NCR
Petroleum Coke	PCK
Paraffin Waxes	PWX
Refinery Feedstocks	RFD
Additives/Blending Components	ADD
Aviation Gasoline	AVG
Ethane	ETH
Gasoline Type Jet Fuel	GJE
Kerosene Type Jet Fuel	JET
Liquefied Petroleum Gases (LPG)	LPG
Motor Gasoline (if no detail)	MOG
Naphtha	NAP
Natural Gas Liquids	NGL
Kerosene	OKE
Non-specified Petroleum Products	OPR
White Spirit & SBP	WSP

SOLID FOSSIL FUELS	
Anthracite	ANT
Other Bituminous Coal	BTC
Coking Coal	CKC
Coal Tar	CLT
Gas Coke	GCK
Hard Coal (if no detail)	HDC
Coke Oven Coke	OCK
Patent Fuel	PAT
Sub-Bituminous Coal	SBC
BKB/Peat Briquettes	BKB
Brown Coal (if no detail)	BRC
Lignite/Brown Coal	LGN
Peat	PEA
Municipal Waste (Non-Renew)	MWN

EDGAR technologies

tech_code	description
FRP	fireplace
MBO	medium size boiler
SBO	small boiler
STV	stoves
NSF	non specified

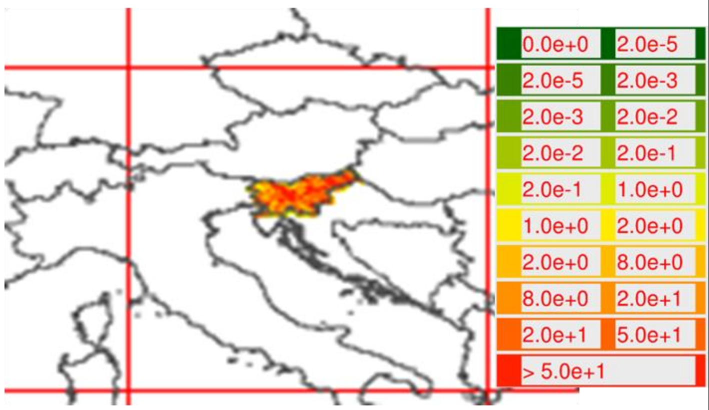
In red: default EDGAR codes for fuels and technology to be used when no details are available

As output, EDGAR.grid2 tool provides both gridmaps in ".txt" format, comma seperated text file wth longitude, latitude and value, and maps in ".png" format or picture output. An example of the EDGAR.grid2 output is presented in Figure 33.

Figure 33. Slovenia, PM10 emissions from fuel used in residential subsector: a) gridmap (part of) in .txt format, b) map in .png

Thursday 04th of May 2017 04:54:17 PM
Compound: **PM10**; emissions_ds_name:DS_NAME_TO_BE_FIXED(edgar_muntean) ; Year:2010; Global
Total:10751.588088716(tons)
lat; **lon**; **emission 2010** (tons)
46.8;15.9;1.54719e+0
46.8;16.0;1.90335e+1
46.8;16.1;1.20308e+1
46.8;16.2;1.14588e+1
46.8;16.3;2.31681e+0
46.7;15.7;3.19697e+0
46.7;15.8;6.55215e+0
46.7;15.9;1.52764e+1
46.7;16.0;3.35323e+1
46.7;16.1;2.53773e+1
46.7;16.2;1.52767e+1
46.7;16.3;4.29239e+0
46.7;16.4;5.31439e-2
46.6;14.8;7.51288e-1
46.6;14.9;5.82055e+0
....

a)

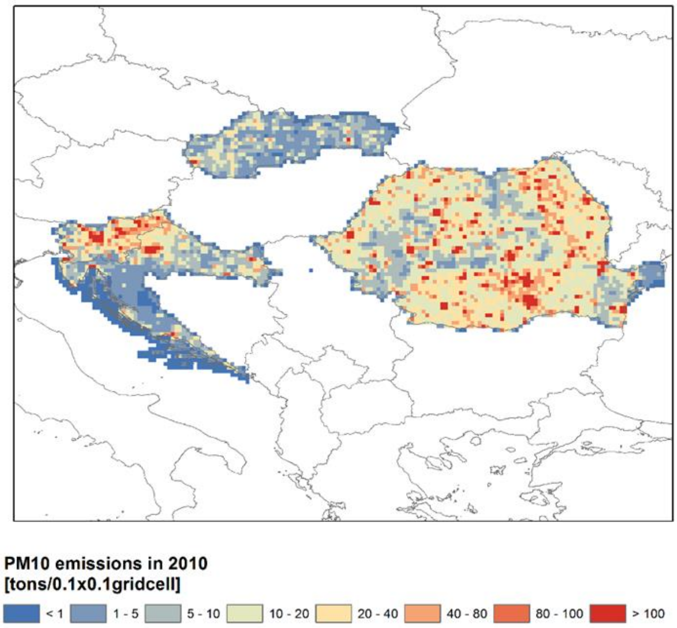


b)

Source: EDGAR.grid2 (WG, 2017).

The gridmaps/maps created with EDGAR.grid4 tool could be further processed with other tools e.g. ArcGis and produce maps for specific purposes as illustrated in Figure 34.

Figure 34. PM10 national emissions from residential subsector for Romania, Slovakia and Croatia



Source: EDGAR.grid2 (WG, 2017).

6 Conclusions

Emissions from small stationary combustion activities sector depend on fuel type and combustion technology. As presented in this study, the fuel mix and technology penetration are country specific and are characterized by large uncertainty. Therefore, to increase the quality of emissions, additional efforts are needed to improve the statistics on the consumed fuel, in particular the biomass (which has not been sold) and the information on technology penetration. Further, these emissions can be used as input for the chemical transport models and contribute to the improvement of impact evaluation, which is a key element in measuring the effectiveness of mitigation measures.

In this study, we present the findings of a comprehensive analysis on fuel shift in this sector over 1990-2012 period for each country belonging to Alpine, Adriatic-Ionian and Danube macro-regions. Emissions levels and gridmaps showing emissions hotspots are discussed and presented. The EDGAR.grid2 Web-based gridding tool has been upgraded; this tool contains two modules: 1. for emissions distribution from small stationary combustion activities sector documented in this study (see section 5) and 2. for emissions distribution from road transport documented in Muntean et al. (2015).

Main achievements:

1. The analysis of fuel mix changes over 1990-2012 shows that:
    - For OECD Europe countries part of the Alpine, Adriatic-Ionian and Danube macro-regions, coal fuel had a low share in fuel mix in 1990, except for Austria (14%) and Germany (22%), for which it decreased abruptly to a share of less than 3% in Germany and 1% for the rest of the countries. The biomass consumption increased in all these countries except France; countries with shares of biomass in total fuel consumption in residential subsector in 2012 greater that biomass share in OECD Europe region (12%) are Austria (38%), France (27%), Greece (21%), Germany (15%) and Italy (14%).
    - For Central Europe countries part of the Alpine, Adriatic-Ionian and Danube macro-regions, Hungary, Croatia, Romania, Slovenia, Slovakia and Ukraine reduced the coal used in household heating to less than 4% and some of them eliminated this fuel from their fuel mix in household whereas Bosnia Herzegovina increased this share to 34% in 2012. Instead, the shares of coal in total fuel consumption in household in Bulgaria (22%), Serbia and Montenegro (16%), and Czech Republic (14%) remained significant in 2012. The biomass consumption increased in all these countries except Albania; countries with shares of biomass in total fuel consumption in household in 2012 greater that biomass share in Central Europe region (27%) are Albania (69%), Bulgaria (70%), Bosnia Herzegovina (53%), Czech Republic (31%), Croatia (34%), Romania (55%), Serbia and Montenegro (68%) and Slovenia (53%).
    - An insight on the uncertainty in activity data is given by the results of the comparison with recent improved data on biomass used in household; for some countries these values are higher than the values previously submitted to Eurostat (see section 4.4).
2. Emissions estimation and emissions gridmaps:
    - Emissions discussed in this study are those in EDGARv4.3.2 and EDGARv4.tox3.
    - A methodology was developed to calculate emissions for the areas included in Alpine, Adriatic-Ionian and Danube macro-regions, which are not full countries but only parts of these countries.
3. Tool in support to country emissions experts

- The EDGAR.grid2 Web-based gridding tool has been updated and tested by emissions country experts.
- Emissions gridmaps can be created by using this tool.
- This Web-based gridding tool is available upon request.

This research led to the conclusion that there are large uncertainties in quantities of biomass and types of appliances used for fuel combustion in small units. In order to improve the quality of emissions estimations and reduce uncertainties, countries should make efforts to identify the existing technologies used for fuel combustion and to improve the evaluation of biomass quantities used in small stationary combustion activities, therefore, improving their reporting to Euroastat and IEA. In the latest years, some countries in these macro-regions recalculated their emissions taking into account also the implementation of modern technologies. The results of an extended investigation on this topic will be provided in Muntean et al. 2018 (in preparation). Finally, the EDGAR.grid2 Web-based gridding tool, with its two modules, supports the emissions country experts to fulfil their obligations under the Convention on Long-range Transboundary Air Pollution (CLRTAP, 1983) and the Directive on the reduction of national emissions of certain atmospheric pollutants (NECD 2016/2284/EU), specifically for emissions distribution from road transport and small stationary combustion activities (TFEIP, 2017).

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List of abbreviations

EUSAIR	European Union Strategy for the Adriatic and Ionian Region
EUSALP	European Union Strategy for the Alpine Region
EUSDR	European Union Strategy for the Danube Region
EU28	European Union (EU), which consists a group of 28 countries
EDGAR	Emissions Database for Global Atmospheric Research
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
CLRTAP	Convention on Long-range Transboundary Air Pollution
EC	European Commission
SDG 7	Sustainable Development Goal "Ensure access to affordable, reliable, sustainable and modern energy for all"
UN	United Nations
IEA	International Energy Agency
CIESIN	Center for International Earth Science Information Network

List of figures and tables

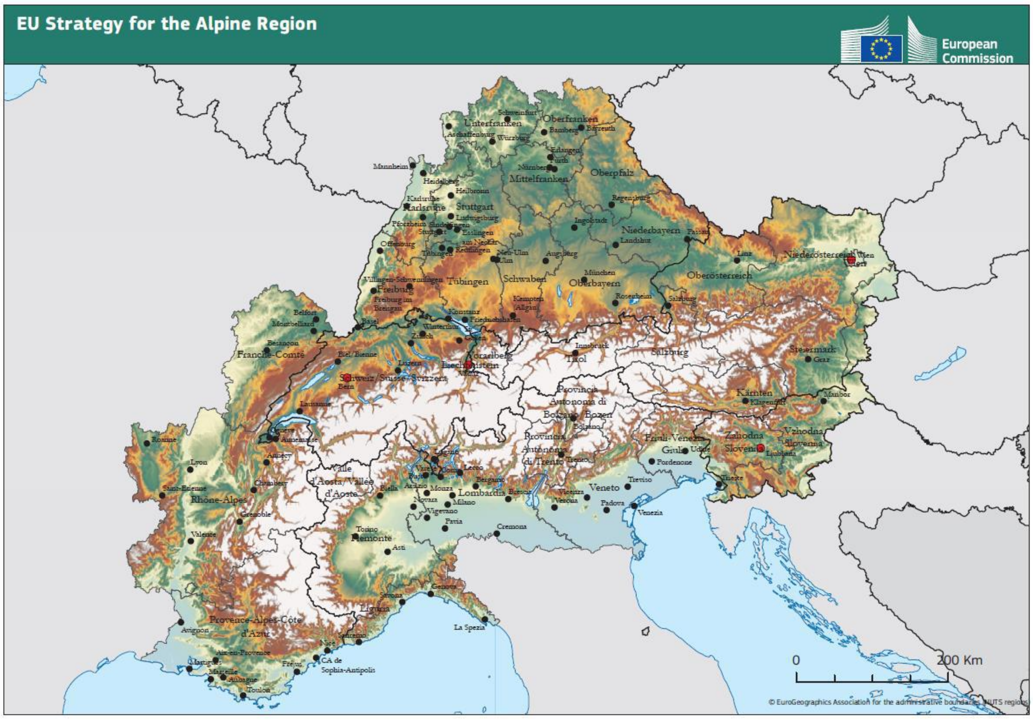
Annexes

Annex 1. Countries in EUSALP, EUSAIR and EUSDR and maps

Countries in EUSALP, EUSAIR and EUSDR.

EUSALP Countries	EUSAIR Countries	EUSDR Countries
Slovenia	Slovenia	Slovenia
Italy (part)	Italy (part)	
	Croatia	Croatia
	Serbia	Serbia
	Bosnia Herzegovina	Bosnia Herzegovina
	Montenegro	Montenegro
Austria		Austria
Germany (part)		Germany (part)
Switzerland		Bulgaria
France (part)	Albania	Czech Rep.
	Greece	Hungary
		Romania
		Slovakia
		Ukraine (part)
		Moldova

Figure 35. Area covered by the EUSALP



Source: EC/SWD, 2016.

Figure 36. Area covered by the EUSAIR

Source: EC/SWD, 2016.

Figure 37. Area covered by the EUSDR

Source: EC/SWD, 2016.

Annex 2. PM2.5, BC and BaP emissions for 2010 and emissions per capita

EUSALP (Source: EDGARv4.3.2)

Country/EUSALP	population 2010	PM2.5 [t/yr] emissions	%shares 2010	Emissions [t/capita]	BC [t/year] emissions	%shares 2010	Emissions [t/capita]	BaP [t/year] emissions	%shares 2010	Emissions [t/capita]
Austria	8391990	6864.990	11.2	0.0008	1501.978	19.1	0.00018	10.293	24.2	1.22655E-06
Switzerland	7866810	8323.656	13.6	0.0011	861.727	10.9	0.00011	4.012	9.4	5.09993E-07
Germany (part)	23255252	9788.650	15.9	0.0004	1677.469	21.3	0.00007	11.145	26.2	4.79225E-07
France (part)	12301609	16598.357	27.0	0.0013	1657.282	21.0	0.00013	8.358	19.6	6.79453E-07
Italy (part)	22746734	13435.975	21.9	0.0006	1356.541	17.2	0.00006	6.557	15.4	2.88256E-07
Liechtenstein	35894	55.995	0.1	0.0016	7.467	0.1	0.00021	0.042	0.1	1.18279E-06
Slovenia	2052480	6360.696	10.4	0.0031	821.309	10.4	0.00040	2.183	5.1	1.06343E-06
tot	76650769	61428.319	100.0	0.0008	7883.773	100.0	0.00010	42.590	100.0	5.55638E-07

EUSAIR (Source: EDGARv4.3.2)

Country/EUSALP	population 2010	PM2.5 [t/yr] emissions	%shares 2010	Emissions [t/capita]	BC [t/year] emissions	%shares 2010	Emissions [t/capita]	BaP [t/year] emissions	%shares 2010	Emissions [t/capita]
Albania	2901880	2984.049	4.6	0.0010	373.883	5.0	0.0001	1.034	3.7	3.5621E-07
Bosnia and Herzegovina	3835260	4094.945	6.3	0.0011	467.306	6.3	0.0001	1.894	6.8	4.9396E-07
Greece	11177500	6137.350	9.4	0.0005	637.585	8.6	0.0001	2.827	10.2	2.5296E-07
Croatia	4316430	4768.350	7.3	0.0011	609.960	8.2	0.0001	1.643	5.9	3.8064E-07
Italy (part)	36624948	21169.658	32.4	0.0006	2143.351	28.8	0.0001	10.348	37.2	2.8255E-07
Montenegro	619001	1487.119	2.3	0.0024	179.673	2.4	0.0003	0.597	2.1	9.6379E-07
Serbia	7306677	18267.101	28.0	0.0025	2207.526	29.7	0.0003	7.326	26.3	1.0026E-06
Slovenia	2052480	6360.696	9.7	0.0031	821.309	11.0	0.0004	2.183	7.8	1.0634E-06
tot	68834176	65269.267	100.0	0.0009	7440.593	100.0	0.0001	28	100.0	4.0463E-07

EUSRD (Source: EDGARv4.3.2)

Country/EUSDR	population 2010	PM2.5 [t/yr] emissions	%shares 2010	Emissions [t/capita]	BC [t/year] emissions	%shares 2010	Emissions [t/capita]	BaP [t/year] emissions	%shares 2010	Emissions [t/capita]
Austria	8391990	6864.990	4.2	0.0008	1501.978	7.2	0.00018	10.293	13.3	1.22655E-06
Bulgaria	7407300	12507.149	7.7	0.0017	1514.910	7.3	0.00020	4.912	6.3	6.63191E-07
Bosnia Herzegovina	3835260	4094.945	2.5	0.0011	467.306	2.2	0.00012	1.894	2.4	4.93958E-07
Czech Rep.	10506600	22810.264	14.1	0.0022	2732.891	13.1	0.00026	9.834	12.7	9.3595E-07
Germany (part)	22866645	9788.650	6.0	0.0004	1677.469	8.0	0.00007	11.145	14.4	4.87369E-07
Croatia	4316430	4768.350	2.9	0.0011	609.960	2.9	0.00014	1.643	2.1	3.80636E-07
Hungary	10014600	12976.327	8.0	0.0013	1551.509	7.4	0.00015	4.913	6.3	4.90627E-07
Moldova	4084480	2400.977	1.5	0.0006	247.279	1.2	0.00006	1.007	1.3	2.46579E-07
Montenegro	621952	1487.119	0.9	0.0024	179.673	0.9	0.00029	0.597	0.8	9.59212E-07
Romania	20298800	53238.365	32.9	0.0026	6778.806	32.5	0.00033	18.451	23.8	9.08987E-07
Serbia	9059050	18267.101	11.3	0.0020	2207.526	10.6	0.00024	7.326	9.4	8.08698E-07
Slovakia	5406900	3789.394	2.3	0.0007	316.590	1.5	0.00006	2.313	3.0	4.27755E-07
Slovenia	2052480	6360.696	3.9	0.0031	821.309	3.9	0.00040	2.183	2.8	1.06343E-06
Ukraine (part)	5898056	2526.384	1.6	0.0004	280.457	1.3	0.00005	1.101	1.4	1.86595E-07
tot	114760543	161880.710	100.0	0.0014	20887.664	100.0	0.00018	77.612	100.0	6.76294E-07

Annex 3. Metadata for national emissions from small stationaty combustion activities sector

Source: WG, 2017

a) Metadata Croatia

Metadata element							
ID							
Resource title	REPUBLIC OF CROATIA 2017 INFORMATIVE INVENTORY REPORT	NFR (1990 – 2015)	DOF	Census 2011	Employment and Wages	Agricultural Census 2003	CORINE Land Cover Croatia
Organization name	EKONERG Ltd. Energy and Environmental Protection Institute	EKONERG Ltd. Energy and Environmental Protection	Republic of Croatia State Geodetic Administration	Croatian Bureau of Statistics	Croatian Bureau of Statistics	Croatian Bureau of Statistics	Croatian Agency for Environment and Nature
Point of contact	Mirela Poljanac	Mirela Poljanac	Mirela Poljanac	Mirela Poljanac	Mirela Poljanac	Mirela Poljanac	Mirela Poljanac
Contact e-mail	mirela.poljanac@ekonerg.hr	mirela.poljanac@ekonerg.hr	mirela.poljanac@ekonerg.hr	mirela.poljanac@ekonerg.hr	mirela.poljanac@ekonerg.hr	mirela.poljanac@ekonerg.hr	mirela.poljanac@ekonerg.hr
Resource abstract	National data on emission, emission factors and activity data and methodology used for the emission calculation. Trend of activity data for period 1990 - 2015 presented in figures, trend of pollutant emissions for period 1990 - 2015 presented in tables. The Croatian IIR is	National data on National totals and NFR sector emissions for main pollutants, PM, POPs, HMs and activity data for period 1990 - 2015 presented in Excel tables. The Croatian	Central registry of spatial units with administrative and territorial constitution for the Republic of Croatia. National boundaries with neighboring countries, administrative boundaries in Croatia (Municipalities/towns as part of 21	Census of Population, Households and Dwellings 2011 provide overview of the territorial organisation of the Republic of Croatia. During the Census 2011 in the Republic of Croatia	Publication gives the annual overview of the number of persons in paid employment in legal entities results from data processing of regular annual and monthly surveys, which comprises 70% of persons in	The purpose of the 2003 Agriculture Census was to collect data on the land reserve, the mode of using agricultural land, the area under orchards and vineyards, and the number of fruit trees	Land cover application covers land cover data for reference years: 1980, 1990, 2000, 2006 and 2012, including land cover change bases for all reference years
Resource type	datset series	datset series	web service	web service	web service	web service, tables, database	interactive web service
Resource locator	http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/2017_submissions/	http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting	http://www.dgu.hr/sitemap.html	http://www.dzs.hr/default_e.htm	http://www.dzs.hr/default_e.htm	http://www.dzs.hr/default_e.htm	http://corine.azo.hr/#sthash.N3XZgCy1.dpbs
Main distribution format	pdf	Excel table	shp	pdf	pdf	xls, html, txt, px	.shp (maybe?)
INSPIRE theme(s)	Energy resources	Energy resources	Administrative units, Cadastral	Administrative units,	Administrative units, Statistical	Administrative units, Statistical	Administrative units,
Constraints applying to access and use	publicly available	publicly available	available on requast, on charged	publicly available	publicly available	publicly available	publicly available (maybe?)/ on charged (maybe?)
Data of publication	2017-03-15, deadline for the official submission under LRTAP Convention	2017-02-15, deadline for the official submission under	-	-	-	-	-
Keywords	air, energy, general, pollution	air, energy, general, pollution	administration, information	information	information	information	information
Lineage / Policy Context	IIRs for Croatia are officially published by Croatian Agency for Environment and Nature	IIRs for Croatia are officially published by Croatian Agency for Environment and	-	-	-	-	-

b) Metadata Slovakia

Metadata element	
ID	
Resource title	Time series of emissions (CO2, SO2, PM10, BaP) based on emissions ionventories of Slovak republic
Organization name	Slovak hydrometeorological institute
Point of contact	M. Zemko
Contact e-mail	marcel.zemko@shmu.sk
Resource abstract	Emissions of CO2: Emissions in the template („wt_template_res.xls") are based on the data from GHG inventory reported under MMR - Greenhouse gas Monitoring Mechanism Regulation. Emissions are split by categories and by fuels (solid, liquid, gaseous and biomas). Air pollutant emissions: Emissions in the template („wt_template_res.xls") are based on the data from emissions inventory reported under NEC directive and CLRTAP. By categories: Air pollutant emissions from categories Commercial and public services and Agriculture/forestry are based on the emissions data from National emission information system (NEIS). These emissions were calculated within the system and it is very difficult to split by fuels. Emissions from the category Residential were estimated based on calculation of Biomass combustion in residential sector.
Resource type	datset series
Resource locator	http://ghg-inventory.shmu.sk/documents.php?download=556
	http://cdr.eionet.europa.eu/sk/eu/nec_revised/inventories/envwmmbxa/
Main distribution format	.xlsx
INSPIRE theme(s)	
Constraints applying to access and use	Reuse is authorised according to the European Commission legal notice at http://ec.europa.eu/geninfo/legal_notices_en.htm
Data of publication	2017-04-15 (2017-03-15)
Keywords	greenhouse gas emissions, air polutant, climatic change, scientific research, Europe, national emision invetories
Lineage / Policy Context	

c) Metadata Romania

Metadata element	
ID	
Resource title	National Air Pollutant Emissions Data
Organization name	National Environmental Protection Agency - Romania
Point of contact	RO NEPA - Air Quality Assesment Centre
Contact e-mail	corina.cristea@anpm.ro; inventare_emisii@anpm.ro
Resource abstract	Emissions as country totals are computed based on fuel consumption provided by the National Statistics Institute (NSI) and Tier1 emission factors from EMEP/EEA air pollutant emission inventory guidebook - 2013, for the NFR categories 1A4ai, 1A4bi and 1A4ci and fuel groups (solid, liquid and gas). The official submitted emissions were further split on fuels, at the level of detail available in the national energy balances (domestic editions).
Resource type	Dataset series
Resource locator	http://cdr.eionet.europa.eu/ro/un/clrtap/inventories/envwkriwg/
	http://cdr.eionet.europa.eu/ro/un/clrtap/iir/envwmlttw/
Main distribution format	xls, pdf
INSPIRE theme(s)	
Constraints applying to access and use	Public data
Data of publication	15.03.2017
Keywords	Europe, Romania, CLRTAP, National Inventory, Stationary combustion, Residential combustion, Commercial/institutional combustion, Activity data, Emissions, UNECE, NEC, reporting, EIONET
Lineage / Policy Context	The following correspondence with NFR notation was used: RCO.COM - 1A4ai Commercial/institutional: Stationary RCO.RES - 1A4bi Residential: Stationary RCO.AGR - 1A4ci Agriculture/Forestry/Fishing: Stationary (including fishing, for which no separated data are available). The emissions were calculated at Tier1 level, with no specific information on technology considered.

d) Metadata Slovenia

Metadata element	
ID	
Resource title	National emission data for Slovenia
Organization name	Slovenian Environment Agency
Point of contact	Martina Logar
Contact e-mail	martina.logar@gov.si
Resource abstract	The file contains national emissions data for Slovenia for small combustion sector. National emission data submitted under UNECE Convention on Long-Range Transboundary Air Pollution and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants were disaggregated according the fuel and technology used. EMEP/EEA methodology was used for emission calculations.
Resource type	datset series
Resource locator	http://cdr.eionet.europa.eu/si/eu/nec_revised/inventories/envwj3zmg/overview
Main distribution format	.xls
INSPIRE theme(s)	
Constraints applying to access and use	Data reported are publicly available.
Data of publication	2017-02-13
Keywords	air pollutants, emissions, air pollution
Lineage / Policy Context	

Annex 4. How to navigate into the EDGAR.grid2 application

Menu

<table>
<tr><th>Menu</th><th>Description</th></tr>
<tr><td>
</td><td>Sections:

1. My profile
2. Emissions datasets
3. Gridding-tool
4. Gridmaps (txt)
5. Maps (png)</td></tr>
</table>

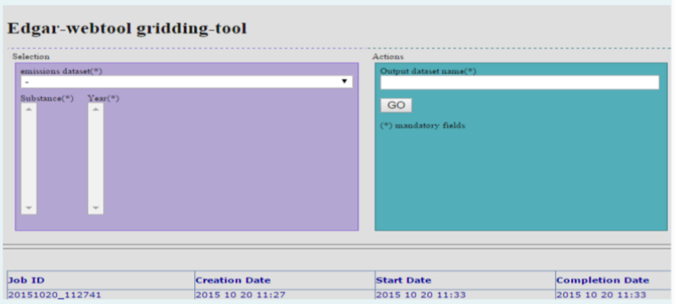
Create emission gridmaps

Step 1: Prepare your emissions input file (see section 5)

Step 2: Upload the emissions input file

<table>
<tr><th>EMISSIONS DATASETS</th><th>Description</th></tr>
<tr><td>
</td><td>➢ Import new emission datasets (input file: the template compiled with countries data/emissions).
➢ Edit datasets
➢ Delete datasets</td></tr>
</table>

Step 3: Run the gridding process

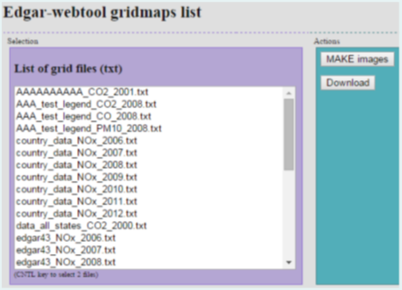
<table>
<tr><th>GRIDDING-TOOL
run the gridding process</th><th>Description</th></tr>
<tr><td>
</td><td><u>Selection panel</u>
➢ select the dataset (previously imported)
➢ select the substance
➢ select the year

<u>Actions panel</u>
➢ insert a name for the output grid-map
➢ click the GO button[1]

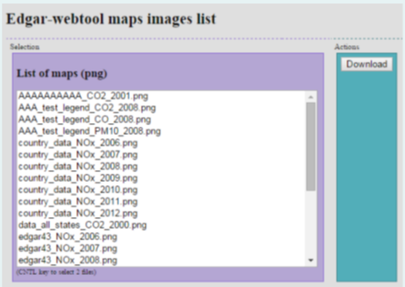
[1]In the list on the bottom of the page is possible to check the process state.</td></tr>
</table>

Once the process has ended, files are available in the GRIDMAPS section.

Step 4: Create pictures of the grid-maps

GRIDMAPS (txt)	Description
	<u>Selection panel</u> ➢ select the grid-maps from the list <u>Actions panel</u> ➢ MAKE images: create pictures of the grid-maps ➢ Download: download the files in zip format

Step 5: Download the gridmaps

MAPS (png)	Description
	<u>Actions panel</u> Download: download the pictures of the grid-maps previously created

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