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HOW TO DEVELOP A SUSTAINABLE ENERGY ACTION PLAN (SEAP) IN THE EASTERN PARTNERSHIP AND CENTRAL ASIAN CITIES

PART II – BASELINE EMISSIONS INVENTORY

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PREFACE

This Guidebook is a revision of the Guidebook 'How to develop a Sustainable Energy Action Plan (2010)', focusing on the 11 Newly Independent States or the Eastern Partnership of the European Union. It has been realised with the support and input of many experts from municipalities, regional authorities, agencies, city networks and private companies. We thank all those who have provided input and contributions and helped to shape the document.

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ACRONYMS

BAU	Business-as-usual
BEI	Baseline Emissions Inventory
CCS	Carbon capture and storage
CH_4	Methane
CHP	Combined heat and power
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2EH	CO_2 emissions related to heat that is exported outside of the territory of the local authority
CO_2-eq.	CO_2-equivalent
CO_2GEP	CO_2 emissions due to the production of certified green electricity purchased by the local authority
CO_2IH	CO_2 emissions related to imported heat from outside the territory of the local authority
CO_2LPE	CO_2 emissions due to the local production of electricity
CO_2LPH	CO_2 emissions due to the local production of heat
CoM	Covenant of Mayors
CO_{2CHPE}	CO_2 emissions from electricity production in a CHP plant
CO_{2CHPH}	CO_2 emissions from heat production in a CHP plant
CO_{2CHPT}	Total CO_2 emissions of the CHP plant
DHC	District heating/cooling
EE	Energy efficiency
EFE	Local emission factor for electricity
EFH	Emission factor for heat
ELCD	European Reference Life Cycle Database
ETS	Emission Trading Scheme
EU	European Union
EU-ETS	European Union Emissions Trading Scheme
GEP	Green electricity purchases by the local authority
GHG	Greenhouse gas
GWP	Global warming potential
HDD	Heating degree days
HDD_{AVG}	Heating degree days in an average year
ICLEI	Local Governments for Sustainability
IEA	International Energy Agency
IEAP	International Local Government Greenhouse Gas Emissions Analysis Protocol
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre of the European Commission
LCA	Life cycle assessment
LHC	Local heat consumption
LHC_TC	Temperature-corrected local heat consumption
LPE	Local electricity production
MEI	Monitoring Emissions Inventory
NIS	Newly Independent States
N_2O	Nitrous oxide

NCV	Net calorific value
NEFE	National emission factor for electricity
OECD	Organisation for Economic Co-operation and Development
P_{CHPH}	Amount of heat produced in a CHP plant
P_{CHPE}	Amount of electricity produced in a CHP plant
PV	Solar photovoltaic installation
RES	Renewable energy sources
SEAP	Sustainable Energy Action Plan
UNFCCC	United Nations Framework Convention on Climate Change
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute
η_e	Energy efficiency from electricity generation
η_h	Energy efficiency from heat production

1. INTRODUCTION

The Baseline Emissions Inventory (BEI) quantifies the amount of carbon dioxide (CO_2) emitted due to energy consumption in the territory of the local authority (i.e. Covenant signatory) ([1]) in the baseline year. It allows for identification of the principal anthropogenic sources of CO_2 emissions and to prioritise the reduction measures accordingly. The local authority may include also methane (CH_4) and nitrous oxide (N_2O) emissions in the BEI. Inclusion of CH_4 and N_2O depends on whether measures to reduce these greenhouse gases (GHGs) also are planned in the Sustainable Energy Action Plan (SEAP), and also on the emission factor approach chosen (standard or life cycle assessment (LCA)). For simplicity, we mainly refer to CO_2 in these guidelines, but it can be understood to also mean other GHGs like CH_4 and N_2O in the case that the local authority includes them in the BEI and SEAP in general.

Elaborating a BEI is of critical importance. This is because the inventory will be the instrument allowing the local authority to measure the impact of its actions related to climate change. The BEI allows for provision of a reference base year from which changes in emissions and in particular reductions will be monitored in view of achieving the local authority's objective of CO_2 reduction. Emission inventories are very important elements to maintain the motivation of all parties willing to contribute to the local authority's CO_2 reductions objective, allowing them to see the results of their efforts.

The overall CO_2 reductions target of the Covenant of Mayors (CoM) signatories is at least 20 % reduction by 2020 achieved through the implementation of the SEAP for those areas of activity relevant to the local authority's mandate. The reduction target is defined in comparison to the baseline year that is set by the local authority. The local authority can decide to set the overall CO_2 emissions reductions target either in relation to a baseline year / BEI (as 'absolute reduction' or 'per capita reduction') or on the basis of a reference scenario called business-as-usual (BAU), as explained in Chapter 5.2

According to the principles laid out in the CoM, each signatory is responsible for the emissions occurring due to energy consumption in its territory. Therefore, emission credits bought or sold on the carbon market do not intervene in the BEI/ Monitoring Emissions Inventory (MEI). However, this does not prevent signatories from using carbon markets and related instruments to finance their SEAP measures.

The BEI quantifies the emissions that occurred in the baseline year. In addition to the inventory of the baseline year, emission inventories will be compiled in later years to monitor progress towards the target. Such an emission inventory is called a MEI. The MEI will follow the same methods and principles as the BEI. The acronym BEI/MEI is used when describing issues that are common for both inventories. Specific instructions for monitoring SEAP implementation will be published further on.

In these guidelines, advice and recommendations for compiling a BEI/MEI under the CoM are presented. Some of the definitions and recommendations are unique to the inventories under the CoM in order to enable the inventories to demonstrate the progress being made towards the target of the Covenant.

However, as far as possible, the concepts, methodologies and definitions in internationally agreed standards are followed in these guidelines. For example, the local authority is encouraged to use emission factors that are in line with those of the Intergovernmental Panel on Climate Change (IPCC) or European Reference Life Cycle Database (ELCD). However, the local authority is given the flexibility to use any approach or tool that it considers appropriate for the purpose.

The results of the BEI are reported by using the online SEAP template available at http://www.soglasheniemerov.eu/ online. The site and the template are available in Russian and in English. Many other related documents such as the instructions on how to fill in the template and also a Microsoft® Excel version of the template are available online in several languages at http://www.soglasheniemerov.eu/support/library_ru.html online.

This Guidebook is tailored to the specific needs of the Eastern Partnership and central Asian countries, which are still recovering from economic reform. As such, various specific indicators were calculated for the 11 Newly Independent States (NIS) and a BAU scenario was developed projecting the growth of their economy, and the increase in CO_2 emissions for 2020 as a result of a 'do nothing' stance in terms of policies and the environmental regulations scenario. Some adaptations were agreed in order not to hinder the development of the local emerging economies but to ensure their sustainable development. This is the main reason why, specifically for these countries, the option to set the emission target based on a BAU scenario for 2020 was added.

[1] 'territory of the local authority' refers to the geographical area within the administrative boundaries of the entity governed by the local authority.

Yet, some references to European regulations and in particular definitions used in the European Union (EU) were maintained as an alignment or common orientation for the authorities of the different countries with very heterogeneous characteristics of the energy market and of the energy and environment regulations. In particular, in the case of an absence of terminology or definitions in some countries, these orientation lines serve to fill the eventual gaps of the national framework.

2. SETTING UP AN INVENTORY

2.1. Key concepts

In the compilation of BEI/MEI, the following concepts are of utmost importance.

a) *Baseline year.* Baseline year is the year against which the achievements of the emissions reductions in 2020 shall be compared. A timeline from 1990 (or exceptionally 1989) onwards applies according to the United Nations Framework Convention on Climate Change (UNFCCC) emission inventory submissions (UNFCCC, 2003 and 2006). The Eastern Partnership countries suffered and are still partly suffering from a recovery of their economy in transition. The breakdown in the early 1990s resulted in a strong economic decline and as such in emissions. Therefore, it is recommended that the CoM signatories of Eastern Partnership countries choose a recent year as a baseline year that is representative for the current economic situation and for which reliable statistical data are available ([2]).

b) *Activity Data*. Activity data quantifies the human activity taking place in the territory of the local authority. Examples of activity data are:
   1. oil used for space heating in residential buildings [MWh_{fuel}];
   2. electricity consumed in municipal buildings [MWh_e];
   3. heat consumed as a final product in buildings (municipal, residential and tertiary) or by industry [MWh_{heat}].

c) *Emission factors*. Emission factors are coefficients that quantify the emission per unit of activity. The emissions are estimated by multiplying the emission factor with corresponding activity data. Examples of emission factors are:
   - amount of CO_2 emitted per MWh of oil consumed [tonnes CO_2/MWh_{fuel}];
   - amount of CO_2 emitted per MWh electricity consumed [t CO_2/MWh_e];
   - amount of CO_2 emitted per MWh heat consumed [t CO_2/MWh_{heat}].

d) *Business-as-usual scenario*. The BAU reference scenario is defined as a continuation of the current trend of economic growth to 2020. Starting from present data, the BAU scenario will analyse the evolution of energy and emissions levels until 2020, under the hypothesis of continuing current trends in population, economy, technology and human behaviour, without the implementation of a SEAP.

   The representativeness of the BAU scenario should be monitored by the local authority at least once before the year 2020 in order to allow for evaluation of the reliability of the principles on which basis the BAU projections were made.

e) *CO_2 emission target*. The signatories from the Eastern Partnership and central Asian countries have three options to set their overall CO_2 emissions reductions target. The objective can be set:
   - on the basis of a BEI (specific baseline year to be chosen):
     - as an absolute reduction, compared to the overall emissions accounted for in the BEI (referring to tonnes (t) of CO_2 or t CO_2-equivalent (CO_2-eq.));
     - as a 'per capita' reduction, compared to the total 'per capita' emissions accounted for in the BEI (referring to t CO_2 per capita or t CO_2-eq. per capita). Some orientation numbers on national CO_2 'per capita' and

[2] Considering that the economic situation in the CoM East countries is very different to that of the EU countries, there are different recommendations regarding the baseline year. For the EU signatories of the CoM, the recommended baseline is 1990.

national CO_2-eq. 'per capita' for all economic sectors (including industry and all transport sectors) are given as an estimation in Annex II. In addition, an estimation of the composition of all emitting sectors is presented for each of the 11 NIS to give an indication of the share of the CoM sectors on total anthropogenic emissions.

- on the basis of a BAU scenario, calculated starting from the results of the BEI and foreseeing CO_2 emissions for the territory of the local authority in 2020 (referring to t CO_2 or t CO_2-eq.) ([3]). For a detailed description of how to apply this option please refer to Section 5.2 of Part II of this Guidebook.

2.2. Boundaries, scope and sectors

The geographical boundaries of the BEI/MEI are the administrative boundaries of the local authority.

The BEI will essentially be based on final energy consumption, including both municipal and non-municipal energy consumption in the local authority's territory. However, those other than energy-related sources may also be included in the BEI.

The BEI quantifies the following emissions that occur in the territory of the local authority.

a) Direct emissions due to fuel combustion within the territory in the buildings, equipment/facilities and transportation sectors.

b) Indirect emissions related to the production of electricity, heat or cold that are consumed within the territory according to the specificity of the heat and power grid mix.

c) Other direct emissions, not related to energy consumption, that occur within the territory, depending on the choice of BEI sectors (see Table 1).

Points a) and c) above quantify the emissions that physically occur within the territory. Inclusion of these emissions follows the principles of the IPCC used in the reporting of the countries to the UNFCCC and its Kyoto Protocol ([4]).

As explained in point b) above, the emissions due to production of electricity, heat and cold consumed within the territory are included in the inventory regardless of the location of the production (inside or outside of the territory) ([5]).

The same principles apply regardless of the approach chosen (IPCC or LCA), only that within the LCA approach the indirect emissions related to the supply chain of the energy carrier are also taken into consideration. Yet, this is done exclusively through the emission factor chosen for each energy carrier. The definition of the scope of the BEI/MEI ensures that all the relevant emissions due to energy consumption within the territory are included, but no double counting takes place. As illustrated in Table 1, emissions other than those that are related to fuel combustion can be included in the BEI/MEI. However, their inclusion is voluntary because the main focus of the Covenant is the energy sector, and the importance of emissions other than energy-related emissions may be small in the territories of many local authorities.

Table 1 illustrates the recommendation of sectors to be included in the BEI/MEI. The following labels are used in the table.

- YES: inclusion of this sector in the BEI/MEI is strongly recommended.
- YES if in SEAP: this sector may be included if the SEAP includes measures for it. Even if measures are planned for a sector in SEAP, its inclusion in the BEI/MEI is not mandatory. However, it is recommended as otherwise the local authority cannot quantitatively show the emissions reductions that took place as a result of such a measure.

[3] The possibility of setting the reductions target using a BAU scenario is characteristic for the CoM Eastern Partnership and central Asian countries. It has the aim of allowing those municipalities that are in a rapid economic growth path to develop their economies in a sustainable manner.

[4] They are comparable with 'scope 1 emissions'; for example, in the methodology of the International Local Government Greenhouse Gas Emissions Analysis Protocol (IEAP) (ICLEI, 2009) and The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (WRI/WBCSD, 2004). However, a major difference is that not all emissions occurring within the territory are included; for example, emissions of large power and industrial plants are excluded (see Sections 3.4 and 3.5 in Part II of this Guidebook).

[5] Such emissions are often referred to as 'scope 2' emissions; for example, in the methodology of ICLEI (2009) and WRI/WBCSD (2004).

- NO: inclusion of this sector in the BEI/MEI is not recommended.
- KS: key sector of the Covenant.

Carbon capture and storage (CCS) and nuclear energy are outside the scope of the Covenant, and therefore any emissions reductions related to such activities should be excluded from the BEI/MEI.

Table 1. Sectors included in the BEI/MEI

Sector	Included?	Note
Final energy consumption in buildings, equipment/facilities and industries		
-Municipal buildings, equipment/facilities	YES, KS	These sectors cover all energy-consuming buildings, equipment and facilities within the territory of the local authority that are not excluded below. For example, energy consumption in water and waste management facilities is included in this sector. Municipal waste incineration plants are also included here if they are not used to produce energy. For energy-producing waste incineration plants, see Sections 3.4 and 3.5.
-Tertiary (non-municipal) buildings, equipment/facilities	YES, KS	
-Residential buildings	YES, KS	
-Municipal public lighting	YES, KS	
-Industries involved in ETS	NO	
-Industries not involved in ETS	YES if in SEAP	
Final energy consumption in transportation		
-Urban road transportation: municipal fleet (e.g. municipal cars, waste transportation, police and emergency vehicles)	YES, KS	These sectors cover all road transportation on the street network that is in the competence of the local authority.
-Urban road transportation: public transportation	YES, KS	
-Urban road transportation: private and commercial transportation	YES, KS	
-Other road transportation	YES if in SEAP	This sector covers road transportation on the roads within the territory of the local authority not under its competence; for example, highways.
-Urban rail transportation	YES	This sector covers urban rail transportation within the territory of the local authority, such as tram, metro and local trains.
-Other rail transportation	YES if in SEAP	This sector covers long-distance, intercity, regional and cargo rail transportation that occurs within the territory of the local authority. Other rail transportation does not only serve the territory of the local authority, but a larger area.
-Aviation	NO	The energy consumption of airport and harbour buildings, equipment and facilities will be included as part of the buildings and facilities above, excluding however mobile combustion.
-Shipping/fluvial transport	NO	
-Local ferries	YES if in SEAP	Local ferries are those that serve as urban public transportation within the territory of the local authority. These are not likely to be relevant for most of the signatories.
-Off-road transport (e.g. agricultural and construction machinery)	YES if in SEAP	
Final energy consumption in other sectors		
Agriculture, Forestry, Fisheries	YES if in SEAP	This sector covers all the energy-consuming processes of activities related to agriculture, forestry and fisheries, which take place within the territory of the local authority. They concern the heating/cooling of buildings, stables, pools or greenhouse gases (GHGs) and the electricity consumption for the equipment of these buildings. The emissions not related to energy consumption should be reported separately (see below the comment on the agriculture sector).
Other emission sources (not related to energy consumption)		
Fugitive emissions from production, transformation and distribution of fuels	NO	

Process emissions of industrial plants involved in ETS	NO	
Process emissions of industrial plants not involved in ETS	NO	
Use of products and fluorinated gases (refrigeration, air conditioning, etc.)	NO	
Agriculture	YES if in SEAP	This refers to all GHG-generating processes **not related to energy consumption**, like animal emissions via enteric fermentation, manure management and soil emissions from rice cultivation and other crops, fertiliser use, open burning of agricultural waste.
Land use, land use change and forestry	NO	This refers to carbon stock changes in, for example, urban forests.
Wastewater treatment	YES if in SEAP	This refers to emissions not related to energy, such as CH_4 and N_2O emissions from wastewater treatment. Energy consumption and related emissions from wastewater facilities are included in the category 'buildings, equipment/facilities'.
Solid waste treatment	YES if in SEAP	This refers to emissions not related to energy, such as CH_4 from landfills. Energy consumption and related emissions from waste treatment facilities are included in the category 'buildings, equipment/facilities'.
Energy production		
Fuel consumption for electricity production	YES if in SEAP	In general, only in the case of plants that are < 20 MW_{fuel} and are not part of an international carbon market scheme. See Section 3.4 for more details.
Fuel consumption for heat/cold production	YES	Only if heat/cold is supplied as a commodity to final end-users within the territory. See Section 3.5 for more details.

3. EMISSION FACTORS

3.1. Choice of emission factors: standard (IPCC) or LCA

Two different approaches may be followed when selecting the emission factors:

a) *Using 'standard' emission factors* in line with the IPCC principles, which cover all the CO_2 emissions that occur due to energy consumption within the territory of the local authority, either directly due to fuel combustion within the local authority or indirectly via fuel combustion associated with electricity and heat/cold usage within the area. The standard emission factors are based on the carbon content of each fuel, like in national GHG inventories in the context of the UNFCCC and the Kyoto Protocol. In this approach, CO_2 is the most important GHG, and the emissions of CH_4 and N_2O do not need to be calculated. Furthermore, CO_2 emissions from the sustainable use of biomass/biofuels, as well as emissions of certified green electricity, are considered to be zero.

   The standard emission factors given in these guidelines are based on the IPCC 2006 Guidelines (IPCC, 2006). However, the local authority may decide to also use other emission factors that are in line with the IPCC definitions.

b) *Using LCA emission factors*, which take into consideration the overall life cycle of the energy carrier. This approach includes not only the emissions of the final combustion, but also all emissions of the supply chain. It includes emissions from exploitation, transport and processing (e.g. refinery) steps in addition to the final combustion. Hence, this also includes emissions that take place outside of the location where the fuel is used. In this approach, the GHG emissions from the use of biomass/biofuels, as well as emissions of certified green electricity, are higher than zero. In the case of this approach, GHGs other than CO_2 may play an important role. Therefore, the local authority that decides to use the LCA approach can report emissions as CO_2-eq. However, if the methodology/tool used only counts CO_2 emissions, then emissions can be reported as CO_2 (in t).

LCA is an internationally standardised method (ISO 14040 series) and used by a large number of companies and governments, including for carbon footprinting. LCA is the scientific basis typically used behind, for example, the Thematic Strategies on Natural Resources and Waste, the Ecodesign Directive and the Ecolabel Regulation. At the EU level, a series of technical guidance documents building on the ISO 14040 series had been developed and is regularly updated, coordinated by the European Commission's Joint Research Centre (JRC): International Reference Life Cycle Data System (ILCD) Handbook. The ILCD Handbook (available at http://lct.jrc.ec.europa.eu/) is the result of a comprehensive process of evaluation and selection of existing methods based on a set of scientific and stakeholder acceptance criteria (Sala et al., 2012), and it aims to provide detailed technical guidance in all step required in an LCA. A related ILCD Data Network (JRC et al., 2009) is currently being established (launch is foreseen for beginning of 2013) that would be open for all data providers to give access to consistent and quality-assured LCA data. The network can host, among others, cost-free data, licensed data and members-only data.

The LCA emission factors given in these guidelines are based on a ELCD (JRC, 2009). The ELCD provides LCA data for most of the fuels and allows calculation of country-specific electricity mix data (see Section 3.4). Both the ELCD and the ILCD datasets work with the IPCC global warming factors for the individual gases.

The advantages of both approaches are summarised in Table 2.

Table 2. Comparison of standard and LCA emission factors

Advantage	Standard	LCA
Is compatible with the national reporting to the UNFCCC	X	
Is compatible with carbon footprint approaches		X
All emission factors needed are easily available	X	
Reflects the total environmental impact also outside the place of use		X

After selecting the emission factor approach, the local authority can either use the default emission factors provided in this Guidebook or choose other emission factors that are considered more appropriate. The standard emission factors depend on the carbon content of the fuels and therefore do not vary significantly from case to case. In the case of an LCA approach, obtaining information on the emissions upstream in the production process may be challenging and considerable differences may occur even for the same type of fuel. This is especially the case for biomass and biofuels. It is recommended that local authorities using the LCA approach consider the applicability of the emission factors presented in these guidelines before using them for the BEI/MEI, and try to obtain case-specific data where appropriate.

The choice of the emission factor is reported in the SEAP template by ticking the appropriate box: 'IPCC' or 'LCA'.

3.2. Greenhouse gases included: CO_2 or CO_2-equivalent emissions

The GHGs to be included in the BEI/MEI depend on the choice of sectors and also on the choice of emission factor approach (standard or LCA).

If the standard emission factors following the IPCC principles are chosen, it is sufficient to report only CO_2 emissions because the importance of other GHGs is small. In this case, the box 'CO_2 emissions' is ticked in the SEAP template, under the point 'emission reporting unit'. However, other GHGs can also be included in the baseline inventory if the standard emission factors are chosen. For example, the local authority may decide to use emission factors that also take into account CH_4 and N_2O emissions from combustion. Furthermore, if the local authority decides to include landfills and/or wastewater treatment in the inventory, then the CH_4 and N_2O emissions will also be included. In this case, the emission reporting unit to be chosen is 'CO_2 equivalent emissions'.

In the case of the LCA approach, GHGs other than CO_2 may play an important role, such as sulphur hexafluoride (SF_6), which has a global warming potential (GWP) 22 800 times higher than CO_2 in the time interval of 100 years (IPCC, 2007). Therefore, a local authority that decides to use the LCA approach will likely also include GHGs other than CO_2 in the inventory, and select the emission reporting unit 'CO_2 equivalent emissions'. However, if the local authority uses a methodology/tool that does not include any

GHGs other than CO_2, the inventory will be based on CO_2 only and the emission reporting unit 'CO_2 emissions' should be chosen.

The emissions of GHGs other than CO_2 are converted to CO_2-equivalents by using the GWP values of the IPCC Second Assessment Report and Third Assessment Report (IPCC, 1995 and 2001). These are also used for the GWP evaluations of the national emission inventories reported to the UNFCCC (2006). For example, 1 kg of CH_4 has a similar impact on global warming as 21 kg of CO_2, when considered over a time interval of 100 years, and therefore the GWP value of CH_4 is 21.

In the context of the CoM, it is suggested to apply the GWP values that are used in the reporting to the UNFCCC and the Kyoto Protocol. These GWP values are based on the IPCC's Second Assessment Report (IPCC, 1995) and are presented in Table 3.

However, the local authority may decide to use other GWP values of the IPCC, for example, depending on the tool they use. The LCA emission factors presented in these guidelines are calculated using the GWP values of the Fourth Assessment Report of the IPCC (IPCC, 2007).

Table 3. Conversion of CH_4 and N_2O to CO_2-equivalent units

Mass of GHG as t compound	Mass of GHG as t CO_2-equivalent
1 t CO_2	1 t CO_2-eq.
1 t CH_4	21 t CO_2-eq.
1 t N_2O	310 t CO_2-eq.

Source: IPCC Second Assessment Report, 1995.

3.3. Fuels and renewable heat

As explained in Section 3.1, the local authority can choose between standard emission factors in line with IPCC principles and LCA emission factors.

The standard emission factors following IPCC principles are based on the carbon contents of the fuels. For simplicity, the emission factors presented here assume that all carbon in the fuel forms CO_2. However, in reality, a small share of carbon (usually < 1 %) in the fuel also forms other compounds such as carbon monoxide (CO) and most of that carbon oxidises to CO_2 later on in the atmosphere.

The LCA emission factors include the actual emissions from all life cycle steps including final combustion, as mentioned earlier. This is of special relevance for biofuels: while the carbon stored in the biofuels themselves may be CO_2 neutral, the cropping and harvesting (fertilisers, tractors, pesticide production) and processing of the final fuel may consume a lot of energy and result in considerable CO_2 releases, as well as N_2O emissions from the field. The various biofuels differ considerably regarding the life cycle of GHG emissions, and therefore the LCA approach supports the choice of the most climate-friendly biofuel and other biomass energy carriers.

Box 1 gives additional information on how to deal with biomass or biofuels ([6]) that are used within the territory of the local authority.

In the case of a biofuel blend, the CO_2 emission factor should reflect the non-renewable carbon content of the fuel. An example of the calculation of an emission factor for a biofuel blend is presented in Box 2.

[6] In these guidelines, biofuel refers to all liquid biofuels, including transportation biofuels, vegetable oils and other fuels in liquid phase. Biomass, instead, refers to solid biomass such as wood, biowaste, etc.

Box 1. Sustainability of biofuels/biomass

Sustainability of biofuels and biomass is an important consideration in the preparation of the SEAP. In general, biomass/biofuels are a form of renewable energy, the use of which does not have an impact on the CO_2 concentration in the atmosphere. However, this is the case only if biomass/biofuels are produced in a sustainable manner. Two sustainability issues should be taken into consideration when deciding on SEAP measures related to biomass/biofuels, and when accounting for them in the BEI/MEI.

1. Sustainability in relation to CO_2 concentration in the atmosphere

Combustion of carbon that is of biogenic origin, for example, in wood, biowaste or transportation biofuels, forms CO_2. However, these emissions are not accounted for in the CO_2 emission inventories if it can be assumed that the carbon released during combustion equals the carbon uptake of the biomass during re-growth within a year. In this case, the standard CO_2 emission factor for biomass/biofuel is equal to zero. This assumption is often valid in the case of crops that are used for biodiesel and bioethanol, and is valid in the case of wood if the forests are managed in a sustainable manner, meaning that on average, forest growth is equal to or higher than harvesting. If wood is not harvested in a sustainable manner, then a CO_2 emission factor that is higher than zero has to be applied (see Table 4).

2. Life cycle emissions, biodiversity and other sustainability issues

Even though biofuel/biomass would represent a neutral CO_2 balance, its usage may not be considered as sustainable if its production causes high emissions of other GHGs — such as N_2O from fertiliser use or CO_2 due to land-use change — or has an adverse impact on biodiversity, for example. Therefore, it is recommended that the local authority check that the biomass/biofuels used meet certain sustainability criteria established in the national regulations.

In the absence of national regulations regarding the sustainability of biomass/biofuels, the local authority might use the criteria ([a]) set in the Directive 2009/28/EC on the promotion of the use of energy from renewable sources. Only biomass/biofuels that meet these criteria should be considered as renewable in the context of the CoM.

In the event that the local authority uses standard emission factors and uses biofuel that does not meet sustainability criteria, it is recommended to use an emission factor that is equal to that of the corresponding fossil fuel. For example, if the local authority uses biodiesel that is not produced in a sustainable manner, the emission factor of fossil diesel is to be used. Even though this rule does not follow the conventional emission estimation standards, it is applied to prevent the use of unsustainable biofuels in Covenant cities.

If the local authority uses LCA emission factors and uses biofuel that does not meet sustainability criteria, it is recommended to develop an emission factor that takes into account all the emissions over the entire life cycle of the biofuel.

[a] See article 17 of the Directive, paragraphs 1 to 6. In very short: 'The greenhouse gas emission saving from the use of biofuels and bioliquids, [calculated in accordance with Article 19] […] shall be at least 35 % […] Biofuels and bioliquids […] shall not be made from raw material obtained from land with high biodiversity value […] from land with high carbon stock […] from land that was peatland in January 2008 […]'.

The emission factors for the fuels that are most commonly used within the territories of the local authorities are presented in Table 4, based on 2006 IPCC Guidelines and the ELCD — available at http://lca.jrc.ec.europa.eu/lcainfohub/index.vm ([7]). Table 4 gives a more complete table of IPCC emission factors. However, the local authority can decide to use other emission factors that are considered appropriate.

[7] The emission factors for fuel combustion are expressed as t/MWh_{fuel}. Therefore, the corresponding activity data to be used must also be expressed as MWh_{fuel}, which corresponds with the net calorific value (NCV) of the fuel.

TABLE 4. CO_2 and CO_2-equivalent emission factors: standard (from IPCC, 2006) and LCA (from ELCD) for most common fuel types

	Covenant of Mayors Template energy carriers	Standard denomination of energy carriers	Sustainability criteria [a]	IPCC		LCA	
				t CO_2 [b] /MWh	t CO_2-eq. /MWh	t CO_2 /MWh	t CO_2-eq. /MWh
Fossil fuels	Natural gas	Natural gas	-	**0.202**	0.202	0.221	**0.237**
	Liquid gas	Liquefied Petroleum Gases	-	**0.227**	0.227	n.a.	**n.a.**
		Natural Gas Liquids	-	**0.231**	0.232	n.a.	**n.a.**
	Heating Oil	Gas/Diesel oil	-	**0.267**	0.268	0.292	**0.305**
	Diesel	Gas/Diesel oil	-	**0.267**	0.268 [c]	0.292	**0.305**
	Gasoline	Motor gasoline	-	**0.249**	0.250 [c]	0.299	**0.307**
	Lignite	Lignite	-	**0.364**	0.365	0.368	**0.375**
	Coal	Anthracite	-	**0.354**	0.356	0.379	**0.393**
		Other Bituminous Coal	-	**0.341**	0.342	0.366	**0.380**
		Sub-Bituminous Coal	-	**0.346**	0.348	0.371	**0.385**
	Other fossil fuels	Municipal Wastes (non-biomass fraction)	-	**0.330**	0.337	0.181	**0.174**
		Peat	-	**0.382**	0.383	0.386	**0.392**
Renewable energies	Plant oil	Other Liquid Biofuels	(s)	**0**	0.001	0.171	**0.182** [d]
			(ns)	**0.287**	0.302		
	Biofuel	Biogasoline	(s)	**0**	0.001	0.194	**0.206** [e]
			(ns)	**0.255**	0.256		
		Biodiesels	(s)	**0**	0.001	0.147	**0.156** [f]
			(ns)	**0.255**	0.256		
	Other biomass	Biogas	-	**0.197**	0.197	n.a.	**n.a.**
		Municipal Wastes (biomass fraction)	-	**0**	0.007	0.107	**0.106**
		Wood	(s)	**0**	0.007	0.006	**0.013**
			(ns)	**0.403**	0.410	0.409	**0.416** [g]
		Wood Waste	-	**0.403**	0.410	0.193	**0.184**
		Other Primary solid biomass	-	**0.360**	0.367	n.a	**n.a**
	Solar thermal		-	-	-	n.a.	**n.a.** [h]
	Geothermal		-	-	-	n.a.	**n.a.** [h]

a. IPCC emission factor should be reported as zero if the biofuels/biomass meet sustainability criteria; fossil fuel emission factors to be used if biofuels are unsustainable. (s) sustainable, (ns) not sustainable

b. Taking into consideration also the CH_4 and N_2O emissions from combustion in stationary sources.

c. If choosing to report in CO_2-eq., please consider that the emission factors for the transport sector are up to 3 % higher than the values provided here, which are characteristic for stationary sources.

d. Conservative figure regarding pure plant oil from palm oil. Note that this figure represents the worst ethanol plant oil pathway and does not necessarily represent a typical pathway. This figure does not include the impacts of direct and indirect land-use change. Had these been considered, the default value could be as high as 9 t CO_2-eq./MWh, in the case of conversion of forest land in the tropics.

e. Conservative figure regarding ethanol from wheat. Note that this figure represents one of the less efficient ethanol production pathways and does not necessarily represent a typical pathway. This figure does not include the impacts of direct and indirect land-use change. Had these been considered, the default value could be as high as 9 t CO_2-eq./MWh, in the case of conversion of forest land in the tropics.

f. Conservative figure regarding biodiesel from palm oil. Note that this figure represents the worst biodiesel pathway and does not necessarily represent a typical pathway. This figure does not include the impacts of direct and indirect land-use change. Had these been considered, the default value could be as high as 9 t CO_2-eq./MWh, in the case of conversion of forest land in the tropics.

g. The figure reflects the production and local/regional transport of wood, representative for Germany, assuming: spruce log with bark; reforested managed forest; production mix entry to saw mill, at plant; and 44 % water content. CO_2 incorporation is considered. It is recommended that the local authority using this emission factor check that it is representative of the local circumstances, and that they should develop an

own emission factor if the circumstances are different. This is only one set of reference values and another LCA case study could be performed to define a fork spanning the range of variation. This will be done for the next update of this Guidebook.

[h] Data not available, but emissions are assumed to be low (however, the emissions from electricity consumption of heat pumps is to be estimated using the emission factors for electricity). Local authorities using these technologies are encouraged to try to obtain such data.

If local authorities prefer to use or develop emission factors that better reflect the properties of the fuels used within the territory, they are welcome to do so. The choice of emission factor used in the BEI has to be consistent with the choice of the emission factor used in the MEI.

Box 2. How to calculate an emission factor for a biofuel blend

A biodiesel blend is used in the city, including 5 % of sustainable biodiesel and the rest conventional diesel oil. Using the standard emission factors, the emission factor for this blend is calculated as:

95 %*0.267 t CO_2/MWh + 5 %*0 t CO_2/MWh = 0.254 t CO_2/MWh

3.4. Electricity

In order to calculate the CO_2 emissions to be attributed to electricity consumption, it is necessary to determine which emission factor is to be used. The same emission factor will be used for all electricity consumption within the territory, including that of rail transportation. The local emission factor for electricity may take the following components into consideration. The contribution of each of them in the estimation of the local emission factor is explained in more detail in the following sub-sections:

a) National emission factor
b) Local electricity production
c) Purchases of certified green electricity by the local authority

Because the estimation of emissions from electricity is based on electricity consumption, the emission factors are expressed as t/MWh_e. Therefore, the corresponding activity data to be used also has to be in the form of MWh_e; that is, in MWh of electricity consumed.

3.4.1. National emission factor

Electricity is consumed within the territory of each local authority, but the main units that produce it are only concentrated on the territory of a few of them. These major production units are often large CO_2 emitters (in the case of fossil fuel thermal plants), but their electricity production is not meant to cover only the electricity needs of the municipality on which they are built, but the needs of a larger area. In other words, the electricity that is consumed in a particular municipality generally comes from different plants either inside or outside the municipality. As a consequence, the CO_2 that is emitted due to this electricity consumption actually comes from those various plants. To quantify this for each individual municipality would be a challenging task, as the physical flows of electricity cross the borders and vary depending on several factors. In addition, the municipalities in question usually have no control over the emissions of such plants. For these reasons, and keeping in mind that the focus of the CoM is on the demand (consumption) side, it is recommended to use a national factor as a starting point to determine the local emission factor. This emission factor reflects the average CO_2 emissions related to the national electricity production.

The national emission factors fluctuate from year to year due to energy mix used in electricity generation. These fluctuations are caused by the heating/cooling demand, availability of renewable energies, energy market situation, import/export of energy and so on. These fluctuations occur independently of the actions taken by the local authority. Therefore, it is recommended to use the same emission factor in the BEI and in the MEI in order to assess the progress in terms of impacts resulting from the local actions implemented; otherwise, the result of the emission inventory could be very sensitive to factors over which the local authority has no influence.

The emission factors for standard and LCA approaches are presented in Table 5.a and Table 5.b for all the Eastern Partnership and central Asian countries. The local authority is welcome to search for more up-to-date information from national sources such as reports and statistics of the National Environmental Agencies or equivalent institutions, or to use the emission factor from the abovementioned tables for the year closest to the inventory year. Note that LCA emission factors should in all cases be higher than standard emission factors.

Table 5.a. National IPCC emission factors for electricity (t CO_2*/MWhe) for the period 2000–2008 ([8])

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Armenia	0.609	0.652	0.375	0.336	0.374	0.357	0.265	0.254	0.252
Azerbaijan	0.874	0.810	0.778	0.737	0.701	0.680	0.713	0.900	0.891
Belarus	0.780	0.752	0.805	0.801	0.920	0.901	0.898	0.899	0.961
Georgia	0.201	0.215	0.074	0.090	0.121	0.135	0.282	0.211	0.174
Kazakhstan	1.398	1.409	1.406	1.483	1.538	1.475	1.459	1.507	1.508
Kyrgyzstan	0.233	0.280	0.272	0.208	0.242	0.212	0.193	0.231	0.149
Moldova	0.876	0.863	0.669	0.603	0.625	0.625	0.593	0.747	0.684
Tajikistan	0.014	0.011	0.008	0.010	0.009	0.007	0.013	0.021	0.017
Turkmenistan	1.369	1.398	1.397	1.397	1.397	1.397	1.396	1.395	1.395
Ukraine	0.923	0.998	1.009	0.982	0.830	0.851	0.933	0.927	0.924
Uzbekistan	0.689	0.701	0.708	0.684	0.663	0.664	0.659	0.693	0.615

*When reporting in CO_2-eq.:

- the same emission factor should be used by Armenia, Georgia and Tajikistan;
- 0.001 t CO_2-eq./MWh should be added to the factors used by signatories from Azerbaijan, Belarus, Moldova, Turkmenistan and Uzbekistan;
- 0.004 t CO_2-eq./MWh should be added to the factors used by signatories from Ukraine;
- 0.007 t CO_2-eq./MWh should be added to the factors used by signatories from Kazakhstan.

Table 5.b. National LCA emission factors for electricity (t CO_2-eq./MWhe) for the period 2000–2008 ([9])

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Armenia	0.637	0.682	0.418	0.406	0.442	0.422	0.368	0.374	0.386
Azerbaijan	1.168	1.028	0.980	0.992	0.953	0.937	0.962	0.929	0.896
Belarus	1.373	1.374	1.376	1.377	1.376	1.378	1.373	1.380	1.380
Georgia	0.332	0.315	0.139	0.167	0.217	0.238	0.406	0.289	0.249
Kazakhstan	2.016	2.027	2.002	2.045	2.081	2.093	2.111	2.115	2.149
Kyrgyzstan	0.257	0.289	0.300	0.238	0.243	0.239	0.233	0.250	0.191
Moldova	1.364	1.353	1.333	1.364	1.343	1.335	1.331	1.340	1.311
Tajikistan	0.070	0.066	0.062	0.064	0.062	0.059	0.068	0.079	0.074
Turkmenistan	1.363	1.363	1.363	1.363	1.363	1.363	1.364	1.364	1.364
Ukraine	1.427	1.451	1.472	1.448	1.266	1.348	1.500	1.532	1.533
Uzbekistan	0.928	0.930	0.920	0.925	0.943	0.943	0.940	0.935	0.821

The national emission factor for electricity has the acronym NEFE in the equation in Sub-section 3.4.4. The emission factor chosen is reported in the SEAP template as 'CO_2 emission factor for electricity not produced locally'.

[8] Methodology for the calculation according to UNFCCC, 2012 (tool to calculate the emission factor for an electricity system). Sources for the calculation: data on national energy consumption and national energy production per energy carrier from the International Energy Agency (IEA), 2010 (energy statistics of non-Organisation for Economic Co-operation and Development (OECD) countries); data on carbon intensity of each energy carrier from IPCC, 2006 (*Guidelines for National Greenhouse Gas Inventories*, Chapter 2 — Stationary Combustion); data on efficiency of each vector according to the technology of electricity production: ELCD, 2013 (electricity emission inventories). Consistency checks have been performed comparing results with EDGARv4.2 and v4.2FT2010 for the CO_2 emissions from fuel combustion (cfr. Emissions Database for Global Atmospheric Research (EDGAR) (http://edgar.jrc.ec.europa.eu/index.php); see also Olivier and Janssens-Maenhout, 2011).

[9] Source for LCA emission factors: as no specific Life Cycle Inventories database can be found for the countries involved in the project, the ELCD has been used as the primary source of life cycle emissions related to the different technologies of electricity production (http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm) (2002). The fine tuning of LCA emission factors may occur in the next update of the guidelines. Data on national electricity production from different energy vectors are acquired from the International Energy Agency (IEA), 2010 (energy statistics of non-Organisation for Economic Co-operation and Development (OECD) countries).

3.4.2. Local electricity production

Reducing CO_2 emissions through the improvement of energy efficiency (EE) and local renewable energy projects is a priority of the Covenant. However, other actions to reduce CO_2 emissions on the supply side can also be accounted for. First, the local authority has to decide whether to include local electricity production (LPE) in the BEI or not. In the event that all the SEAP measures are focused on the demand side, inclusion of LPE is not needed, and the factors LPE and CO_2LPE (CO_2 emissions due to the local production of electricity) in the equation in Sub-section 3.4.4 below are zero.

If the local authority decides to include LPE in the BEI, all the plants/units that meet the following criteria have to be included:

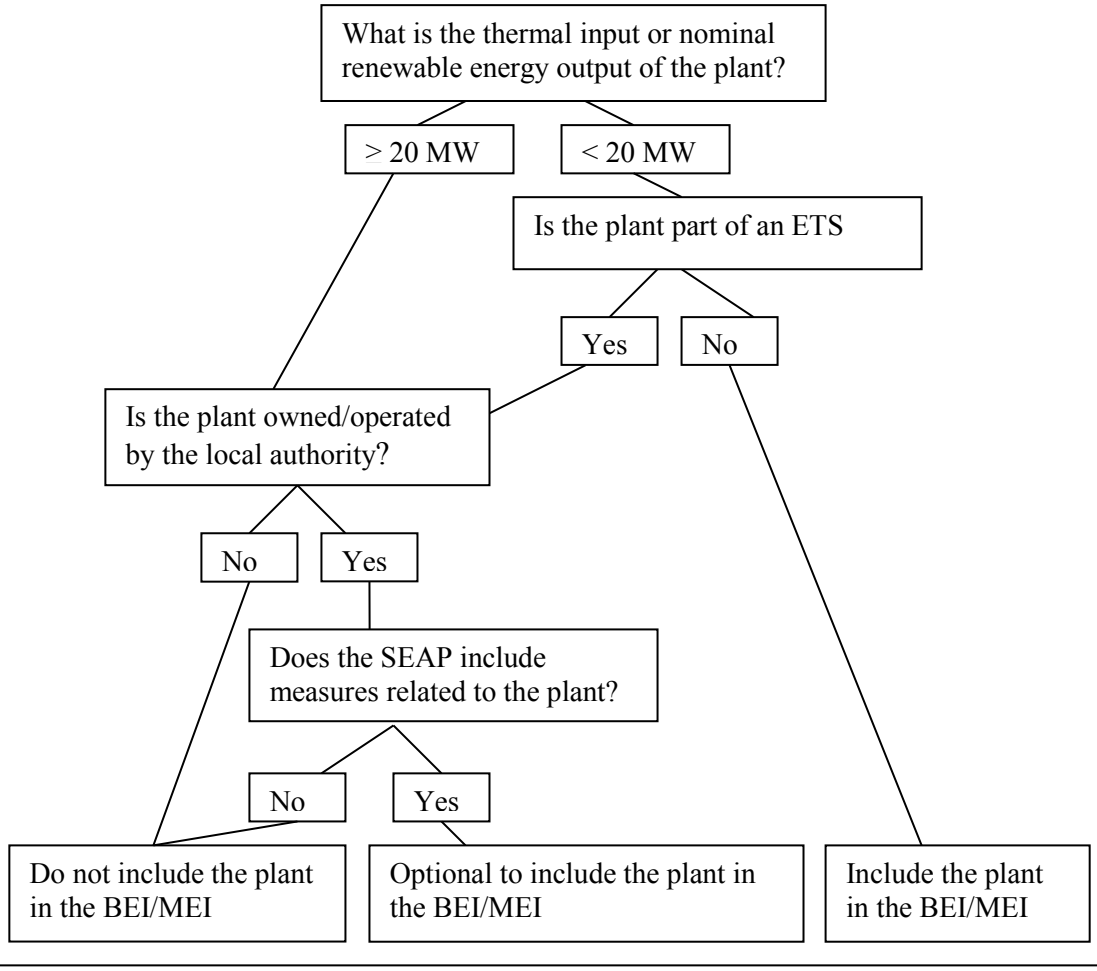
- the plant/unit is not included in an international Emission Trading Scheme (ETS);
- the plant/unit is below or equal to 20 MW_{fuel} as thermal energy input in the case of fossil fuel and biomass combustion plants ([10]), or below or equal to 20 MW_e as nominal output in the case of other renewable energy plants (e.g. wind or solar).

The criteria above are based on the assumption that smaller plants/units primarily serve local electricity needs, whereas larger plants primarily produce electricity for the larger grid. Usually, the local authority has more control over or influence on smaller plants than larger ones. However, in some cases, larger plants or units can also be included in the BEI/MEI. For example, if a local authority owns utilities or plans to develop and finance large renewable installations like wind farms within its territory, such projects may be incorporated as long as the priority remains on the demand side (final energy consumption reductions).

The local authority can use the decision tree presented in Box 3 to decide, for each of the plants/units located within the territory, whether to include them in the BEI/MEI or not.

[10] 20 MW_{fuel} refers to fuel input of the plant, and corresponds to the EU-ETS threshold for combustion installations. The threshold 20 MW_e set for other renewables refers to nominal electricity generation capacity, and is thus higher than the threshold for combustion installations.

Box 3. Decision tree for the inclusion of local electricity production



Based on the decision tree in Box 3, it is recommended that the local authority fill in a table including all the electricity generation plants within the territory and determine whether they are to be included in the BEI/MEI or not. An example of such a table is given in Box 4.

Box 4. An example of the identification of local electricity generation facilities

The following electricity generation facilities are located within the territory of the local authority:

a) wind power park owned by a private company;
b) solar panels on the roof of a building owned by the local authority;
c) solar panels on the roof of a building owned by a private company;
d) combined heat and power (CHP) plant using natural gas;
e) gas turbine plant owned by a private company;
f) group of three wind turbines owned by a private company.

In order to identify which plants and facilities belong to the scope of the BEI/MEI, the local authority has filled in the table below.

Local electricity generation in [name of the Signatory] in [inventory year]				
Plant/unit	**Size (thermal (fuel) input)**	**Size (nominal renewable electricity generation capacity)**	**Included in ETS?**	**Part of BEI?**
a)	-	25 MW_e	NO	NO
b)	-	250 kW_e	NO	YES
c)	-	500 kW_e	NO	YES
d)	200 MW_{fuel}	-	YES	NO
e)	15 MW_{fuel}	-	NO	YES
f)	-	3 MW_e	NO	YES

All plants that are to be included in the BEI/MEI, as per the above rule, should be listed in the SEAP template ([11]), with the corresponding quantity of locally generated electricity, energy inputs and corresponding CO_2 emissions. For convenience, similar production units may be grouped (for example solar photovoltaic installations (PVs) or combined heat and power plants (CHPs)).

Waste incineration plants that produce electricity are treated similarly to any other power plants. Waste incinerated in plants that do not produce electricity or heat is included in the ENERGY CONSUMPTION TABLE of the SEAP template and the related emissions in the EMISSIONS TABLE.

Further guidance on activity data collection regarding LPE is available in Section 4.3.

The emissions from LPE (CO_2LPE) are estimated, in the case of plants combusting fuel, by using emission factors in Table 4. In the case of local renewable electricity production (other than biomass/biofuels), the emissions can be estimated by using the emission factors in Table 6.

Table 6. Emission factors for local renewable electricity production

Electricity source	**Standard emission factor (t CO_2/MWh_e)**	**LCA emission factor (t CO_2-eq./MWh_e)**
Solar PV	0	0.020–0.050 ([a])
Windpower	0	0.025[b]
Hydropower	0	0.010–0.100 ([b])

[a] Source: Vasilis et al., 2008.
[b] Source: Evans et al., 2009.

[11] The SEAP template is published online at http://www.soglasheniemerov.eu/support/library_ru.html (both the Russian and the English versions are available).

3.4.3. Purchases of certified green electricity by the local authority

Instead of purchasing 'mixed' electricity from the grid, the local authority can decide to purchase certified green electricity. For the sake of comparability, transparency and consistency, it is strongly recommended to use the definitions that are standard to the EU, described in the Directive 2001/77/EC (updated in the Directive 2009/28/EC). However, whenever the adequate national legal framework exists, green electricity can be also defined by the electricity that meets the criteria for *guarantee of origin of electricity produced from renewable energy sources* (RES) set in those national regulations. The local authority will report the amount of purchased green electricity (GEP) in the 'emission' section of the SEAP template.

In the case that the standard emission factors are used, the emission factor for certified green electricity is zero. If the LCA emission factors are used, the local authority has to estimate the LCA emissions of the green electricity purchases (CO_2GEP) either by requesting required information from the power provider or by using the default factors provided for local renewable electricity generation in Table 6, if they are deemed suitable.

Also, other actors within the territory of the local authority may purchase green electricity. However, it may be difficult to obtain data about such purchases. In addition, green electricity purchases reduce GHG emissions only in the case that electricity production by fossil fuels is actually replaced by production from new renewable electricity installations, due to such purchases, which is not necessarily the case. For these reasons, and also because the focus of the Covenant is on the demand side, the green electricity purchases of other actors (companies, consumers, institutions, etc.) within the territory are not accounted for in the local electricity emission factor.

3.4.4. Calculation of local emission factor for electricity

Based on the information presented in the sections above, the local emission factor for electricity (EFE) can be calculated using the equation ([12]):

$$EFE = \frac{(TCE - LPE - GEP) \times NEFE + CO_2LPE + CO_2GEP}{TCE}$$

Where:

EFE = local emission factor for electricity [t/MWh_e]
TCE = total electricity consumption in the local authority (as per ENERGY CONSUMPTION TABLE of the SEAP template) [MWh_e]
LPE = local electricity production (as per LOCAL ELECTRICITY PRODUCTION TABLE of the template) [MWh_e]
GEP = green electricity purchases by the local authority (as per the BEI/MEI section of the template) [MWh_e]
NEFE = national emission factor for electricity [t/MWh_e]
CO_2LPE = CO_2 emissions due to the local production of electricity (as per LOCAL HEAT/COLD PRODUCTION TABLE of the template) [t]
CO_2GEP = CO_2 emissions due to the production of certified green electricity purchased by the local authority [t]

In the exceptional case where the local authority would be a net exporter of electricity, then the calculation formula would be:

$$EFE = (CO_2LPE + CO_2GEP) / (LPE + GEP)$$

These principles and rules allow for rewarding the increase in local renewable energy production, or improvements of efficiency in the local energy generation, whilst still keeping the main focus on final energy (demand side).

3.5. Heat/cold

If heat or cold is sold/distributed as a commodity to end users within the territory of the local authority (see ENERGY CONSUMPTION TABLE of the SEAP template), then it is necessary to establish the corresponding emission factor.

[12] This formula neglects transport and distribution losses in the local authority's territory, as well as auto-consumption of energy producers/transformers and tends to double count local renewable production. However, at the scale of the local authority, these approximations will have a minor effect on the local CO_2 balance and the formula may be considered as robust enough to be used in the context of the CoM.

First, the local authority has to identify all the plants and units that provide heat/cold as a commodity to end users within the territory (for example, from district heating, or a CHP plant). All such plants should be listed in the LOCAL HEAT/COLD PRODUCTION TABLE of the SEAP template, with the corresponding quantity of locally generated heat, energy inputs and corresponding CO_2 emissions. For convenience, similar production units may be grouped (e.g. CHPs).

Waste incineration plants that produce heat to be sold as a commodity to end users are treated similarly to any other heating plants. Amount of waste incinerated and the related CO_2 emissions from plants that do not produce electricity or heat are included in the ENERGY CONSUMPTION TABLE and EMISSION TABLE, respectively.

Please note that energy consumption and CO_2 emissions related to heat and cold locally produced by end users for their own usage are already covered by the ENERGY CONSUMPTION TABLE and EMISSION TABLE (columns for fossil fuel and renewable energy consumption). In principle, the total amount of heat/cold produced referenced in the LOCAL HEAT/COLD PRODUCTION TABLE should be equal (or very close) to the quantity of heat/cold consumed and reported in the ENERGY CONSUMPTION TABLE, column 'Heat/cold'. Differences may occur due to:

- auto-consumption of heat/cold by the utility producing it;
- transport and distribution losses of heat/cold.

Further guidance on activity data collection regarding heat production is available in Section 4.4.

If a part of the heat/cold that is produced within the territory of the local authority is exported, then the corresponding share of CO_2 emissions should be deducted when calculating the emission factor for heat/cold production (EFH), as indicated in the formula below. In a similar manner, if heat/cold is imported from a plant situated outside the local authority, then the share of CO_2 emissions of this plant that correspond to heat/cold consumed within the territory of the local authority should be accounted for when calculating the emission factor (see formula below).

The following formula may be applied to calculate the emission factor for heat, taking the above mentioned issues into consideration.

$$EFH = \frac{CO_2LPH + CO_2IH - CO_2EH}{LHC}$$

Where:

EFH = emission factor for heat [t/MWh_{heat}]

CO_2LPH = CO_2 emissions due to the local production of heat (as per the LOCAL HEAT/COLD PRODUCTION TABLE of the template) [t]

CO_2IH = CO_2 emissions related to any imported heat from outside the territory of the local authority [t]

CO_2EH = CO_2 emissions related to any heat that is exported outside of the territory of the local authority [t]

LHC = local heat consumption (as per the ENERGY CONSUMPTION TABLE) [MWh_{heat}]

A similar formula may apply for cold.

District cooling — i.e. purchased chilled water — is in principle a similar product as purchased district heating. However, the process to produce district cooling is different from the process to produce district heating, and there is a larger variety of production methods.

If local production of district cooling occurs, or if district cooling is consumed as a commodity by end users, it is recommended that the local authority contact the district cooling provider for information on the use of fuels or electricity to provide cooling. Then the emission factors for fuels and electricity presented in the sections above can be applied.

3.5.1. Combined heat and power production

Part or all of the heat used within the territory of the local authority may be generated in a CHP plant. It is essential to divide the emissions of a CHP plant between heat and electricity when filling in the LOCAL ELECTRICITY TABLE and the LOCAL HEAT/COLD PRODUCTION TABLE of the template. This is especially the case when the heat is used locally (input to the BEI) but the electricity is sold to the regional grid (no direct input to the BEI).

The fuel use and emissions can be allocated between heat and electricity generation by using the following equation:

$$CO_{2CHPH} = \frac{\frac{P_{CHPH}}{\eta_h}}{\frac{P_{CHPH}}{\eta_h} + \frac{P_{CHPE}}{\eta_e}} * CO_{2CHPT}$$

$CO_{2CHPE} = CO_{2CHPT} - CO_{2CHPH}$

Where:

CO_{2CHPH} denotes CO_2 emissions from heat production [t CO_2]
CO_{2CHPE} denotes CO_2 emissions from electricity production [t CO_2]
CO_{2CHPT} denotes total CO_2 emissions of the CHP plant calculated based on fuel consumption and fuel-specific emission factors [t CO_2]
P_{CHPH} denotes the amount of heat produced [MWh_{heat}]
P_{CHPE} denotes the amount of electricity produced [MWh_e]
η_h denotes the energy efficiency from heat production. The recommended value to be used is 90 %.
η_e denotes the energy efficiency from electricity generation. The recommended value to be used is 30 %.

3.6. Other sectors

In the case of other sectors, the emissions of which are not related to fuel combustion, it is recommended that the local authority uses methodologies developed by specialised organisations.

If the local authority has chosen to use the standard emission factors in line with IPCC principles, it may consider using the methodologies of the Local Governments for Sustainability (ICLEI) and IPCC.

The ICLEI's International Local Government GHG Emissions Analysis Protocol (IEAP) also includes peer-reviewed and approved Specific Country Supplements for certain countries, with country-specific emission factors.

The 2006 IPCC Guidelines are available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html online. If the local authority has chosen to use the LCA emission factors, such emission factors for landfills are available from the ELCD database, available at http://lca.jrc.ec.europa.eu/lcainfohub/datasetList.vm?topCategory=End-of-life+treatment&subCategory=Landfilling online.

4. ACTIVITY DATA COLLECTION

4.1. Introduction

The key issues in collecting activity data in the context of the CoM are outlined below.

- The data should be relevant to the particular situation of the local authority. For example, estimates based on national averages would not be appropriate, as in the future they would only reflect trends occurring at the national level, and they would not allow taking into account the specific efforts made by the local authority to reach its CO_2 targets.
- The data collection methodology should be consistent through the years: if the methodology changes, this may cause changes in the inventory that are not due to any action of the local authority to reduce its CO_2 emissions. For this reason, it is important to document very clearly the ways in which data are collected and inventories are carried out so that consistency can be kept in future years. In the case of methodological changes, recalculation of the BEI may be necessary (see Chapter 7).
- The data should cover at least all sectors in which the local authority intends to take action so that the results of those actions can be reflected in the inventory.
- The sources of data used should be available in the future.
- Within the limits of possibility, the data should be accurate or at least represent a vision of the reality.
- The collection process and data sources should be well documented and publicly available so that the BEI elaboration process is made transparent and stakeholders can be confident with the inventory.

4.2. Final energy consumption

Reducing final energy consumption should be considered as a priority in the SEAP. The final energy consumption should be reported in the ENERGY CONSUMPTION TABLE of the template (see Annex II).

Final energy consumption is split into two main sectors, for both of which data are mandatory:

1. Buildings, equipment/facilities and industry
2. Transport

Those sectors are in turn divided into sub-sectors. See Table 1 for the details of the sectors to be covered.

Note: the term 'equipment/facilities' covers all energy-consuming entities that are not buildings (e.g. water treatment units). In the case there is a waste incineration plant that does not produce electricity or heat, the fuel (waste) incinerated is included in the row 'Municipal buildings, equipment/facilities' in the ENERGY CONSUMPTION TABLE. The renewable fraction (i.e. biomass) is included in the column 'Other biomass' and the non-renewable part in the column 'Other fossil fuels'.

Notes about the energy carriers referred to in the ENERGY CONSUMPTION TABLE of the template:

- 'Electricity' refers to the total electricity consumed by end users, whatever the production source is. If the local authority is purchasing certified green electricity, please complete also the corresponding cell. In the LCA approach, the corresponding emission factor also needs to be specified. 'Certified green electricity' means electricity produced from RES covered by guarantee of origins as set in the local authority's national legislation, if available, otherwise as set in Article 5 of the Directive 2001/77/EC, Article 15 of the Directive 2009/28/EC and Article 3 (6) of the Directive 2003/54/EC. Electricity consumption is reported in the table as the amount of electricity consumed by end user, MWh_e.
- 'Heat/cold' refers to heat/cold that is supplied as a commodity to end users within the territory (for example, from a district heating/cooling (DHC) system, a CHP plant or waste heat recovery). Heating produced by end users for their own use should not be included here, but under the columns of the energy carriers that produce the heat (fossil fuels or renewable energies). With the exception of CHP heat, as a CHP unit also generates electricity, it is preferable to include it under production (LOCAL PRODUCTION TABLES), especially if it concerns large units. Heat/cold consumption is reported in the table as the amount of heat/cold consumed by the end user, MWh_{heat}/MWh_{cold}.
- 'Fossil fuels' cover all fossil fuels consumed as a commodity by end users. It includes all fossil fuels bought by end users for space heating, sanitary water heating or cooking purposes. It also includes fuels consumed for transportation purposes, or as an input in industrial combustion processes ([13]). Fossil fuel consumption is reported in the table as the amount of fuel consumed by the end user, MWh_{fuel}.
- 'Renewable energies' covers all plant oil, biofuels, other biomass (e.g. wood), solar thermal and geothermal energy consumed as a commodity by end users. Note: if peat is consumed within the local authority, it should be accounted for in the 'Other fossil fuel' column (even if it is not strictly speaking a fossil fuel). Renewable fuel consumption is reported in the table as the amount of fuel consumed by the end user, MWh_{fuel}. Renewable heat consumption is recorded as the amount of heat consumed by the end user, MWh_{heat}.

4.2.1. Buildings, equipment/facilities and industries

Municipal buildings and equipment/facilities

In principle, the local authority should be able to collect accurate and comprehensive energy consumption data related to its own buildings and facilities. Well advanced local authorities already have a full energy accounting system in place. For other local authorities that have not yet initiated such a process, the energy data collection could require the following steps:

- identify all buildings and facilities owned/managed by the local authority;
- within those buildings and facilities, identify all energy delivery points (electricity, natural gas, heat from heating district network, fuel oil tanks, etc.);
- for all those energy delivery points, identify the person/department receiving the invoices and energy data;
- organise a centralised collection of these documents/data;

[13] Only if the SEAP includes actions in this sector. However, energy use of industries involved in ETS is excluded.

- select an appropriate system to store and manage the data (this could be a simple Excel sheet or a more elaborate software, available commercially);
- make sure the data are collected and introduced in the system at least every year. Tele-measurement is possible and can ease the process of data collection.

Note that this process of data collection may be the opportunity to deal with other important energy-related issues:

- rationalise the number of energy delivery and invoicing points;
- renew/improve contractual arrangements with energy suppliers;
- initiate a real energy management process within the territory of the local authority: identify buildings that consume the most energy and select them for priority action, such as daily/weekly/monthly monitoring of energy consumption thus allowing for the identification of abnormalities and taking immediate corrective action or other actions (see Section 8.1 in Part I of this Guidebook).

Regarding heating fuel oil or other energy carriers delivered periodically as bulk, it is often preferable to install a measurement device (gauge, metre, etc.) to help determine exactly the quantity of energy consumed during a given period. An alternative is to assume that the fuel purchased each year is equal to fuel consumed. This is a good assumption if the fuel tanks are filled at the same period each year, or if many deliveries of fuel occur each year.

Renewable heat and cold produced and consumed locally by end users should be measured and reported separately (columns related to 'Renewable energies' in the ENERGY CONSUMPTION TABLE of the template).

It is important that all fuel supplied for purposes of producing electricity or DHC is tracked and reported separately as fuel used for electricity or DHC generation (LOCAL ELECTRICITY TABLE and LOCAL HEAT/COLD PRODUCTION TABLE of the template).

If the local authority buys green electricity of guaranteed origin, this will not affect its energy consumption, but it may be counted as a bonus to improve the CO_2 emission factor (see Section 3.4.3). The quantity of such green electricity has to be derived from the supplier's invoices, which indicate the origin of the electricity. The amount of GEP has to be reported in the SEAP template ([14]).

Municipal public lighting

The local authority should be able to collect all data regarding municipal public lighting. If this is not the case, an identification and data collection process similar to the one indicated in the previous paragraph may have to be initiated. In some cases, it may be necessary to place additional meters, for instance when an electricity supply point feeds both public lighting and building/facilities.

Note: any non-municipal public lighting should be referred to in the category 'Tertiary (non municipal) buildings, equipment/facilities'.

Other buildings and facilities

This section covers:

- Tertiary (non municipal) buildings, equipment/facilities
- Residential buildings
- Industries (optional, excluding industry that is part of an ETS)

Collecting information from every individual energy consumer within the territory of the local authority is not always possible or practical. Therefore, a variety of approaches are likely to be needed to develop an estimate of energy consumption. Several options are available, and often a combination of them is necessary to have an overall picture of energy consumption within the territory of the local authority.

► Get data from the market operators

If there are several actors on the gas and electricity market, then the data related to energy consumption might be considered commercially sensitive information and therefore more difficult to obtain from energy suppliers. Therefore, in order to get the data from them, you have to identify which suppliers are active within the territory of the local authority and prepare a table that they would have to fill in.

[14] The SEAP template is published online at http://www.soglasheniemerov.eu/support/library_ru.html (both the Russian and the English versions are available).

As several energy suppliers may be active, it may be simpler to contact grid operators (for heat, gas and electricity) whenever possible (it is not very likely that more than one of them is active within the territory of a single municipality, for each energy carrier).

Note that such data are generally considered as commercially sensitive and that in the best case you will probably only be able to get aggregated data. Ideally, a disaggregation between the residential, services and industry sectors, for the different energy carriers (electricity, natural gas, etc.) for all the postal codes that relate to your municipality should be obtained.

If a greater level of disaggregation is available, then do not hesitate to ask for it (e.g. you should distinguish between the various sub-sectors for services and industry, and ask whether for private or public, individual houses or apartments, etc.). It is recommended to use the standard nomenclature for reporting (NFR) as defined in the IPCC Guidelines 1996 and used for the UNFCCC emission inventory submissions.

Other interesting information relates to the names and addresses of the largest energy consumers within the territory of the local authority, and their overall energy consumption (individual energy consumption is not likely to be available as it would be commercially too sensitive information). This may be useful for targeted actions and questionnaires (see further).

► Get data from other entities

Energy suppliers and grid operators may be reluctant to provide consumption data to the local authority (for reasons related to confidentiality, commercial secrecy and administrative burden, especially in the case where many local authorities would ask for similar data from the same operators).

However, valuable data may be available at regional or national levels (from statistical, energy, environmental, or economic ministries or agencies, Supporting Structures of the CoM, and regulatory authorities for gas and electricity).

► Inquiries addressed to energy consumers

If all data cannot be obtained in the desired format from the market operators or from other entities, it may be necessary to make some inquiries directly to the energy consumers, in order to obtain the missing data.

This is especially the case for energy carriers that do not pass through a centralised grid (fuel oil, wood, natural gas supplied in bulk, etc.). If it is not possible to identify all suppliers active within the territory of the local authority and to get data from them, it may be necessary to ask the consumers themselves.

It is worth bearing in mind that energy or statistical agencies may already be collecting such data, so make sure that data are not available elsewhere before considering sending a questionnaire.

Several options are possible.

- For sectors in which there is a large number of small consumers (like the residential sector), we recommend addressing a questionnaire to a representative sample of the population (for example, 1 000 households), spread over all districts of the local authority. The questionnaire may be online, but in this case make sure that this does not prevent some categories of customers from providing data, otherwise the results will be biased.
- For sectors in which the number of players is limited, it may be worthwhile addressing the questionnaire to all energy consumers (this may be the case, for example, for the industrial sector).
- For sectors in which there is a great number of players, but where there are some large ones (e.g. tertiary sector), it may be worthwhile making sure to address the questionnaire at least to all large players (e.g. all supermarkets, hospitals, universities, housing companies, large office buildings, etc.). Their identification can be done through knowledge, statistical or commercial data (such as telephone directories) inquiry to the grid operator (ask who are the 1 000 largest electricity/gas consumers within the territory of the local authority). Another option for identifying large electricity consumers is to ask grid operators the identity of all consumers connected to the middle- and high-voltage distribution networks (or even to the transmission network in some extreme cases).

What to ask?: It may be tempting to ask a lot of questions in the questionnaire (e.g. Is your building insulated?, Do you have solar panels?, Have you recently made EE improvements?, Do you have air conditioning?, etc.). However, it should be kept in mind that it is very important to keep the questionnaire simple and short (ideally not more than 1 page) in order to obtain a satisfactory rate of

answers. Besides the type and quantity of energy consumed and eventual local energy production (renewable, CHP, etc.), we recommend asking at least one or two questions related to variables that can explain the energy consumption (for comparison or extrapolation purposes); for example, floor space (m^2) of a building and/or number of inhabitants, or number of pupils in a school, etc. For industry or services, ask the branch they belong to (propose some categories, if possible). For the residential sector, it is useful to ask questions that would allow extrapolation of the collected data. This depends on what kind of statistical information is available at the municipal level. It could be, for example, household size (number of occupants), class of revenue, location (postal code and/or rural/urban area), dwelling type (detached house, semi-detached house, apartment), size of the dwelling (m^2), and so on.

Tips:

- Make sure the questions are clear and precise so that they will be understood by all in the same manner. Provide some short instructions if necessary.
- To increase the amount and quality of answers, inform clearly about the purpose of the questionnaire (for energy statistics and not tax purposes, for example). Motivate people to answer (for example, inform them that the questionnaire allows for measuring progress in reaching the CO_2 emissions reductions objectives of the local authority, or provide any other incentive you find relevant).
- Make the inquiries anonymous (especially in the residential sector) and explain that the data will be kept confidential.
- Do not hesitate to send reminders to those who do not reply on time, in order to increase the rate of answers, and call the largest energy consumers directly to make sure they reply.
- Make sure that the collected data sample is representative of the population. You should be aware that the response rate is generally low and those who respond are generally the most educated and climate-aware, and therefore there is the risk that the data collected is strongly biased, even if the questionnaire was addressed to a representative sample of the population. To avoid this, it may be advisable to organise data collection via face-to-face or phone interviews, especially in the residential sector.
- Decide in advance what you want to do with the data collected, to make sure that you ask the really useful and necessary questions.
- Do not hesitate to get the help of specialists (statisticians) to design your inquiry.
- It is advisable to communicate in advance your aims (SEAP development) through the local media, explaining the context and expected benefits for your local community.

What to do with the data

Generally speaking, data collected via inquiries should help you to construct the energy and CO_2 data related to the territory of the local authority. Following are a few examples of possible usages.

- Aggregated data should be broken down into sectors and sub-sectors in order to target your actions and measure the results achieved by different target groups.

- Extrapolate some ratios obtained from the sample to the overall energy consumption. For example, if you know the overall energy and gas consumption of a given sector but you do not know its heating fuel oil consumption, you could extrapolate the electricity/fuel oil ratio or natural gas/fuel oil ratio of your sample to the whole population, provided your sample is representative.

► Making estimates

From data collected via a sample of the population (see above), you could estimate the overall consumption. For example, from the sample data you could calculate the energy consumption per square metre or per inhabitant in the household sector for different types of buildings and different classes of revenues, and extrapolate to the entire sector using statistical data related to the territory of the local authority.

Ideally, this kind of exercise should be done with the help of statisticians to make sure the data collected and method of extrapolation provide results that are statistically meaningful.

In addition, checks should be carried out to make sure that the overall results are compatible with the data available at a more aggregate level.

Notes:

- If energy consumption data cannot be disaggregated between individual sectors (i.e. residential, services and industry), then report the total consumption in the template and do not fill in the data at the sector level.
- If the data collected do not allow the possibility to distinguish the municipal consumption from other usages, then there is a risk of double counting. To avoid this, subtract the municipal usage (calculated separately, see above) from the overall energy consumption of each sector and report each of them in the relevant section of the template.

4.2.2. Road transportation

Road transportation within the territory of the local authority can be divided into two parts:

a) Urban road transportation, which includes road transportation on the local street network that is usually in the competence of the local authority. The inclusion of this sector in the BEI is strongly recommended.

b) Other road transportation, which includes road transportation in the territory of the local authority on the roads that are not in the competence of the local authority. An example of such road transportation is transportation on a highway that goes through the territory of the local authority. These emissions can be included in the BEI if the local authority intends to include measures to reduce these emissions in the SEAP.

The same methods can be used to estimate emissions of both urban and other road transportation.

The activity data for the road transportation sector is the amount of fuel consumed in the territory. Usually the amount of fuel used is not equal to the amount of fuel sold (see Box 5). Therefore, the estimate of the fuel used has to be based on estimates of:

- mileage driven within the territory of the local authority [km];
- vehicle fleet within the territory of the local authority (cars, buses, two-wheelers, heavy and light-duty vehicles);
- average fuel consumption of each vehicle type [l fuel/km].

The EMEP/EEA Guidebook (2009) and the 2006 IPCC Guidelines provide detailed guidance on the estimation of activity data for the road transportation sector. Even though the focus of these guidelines is on the national level, the information can also be useful to understand the principles for calculation of emissions at the local level.

Box 5. Use of fuel sales data to estimate emissions from transportation

The local authority may consider that it is easier to collect data on local fuel sales than to estimate fuel use based on estimates of mileage driven. The study of Kennedy et al. (2009) concluded that use of fuel sales data is appropriate for cities for which the number of vehicle trips over the border of the city is small relative to the number of trips within the city. They compared the results of using fuel sales data, scaling down from wider regions and estimating emissions based on mileage for three megacities, Bangkok, New York City and Toronto, and concluded that the differences between the methods may be less than 5%.

However, fuel sold in the territory of the local authority may not in all cases correctly reflect the fuel used within the territory. The amount of fuel sold and fuel consumed may be different for various reasons (comfort of fuelling, availability of filling stations, prices, etc.). This is the case especially for smaller cities in which the number of filling stations is small. In addition, the factors having an impact on fuel sales may change in time (for example, opening/closing of filling stations) and therefore the changes in fuel sales data may not correctly reflect the changes in traffic (fuel use).

If fuel sales data are used, the local authority should be aware that it may also include fuel used for off-road transportation.

Mileage driven

The mileage driven on the street network of the local authority can be estimated based on information on traffic flows and length of the street network. As a first step, it is recommended that the local authority search for information from one of the potential data sources listed below.

- The transport department of the local authority may have estimated vehicle flows and mileage driven for transport planning purposes.
- National or local street administration often carries out sample surveys, either automatic or manual. In these surveys, the numbers of vehicles passing fixed points are counted. Some surveys count vehicle numbers by type of vehicle, but information on the fuel (e.g. diesel or gasoline) is usually not available.
- Household transport surveys (origin and destination surveys).
- The Mobility in cities database contains information on transportation in selected cities for the year 2001. The data can be purchased at http://www.uitp.org/publications/index2.cfm?id=5#MCDBIS online.

In the case of the local authority's own fleet and public transportation fleet, the mileage driven can be estimated using the information in the odometers of the vehicles. However, attention has to be paid to the fact that the BEI/MEI should consider only mileage driven within the territory of the local authority.

In the case of contracted services for public transport or other services, the information should be available from the operator.

The local authority may find it difficult to collect mileage data. However, data collection is of great importance, because without such information the actual impact of the measures taken cannot be estimated.

Vehicle fleet distribution

The vehicle fleet distribution indicates the share of mileage of each vehicle type. At minimum, the fleet distribution should distinguish between:

- passenger cars and taxis;
- heavy- and light-duty vehicles;
- buses and other vehicles used for public transport services;
- two-wheelers.

The fleet distribution can be estimated based on one of the following sources:

- traffic counts as discussed above;
- vehicles registered in the municipality;
- national statistics.

Use of any of the data sources above should be accompanied with a consideration on whether it represents an appropriate estimate of the distribution of mileage driven within the territory of the local authority. If needed, the data can be adjusted to better suit the local authority's territory. For instance, the share of mileage driven in a city by heavy-duty vehicles may be lower than the share of heavy-duty vehicles registered at national level.

Some of the existing tools for local emission inventories may include default fleet distributions for different regions. These can be used if they are considered appropriate by the local authority.

Average fuel consumption per km

Average fuel consumption of each vehicle category depends on the types of vehicles in the category, their age and also on a number of other factors, such as the driving cycle. It is recommended that the local authority estimate the average fuel consumption of vehicles driving on the street network based on polls, information from inspection agencies or information on vehicles registered in the municipality or in the region. Auto clubs and national transport associations are also sources of useful information.

The use of national-level average fuel consumption for each vehicle category may produce biased estimates, in particular for urban areas. This might occur especially in countries with a dense motorway network linking cities and where a high number of rural trips are made, as the figures for fuel consumption would not be representative for urban areas.

If the local authority is planning measures to reduce the average fuel consumption of vehicles, for instance by promoting the use of electric or hybrid vehicles, it is recommended not to use national fuel consumption figures, but to make a more detailed estimate (as explained above) including hybrid and

electric cars separately. This is because if averages are used, the reduction in fuel consumption due to measures will not be visible when comparing the BEI and MEI.

Calculation of activity data

The activity data for each fuel and vehicle type will be calculated using the following equation:

Fuel used in road transportation [kWh] = mileage [km] x average consumption [l/km] x conversion factor [kWh/l]

The most typical conversion factors are presented in Table 7. A full list of conversion factors (NCVs) is presented in Annex I. An example of the use of the equation is given in Box 6.

Table 7. Conversion factors for the most typical transportation fuels

Fuel	Conversion factor (kWh/l)
Gasoline	9.2
Diesel	10.0

Source: EMEP/EEA, 2009; IPCC, 2006.

Box 6. Example of calculation of activity data for road transportation

	Passenger cars	Heavy-duty vehicles	Light-duty vehicles	Busses	Two wheelers	Total
Mileage (million km) from activity data collection						
Total						**1 641**
Fleet distribution from activity data collection (as % of mileage)						
Total mileage	76 %	11 %	7 %	3 %	3 %	100 %
-Gasoline	73 %	3 %	7 %	0 %	3 %	86 %
-Diesel	4 %	8 %	0 %	3 %	0 %	14 %
Average fuel consumption from activity data collection (l/km)						
Gasoline	0.087	0.429	0.147		0.044	
Diesel	0.069	0.352	0.352	0.456		
Calculated mileage (million km)						
Gasoline	1 190.3	51.4	119.9	0.0	50.1	1 412
Diesel	58.8	126.7	0.0	44.5	0.0	230
Calculated consumption (million l fuel)						
Gasoline	103.6	22.0	17.6	0.0	2.2	145
Diesel	4.1	44.6	0.0	20.3	0.0	69
Calculated consumption (GWh)						
Gasoline	953	203	162	0	20	1 338
Diesel	41	446	0	203	0	689

Share of biofuels

If the local authority plans to promote the use of biofuels, produced in a sustainable manner, in the SEAP, it is important to estimate the share of biofuels in the fuel used within the territory of the local authority. This can be done, for instance, by conducting polls on the most important fuel distributors in the territory of the local authority and surrounding areas.

In the case of the use of biofuels in the municipal fleet (beyond the average use in the territory), the local authority is likely to have access to the amount of biofuel consumed, especially if special filling stations are used for the municipal fleet.

If the local authority does not intend to promote biofuels in the SEAP, a national average share of biofuels can be used.

4.2.3. Rail transportation

Rail transportation in the territory of the local authority can be divided into two parts.

a) Urban rail transportation. For example, tram, metro and local trains. The inclusion of this sector in the BEI is strongly recommended.
b) Other rail transportation. This covers the long-distance, intercity and regional rail transportation that occurs within the territory of the local authority. Other rail transportation does not only serve the territory of the local authority, but a larger area. Other rail transportation also includes freight transport. These emissions can be included in the BEI if the local authority has included measures to reduce these emissions in the SEAP.

The same methods can be used to estimate emissions of both urban and other rail transportation.

There are two types of activity data for rail transportation: consumption of electricity and consumption of fuel in diesel locomotives. Use of diesel locomotives in urban rail transportation is less common for local services.

The number of providers of rail transport in the territory of the local authority is usually low. The local authority is advised to ask for annual electricity and fuel-use data directly from the service providers. If such data are not available, the local authority can estimate the emissions based on mileage travelled and average electricity or fuel consumption.

4.3. Local electricity production (if applicable)

Identification of LPE plants that are included in the BEI is explained in Sub-section 3.4.2.

For larger plants (such as CHPs), the data should be obtained via direct contact with the plant managers. For smaller units (domestic PVs), the data can either be obtained through questionnaires or derived from statistics related to the amount of installations present within the territory of the local authority: number of permits delivered if such installations require a permit, number of subsidies granted or regional/national statistics with a sufficient level of disaggregation.

Market operators may also have data about entities that provide electricity to the grid and may help to identify them.

All plants that are to be included in the BEI/MEI should be listed in the LOCAL ELECTRICITY PRODUCTION TABLE with the local electricity of the SEAP template ([15]) with corresponding quantity of locally generated electricity, energy inputs and corresponding CO_2 emissions. Make sure that all energy used as an input for plants listed here is excluded from fuel consumption recorded in the ENERGY CONSUMPTION TABLE, in order to avoid double counting.

4.4. Local heat/cold production

Identification of local heat/cold production plants that are included in the BEI/MEI is explained in Section 3.5.

The data should be obtained via direct contact (or questionnaires) with the plant managers, as mostly large units will be listed here. All plants that are to be included in the BEI/MEI should be listed in the LOCAL HEAT/COLD PRODUCTION TABLE of the SEAP template ([15])) with the corresponding quantity of generated heat/cold, energy inputs and corresponding CO_2 emissions. Make sure that all energy used as an input for plants listed here is excluded from fuel consumption recorded in the ENERGY CONSUMPTION TABLE.

Note: the case of micro cogeneration

Micro cogeneration units may be too small, too numerous and scattered to obtain individual data about them. In such a case, the energy input of those units should be reported in the ENERGY CONSUMPTION TABLE as final energy consumption, and consequently the heat and electricity produced should **not** be reported in LOCAL PRODUCTION tables. In addition, the electricity produced should not be accounted for as electricity consumption in the ENERGY CONSUMPTION TABLE.

[15] The SEAP template is published online at http://www.soglasheniemerov.eu/support/library_ru.html (both the Russian and the English versions are available).

On the contrary, if data are available (for example, via support schemes or sales data from suppliers), then micro cogeneration units could be reported in LOCAL PRODUCTION tables, with the energy input and heat/electricity production data.

4.5. Other sectors

In the case of other sectors, the emissions of which are not related to fuel combustion, the local authority should use methodologies developed by specialised organisations. The local authority may consider using the methodologies of the ICLEI or IPCC.

The 2006 IPCC Guidelines are available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html online.

5. REPORTING AND DOCUMENTATION

5.1. Reporting of the BEI/MEI

The Covenant signatories commit themselves to submitting their SEAP, including the BEI, within the year following signing up to the CoM.

Furthermore, the signatories are committed to submit an implementation report at least every second year after the submission of the SEAP for evaluation, monitoring and verification purposes. The MEI is a recommended part of such an implementation report.

The local authority is encouraged to compile emission inventories on an annual basis. The advantages are:

- closer monitoring and better understanding of the various factors that influence the CO_2 emissions;
- annual input to policymaking, allowing for quicker reactions;
- the specific expertise necessary for inventories can be maintained and consolidated.

However, if the local authority considers that such regular inventories put too much pressure on human or financial resources, it may decide to carry out the inventories at longer intervals. The signatories are committed to submit an implementation report at least every second year. Consequently, a MEI should be included in at least every second implementation report. This means that a MEI is carried out and reported at least every fourth year.

The BEI will be documented by using Tables A–C in the SEAP template. The SEAP template also includes instructions on how the BEI data should be filled in.

In addition to filling in the tables in the 'Emission monitoring' section of the SEAP template (BEI or MEI), the local authority is encouraged to make an inventory report for each inventory. It is recommended that the following information be included in the inventory report.

- Information about the geographical boundaries of the local authority.
- Choice of emission factor approach (standard or LCA).
- Emission reporting unit (CO_2 or CO_2-eq.).
- Choices made regarding inclusion of voluntary sectors and sources.
- Identification of local electricity generation plants.
- Identification of local heat/cold plants.
- Information on data collection methods.
- Emission factors used and their sources.
- Assumptions made.
- References used.
- Information on any changes related to approach/methodology/data sources, etc. since the previous inventory.
- Comments that facilitate understanding and interpretation of the inventory. For example, it may be useful to provide explanations on which factors have influenced CO_2 emissions since previous inventories, such as economic conditions or demographic factors.
- Names and contact information of people who provided information for the inventory.

It is in the interest of the local authority to document the inventory and to archive the files; for example, spreadsheets used for the compilation of the BEI. This will facilitate the compilation of the MEI in the following years.

5.2. Target setting

The local authority can decide to set the overall CO_2 emissions reductions target either in relation to the base year (as 'absolute reduction' or 'per capita reduction') or in relation to a BAU scenario or reference scenario. The local authority is encouraged to report on the choice in the inventory report.

2020 target basis	GHG reductions target
Base year levels	Absolute Per capita
2020 BAU projection levels	Absolute

- **Setting the target on the basis of the BEI results.**

  The GHG reductions target can be set as an 'absolute' percentage or a 'per capita' target of at least 20 % from the results reported in the BEI.

  The 'per capita' option is recommended when the scenarios until 2020 show either a sharp decrease or a sharp increase of population within the territory of the local authority. In the case of a strong decrease of population over the years, it is highly recommended that the local authority choose a 'per capita' objective.

  Despite the choice, the emissions in the BEI are first calculated as absolute emissions. In case the 'per capita' reduction is chosen, the emissions of the baseline year are divided by the number of inhabitants in the same year, and these 'emissions *per capita* in the baseline year' are used as a basis for calculation of the target.

  Even if the authority might find it useful to present the results of the BEI/MEI as 'per capita' in the official SEAP document, in the **online template used for reporting**, it is strongly recommended to use the **absolute values** both for the inventory part and for the SEAP part.

- **Setting the target on the basis of a BAU scenario.**

  The local authority has the option to calculate its final target starting from the results of the BEI and foreseeing CO_2 emissions for the territory of the local authority in 2020 (referring to t CO_2 or t CO_2-eq.) ([16]) using a BAU scenario.

  When preparing a BAU scenario, the local authority has two options.

  - Develop its own approach (whenever this option is chosen a reference to the tool/methodology used should be provided in the SEAP document and in the SEAP online template and a short description of the methodology should be included in the SEAP document) ([17]).
  - Use the national coefficients provided in Table 8 for each country.

    The above mentioned national coefficients were calculated by the JRC based on a BAU scenario developed for each of the countries participating in the Eastern Partnership and central Asian CoM. Starting from present data, the BAU scenario projects the evolution of energy and emissions levels until 2020, under the hypothesis of continuing current trends in population, economy, technology and human behaviour, without the implementation of

[16] The possibility of setting the reduction target using a BAU scenario is characteristic for the CoM Eastern Partnership and central Asian countries. It has the aim of allowing those municipalities that are on a rapid economic growth path to develop their economies in a sustainable manner.

[17] From open source information, several emissions projection tools and instruments for energy policy analysis and climate mitigation assessments are available.

a SEAP or any other national or local policy measures (Janssens-Maenhout et al., 2012) ([18]).

The local authority can select its national coefficient according to the chosen baseline year. The coefficient indicates the relative projected increase in GHG emissions between the baseline year and 2020. This implies that to obtain the GHG emissions foreseen for the year 2020, the emission in the baseline year has to be multiplied by the national coefficient K according to the following formula:

$$Emission_{co2}^{2020} = Emission_{co2}^{Baseline\_year} \cdot K$$

Where:

K is the national coefficient from Table 8, selected according to the chosen baseline year, $Emission_{CO2}^{Baseline\_year}$ are the emissions in the baseline year.

$Emission_{CO2}^{2020}$ are the estimated emissions for 2020.

Therefore, the final reductions target of at least 20 % refers to $Emission_{CO2}^{2020}$— the emissions foreseen for the year 2020 according to the BAU scenario.

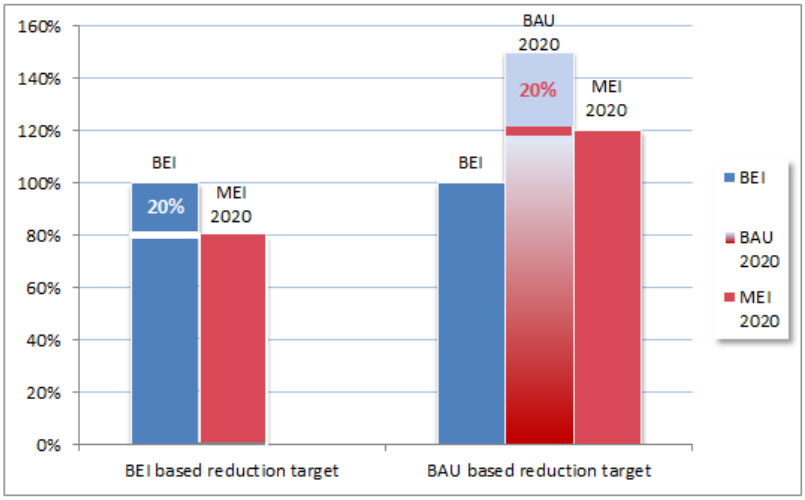


Figure 1 Absolute 20 % reduction target based on the BEI results vs. absolute target based on BAU projections

As mentioned in Section 2.1, it is recommended to monitor the representativeness of the BAU scenario at least once before 2020. In case the assessment highlights a strong deviation between the BAU predictions and the actual situation, the actions and measures foreseen by the SEAP should be revised and an adjustment of the reductions target might be advisable.

The same national coefficient can be applied both for CO_2 inventories and for inventories that take into account other GHGs and report in CO_2-eq.

Table 8. Summary of the country-specific coefficients for CoM East signatories to estimate their CO_2 or GHG emissions in 2020 based on baseline year estimates for the buildings and transport sectors

[18] The BAU scenario was developed based on the energy consumption projections with an in-house European Commission model for energy-related activity increase. For more information related to the hypothesis assumed and the indicators taken into consideration when calculating the national coefficients, please refer to the JRC report *An approach with a Business-as-Usual scenario projection to 2020 for the Covenant of Mayors from the Eastern Partnership* (http://edgar.jrc.ec.europa.eu/com/JRC-IES_CoM-East_report_BAUprojections2.pdf).

BAU projec-tions	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
ARM	1.24	1.25	1.27	1.28	1.29	1.31	1.28	1.25	1.23	1.20	1.17	1.14	1.11	1.07	1.04	1.00
AZE	1.98	1.96	1.95	1.93	1.91	1.87	1.78	1.69	1.61	1.52	1.42	1.33	1.25	1.17	1.08	1.00
BLR	1.09	1.09	1.10	1.10	1.10	1.10	1.10	1.09	1.08	1.07	1.05	1.04	1.03	1.02	1.01	1.00
GEO	1.66	1.65	1.64	1.63	1.62	1.61	1.55	1.49	1.42	1.36	1.30	1.24	1.18	1.12	1.06	1.00
KAZ	1.11	1.10	1.09	1.09	1.08	1.07	1.06	1.06	1.05	1.04	1.04	1.03	1.02	1.01	1.01	1.00
KGZ	1.47	1.52	1.57	1.62	1.67	1.72	1.66	1.59	1.52	1.45	1.39	1.31	1.24	1.16	1.08	1.00
MDA	1.17	1.20	1.22	1.24	1.26	1.27	1.25	1.23	1.20	1.18	1.15	1.12	1.09	1.06	1.03	1.00
TJK	2.78	2.76	2.73	2.71	2.68	2.56	2.39	2.23	2.07	1.91	1.70	1.56	1.42	1.28	1.14	1.00
TKM	0.98	0.98	0.99	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.00	1.00	1.00	1.00
UKR	0.98	0.99	0.99	1.00	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.00	1.00	1.00	1.00
UZB	1.54	1.50	1.46	1.42	1.38	1.32	1.29	1.26	1.22	1.19	1.15	1.12	1.09	1.06	1.03	1.00

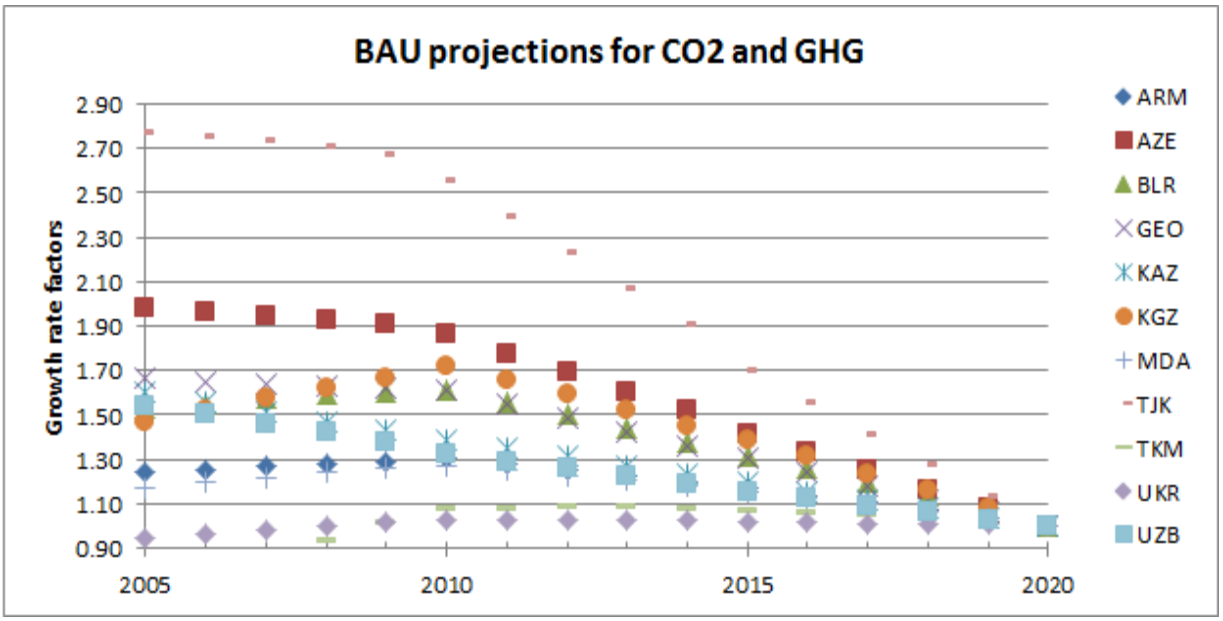


Figure 2 Country-specific coefficients for CoM East signatory cities to estimate their CO_2 or GHG emissions in 2020 based on base year (2005–2020) estimates for the buildings and transport sectors

Setting a 'per capita' target on the basis of a BAU scenario it is <u>not</u> recommended because the elaboration of the BAU scenario, general or custom-made for a city, implies already a certain assumption on the population trend until 2020.

In elaborating the national coefficients provided in this Guidebook (to be used for calculating the projection for the total emissions in 2020), based on the results from the BEI (Table 8), trends related to the population evolution at national level were used. Therefore, setting a 'per capita' target based on these coefficients and on the local population trends is not coherent with the general procedure.

5.3. Temperature correction

The local authority may choose to use temperature correction for emissions from space heating when reporting the emissions and monitoring progress towards the target. Temperature-corrected emissions can be calculated using the following equation:

$$LHC\_TC = \frac{LHC * HDD_{AVG}}{HDD}$$

Where:

LHC_TC = temperature corrected heat consumption in year x [MWh_{heat}]
LHC = actual heat consumption in the year x [MWh_{heat}]
HDD_{AVG} = heating degree days in an average year (defined over a certain time period) [K · d]

HDD = heating degree days in the year x [K · d]

Heating degree days (HDD) denote the heating demand in a specific year. HDD is derived from daily temperature observations, and defined relative to a base temperature — the outside temperature above which a building needs no heating. For each day, during which the temperature is below the base temperature, the HDD is the difference of the base temperature and actual temperature. See Box 7 for an example.

In some countries, meteorological offices provide HDD data for different parts of the country. HDD_{AVG} denotes a long-term average of HDD, which may also be available from the meteorological office. If a long-term average is not available, the local authority may keep the BEI emissions uncorrected, and correct the emissions in the MEI using the HDD of baseline year instead of the average.

A similar approach can also be used to correct the emissions from cooling based on cooling demand.

Box 7. Calculation of heating degree days (HDD)

Heating of buildings in the territory of the local authority usually begins when the outside temperature is less than 15 degrees Celsius. The local authority collects the data for each of the days of the year in the table below and, as a sum of the results, the local authority gets the annual HDD.

Day	temperature	Difference to base temperature (when smaller than base temperature)	HDD_day
Day 1	12	3	3
Day 2	9	6	6
Day 3	5	10	10
Day 4	-2	17	17
...	...	...	...
...	...	...	...
Day 365	17	0	0
HDD (total of the year)			700

6. USE OF EXISTING TOOLS AND MORE ADVANCED METHODOLOGIES

There are a number of tools available for the compilation of local emission inventories ([19]). The local authority is free to choose any methodology or tool that it considers suitable for the compilation of the BEI/MEI. However, it is recommended that the local authority ensure that the results of the inventory are in line with the specifications given for the BEI/MEI in these guidelines and in the SEAP template and accompanying instructions.

The local authority is welcome to use more advanced methods than those described in these guidelines, if the method is in line with the present specifications for the BEI/MEI.

7. RECALCULATIONS

In general, once the BEI is completed, there is no need to change the numbers later on. By also using similar methods in the MEI, the local authority can ensure that the results are consistent, and thus that the difference between the MEI and the BEI correctly reflects the changes of emissions between the baseline year and the monitoring year. However, there are a few occasions when recalculation of the BEI is needed to ensure consistency between the emission estimates of the BEI and of the MEI. Examples of such occasions are:

- industry delocalisation;
- new information on emission factors;

[19] Bertoldi, P., Bornas Cayuela, D., Monni, S., Piers de Raveschoot, R., *Existing methodologies and tools for the development and implementation of Sustainable Energy Action Plans*, 2010.

- methodological changes;
- changes in the local authority's boundaries.

Emissions reductions due to industry delocalisation are explicitly excluded from the CoM. In these guidelines, industry delocalisation means a full and permanent closure of an industrial plant, the emissions of which represented more than 1 % of the baseline emissions. An example of recalculation due to industry delocalisation is presented in Box 8.

Recalculation due to new information on emission factors or methodological changes has to be carried out only in the event that the new information reflects the situation in the baseline year more accurately than the information used in compilation of the BEI (see Box 9). If real changes in emission factors have occurred between the baseline year and the monitoring year — for instance due to the use of different fuel types — then different emission factors will correctly reflect the changed circumstances, and recalculation is not needed ([20]).

Box 8. Recalculation due to industry delocalisation

The local authority decided to include emissions from industrial plants not included in an ETS in the BEI, because the SEAP included measures to improve EE in the plants. However, one of the plants (Plant A), the emissions of which were 45 kt CO_2 in the baseline year (1.4 % of the baseline emissions), closed down before the monitoring year. Inclusion of this emission source in the BEI but excluding it from the MEI would mean that the local authority would gain benefit due to industry delocalisation. Therefore, the local authority has to recalculate the baseline year emissions so that the emissions of Plant A are excluded.

The BEI of the local authority, as reported in the SEAP, was as follows:

Category	**CO_2 emissions (kt)**
Residential buildings	2 000
…	…
Industries (excluding industry part of an ETS)	70
Subtotal buildings, facilities and industry	**2 735**
…	
Subtotal transport	500
Total	**3 235**

In the recalculated BEI, the emissions of Plant A have been removed and the inventory is as follows:

Category	**CO_2 emissions (kt)**
Residential buildings	2 000
…	…
Industries (excluding industry part of an ETS)	25
Subtotal buildings, facilities and industry	**2 690**
…	
Subtotal transport	500
Total	**3 190**

[20] Extensive guidance for recalculation is given in the chapter Time series consistency' of IPCC (2006), available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_5_Ch5_Timeseries.pdf online.

Box 9. Recalculation due to new information on the emission factor

The local authority had used the standard emission factor provided in Table 4 to estimate the base year emissions from coal combustion in a local district heating plant. The emission factor was 0.341 t CO_2/MWh. In the monitoring year, the local authority asked the coal provider to provide information on the carbon content and thus the emission factor of the coal type provided. The coal provider informed the local authority that the emission factor of that coal type is 0.335 t CO_2/MWh, and that the same coal type has been provided to the city for many years.

If the local authority started to use the new emission factor only since the MEI, it would gain benefit as estimated emissions would be lower than in the BEI even if the same amount of fuel would be used. Therefore, the local authority has to recalculate the BEI using the same emission factor that will be used in the MEI.

8. OUTLOOK

THE COVENANT OF MAYORS INITIATIVE HAS IN THE EUROPEAN UNION BEEN SHOWN TO REACH WITHIN FIVE YEARS ALMOST HALF OF THE EUROPEAN CITIZEN POPULATION. THE COM (WEST) GUIDEBOOK SERVED AS THE BASIS FOR ESTABLISHING FIRST EMISSION INVENTORIES. A GUIDANCE FOR STANDARDISATION AND APPLYING COMMON DEFINITIONS IS FRUITFUL IN ORDER TO KEEP TRANSPARENCY, COMPARABILITY AND CONSISTENCY ACROSS BORDERS. THE COM EAST TEAM AT THE JRC AIMS TO REACH WITH THIS GUIDEBOOK A SIMILAR SHARE OF CITIZENS AND TO HELP SET UP GOOD EMISSION INVENTORIES FOR THE DIFFERENT CITIES, USING A STANDARD THAT CAN ALSO BE RECOGNISED BY EU MEMBER STATES.

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ANNEX I. CONVERSION FACTOR AND IPCC EMISSION FACTOR TABLES

Table A. Basic conversion factors

To	**TJ**	**Mtoe**	**GWh**	**MWh**
From	Multiply by:			
TJ	1	2.388×10^{-5}	0.2778	277.8
Mtoe	4.1868×10^{4}	1	11 630	11 630 000
GWh	3.6	8.6×10^{-5}	1	1 000
MWh	0.0036	8.6×10^{-8}	0.001	1

A unit converter is available on the website of the International Energy Agency (IEA) (http://www.iea.org/stats/unit.asp).

Table B. Conversion of fuels from mass to energy units (IPCC, 2006)

Fuel type	Net calorific value [TJ/Gg]	Net calorific value [MWh/t]
Crude Oil	42.3	11.8
Orimulsion	27.5	7.6
Natural Gas Liquids	44.2	12.3
Motor Gasoline	44.3	12.3
Aviation Gasoline	44.3	12.3
Jet Gasoline	44.3	12.3
Jet Kerosene	44.1	12.3
Other Kerosene	43.8	12.2
Shale Oil	38.1	10.6
Gas/Diesel Oil	43.0	11.9
Residual Fuel Oil	40.4	11.2
Liquefied Petroleum Gases	47.3	13.1
Ethane	46.4	12.9
Naphtha	44.5	12.4
Bitumen	40.2	11.2
Lubricants	40.2	11.2
Petroleum Coke	32.5	9.0
Refinery Feedstocks	43.0	11.9
Refinery Gas 2	49.5	13.8
Paraffin Waxes	40.2	11.2
White Spirit and SBP	40.2	11.2
Other Petroleum Products	40.2	11.2
Anthracite	26.7	7.4
Coking Coal	28.2	7.8
Other Bituminous Coal	25.8	7.2
Sub-Bituminous Coal	18.9	5.3
Lignite	11.9	3.3
Oil Shale and Tar Sands	8.9	2.5
Brown Coal Briquettes	20.7	5.8
Patent Fuel	20.7	5.8
Coke Oven Coke and Lignite Coke	28.2	7.8
Gas Coke	28.2	7.8
Coal Tar	28.0	7.8
Gas Works Gas	38.7	10.8
Coke Oven Gas	38.7	10.8
Blast Furnace Gas	2.47	0.7
Oxygen Steel Furnace Gas	7.06	2.0
Natural Gas	48.0	13.3
Municipal Wastes (non-biomass fraction)	10	2.8
Waste Oil	40.2	11.2
Peat	9.76	2.7

Table C. CO_2 emission factors for fuels (IPCC, 2006)

Fuel type	CO_2 emission factor [kg/TJ]	CO_2 emission factor [t/MWh]
Crude Oil	73 300	0.264
Orimulsion	77 000	0.277
Natural Gas Liquids	64 200	0.231
Motor Gasoline	69 300	0.249
Aviation Gasoline	70 000	0.252
Jet Gasoline	70 000	0.252
Jet Kerosene	71 500	0.257
Other Kerosene	71 900	0.259
Shale Oil	73 300	0.264
Gas oil / diesel	74 100	0.267
Residual Fuel Oil	77 400	0.279
Liquefied Petroleum Gases	63 100	0.227
Ethane	61 600	0.222
Naphtha	73 300	0.264
Bitumen	80 700	0.291
Lubricants	73 300	0.264
Petroleum Coke	97 500	0.351
Refinery Feedstocks	73 300	0.264
Refinery Gas	57 600	0.207
Paraffin Waxes	73 300	0.264
White Spirit & SBP	73 300	0.264
Other Petroleum Products	73 300	0.264
Anthracite	98 300	0.354
Coking Coal	94 600	0.341
Other Bituminous Coal	94 600	0.341
Sub-Bituminous Coal	96 100	0.346
Lignite	101 000	0.364
Oil Shale and Tar Sands	107 000	0.385
Brown Coal Briquettes	97 500	0.351
Patent Fuel	97 500	0.351
Coke Oven Coke and Lignite Coke	107 000	0.385
Gas Coke	107 000	0.385
Coal Tar	80 700	0.291
Gas Works Gas	44 400	0.160
Coke Oven Gas	44 400	0.160
Blast Furnace Gas	260 000	0.936
Oxygen Steel Furnace Gas	182 000	0.655
Natural Gas	56 100	0.202
Municipal Wastes (non-biomass fraction)	91 700	0.330
Industrial Wastes	143 000	0.515
Waste Oil	73 300	0.264
Peat	106 000	0.382

ANNEX II. CO_2 INDICATIVE EMISSIONS WITH CO_2/CAP, CO_2-EQ./CAP AND TOTAL CO_2 COUNTRY AND SECTOR BREAKDOWN

Table A. CO_2 emissions per capita ([21])

	1990	1995	2000	2005	2008	2009	2010
	Tonnes CO_2/cap	Tonnes CO_2/cap	Tonnes CO_2/cap	Tonnes CO_2/cap	Tonnes CO_2/cap	Tonnes CO_2/cap	Tonnes CO_2/cap
World Total	4.3	4.1	4.1	4.5	4.7	4.6	4.8
European Union EU-27	8.78	7.23	8.19	8.34	8.09	8.09	8.57
Luxembourg	30.74	22.06	20.16	25.88	22.49	20.35	20.54
Australia	16	16.3	18.6	20.3	20.3	19.9	17.9
USA	19.7	19.7	20.8	20	18.8	17.3	17.8
Canada	16.2	16.3	17.9	17.8	17	15.7	16
Estonia	23.26	11.13	10.7	12.58	13.89	12.99	13.54
Kazakhstan	15.47	11.37	9.34	12.64	14.54	12.92	13.2
Russian Federation	16.5	11.8	11.3	12	12.6	12.1	12.4
Taiwan	6.2	8.1	10.5	11.9	11.6	11.1	11.7
Czech Republic	16.25	12.59	13.58	12.49	12.01	11.16	11.56
Iceland	9.23	9.2	10.14	10.47	12.66	12.02	11.53
Finland	11.44	11.63	11.07	11.18	11.44	10.53	10.79
Netherlands	10.8	11.2	10.9	11	10.3	9.9	10.5
Belgium	11.57	12.09	12.09	11.17	10.95	10.07	10.32
Germany	12.9	11.2	10.5	10.2	10.4	9.7	10.2
Ireland	9.23	9.65	11.42	11.18	10.84	9.89	10.05
Japan	9.5	10	10.1	10.4	9.9	9.3	10
Turkmenistan	13.32	8.57	8.63	9.49	10.87	9.65	9.85
Israel	7.75	8.98	9.83	9.67	9.46	9.32	9.78
Singapore	9.96	11.53	9.8	9.61	8.93	8.64	9.05
Austria	8.18	8.18	8.37	10.05	9.52	8.77	9
Slovenia	7.65	7.49	8.37	8.89	9.23	8.6	8.93
Poland	8.2	8.3	7.5	8.1	8.5	8.1	8.8
Denmark	10.33	11.56	9.84	9.19	9.09	8.37	8.57
Greece	7.72	7.66	8.75	9.26	9.03	8.33	8.55
Norway	8.96	9.77	9.62	9.56	9.24	8.81	8.49
New Zealand	6.73	7.05	9.02	9.82	9.13	8.71	8.39
UK	10.3	9.6	9.3	9.2	8.7	7.9	8.1
Hong Kong	6.03	6.17	6.18	6.32	6.98	6.99	7.42
Slovakia	11.43	8.38	7.85	7.62	7.62	7.11	7.39
Bulgaria	9.4	7.11	5.86	6.64	7.24	6.81	7.14
South Africa	7.3	7	6.9	7.5	7.4	7	7.1
Cyprus	5.8	6.76	7.39	7.57	7.45	6.88	7.08
Belarus	10.24	5.92	5.73	6.47	7.47	6.75	7
Italy	7.5	7.7	8.1	8.2	7.6	6.8	6.9
Ukraine	14.9	8.8	7.2	7.1	7.4	6.1	6.7
China	2.2	2.9	2.8	4.5	5.9	6.2	6.6
Spain	5.9	6.4	7.6	8.4	7.4	6.6	6.3
Croatia	5.52	3.57	4.24	5.07	5.69	5.75	6.17
France	6.9	6.7	6.9	6.7	6.4	6.1	6.1
Venezuela	5.62	5.89	5.86	5.58	5.75	5.71	6.02
Switzerland	6.7	6.3	6.16	6.27	6.15	5.9	5.7
Other Annex I-EIT ([a])	10.3	6.1	5.4	5.6	6.2	5.6	5.7
Hungary	7.25	6.04	5.73	5.87	5.75	5.39	5.62
Bosnia and Herzegovina	5.69	1.12	3.78	4.38	5.13	5.18	5.57
Sweden	6.71	7.08	6.53	6.1	5.46	5.01	5.12
Portugal	4.36	5.26	6.24	6.39	5.21	4.81	4.94
Mongolia	6.43	4.35	4.66	4.1	4.6	4.57	4.82
Argentina	3.27	3.47	4.03	4.08	4.45	4.45	4.73
Jamaica	3.18	3.58	3.99	4.19	4.32	4.35	4.64
former Yugoslav Republic of Macedonia	5.92	3.65	4.14	4.48	4.37	4.37	4.63

[21] Source and complete database: JRC/PBL Netherlands Environmental Assessment Agency, 'Emission Database for Global Atmospheric Research (EDGAR)', release version 4.2, 2010. See http://edgar.jrc.ec.europe.eu online.

Lithuania	9.49	4.11	3.28	3.93	4.68	4.4	4.6
Serbia and Montenegro	6.2	4.02	3.96	2.22	4.25	4.28	4.58
Romania	7.96	5.7	4.27	4.67	4.53	4.24	4.43
Uzbekistan	6.05	4.41	4.8	4.41	4.69	4.17	4.26
Mexico	3.7	3.6	3.8	3.9	4	3.9	3.9
Latvia	7.5	3.79	3.04	3.48	3.71	3.48	3.64
Turkey	2.75	3.01	3.55	3.61	4.01	3.56	3.64
Azerbaijan	8.84	4.05	3.72	3.77	3.77	3.34	3.41
Thailand	1.6	2.7	2.7	3.4	3.3	3.1	3.3
Tunisia	1.81	1.93	2.22	2.28	2.5	2.5	2.65
Egypt	1.6	1.56	1.87	2.3	2.41	2.39	2.52
Armenia	5.9	1.14	1.21	1.47	2.6	2.33	2.41
Guyana	0.95	1.25	1.95	2.1	2.2	2.22	2.37
Dominican Republic	1.16	1.55	2.22	2.05	2.21	2.2	2.32
Other Big DC ([b])	1.5	1.7	1.8	2	2.2	2.2	2.3
Mauritius	1.14	1.26	1.64	1.91	2.08	2.09	2.22
Brazil	1.5	1.6	2	2	2.1	2	2.2
Ecuador	1.53	1.74	1.69	1.97	1.97	1.96	2.07
Indonesia	0.9	1.1	1.4	1.6	1.7	1.9	2
Morocco	0.91	1.07	1.22	1.75	1.76	1.76	1.86
Uruguay	1.25	1.47	1.66	1.65	1.69	1.7	1.81
Colombia	1.57	1.69	1.57	1.39	1.49	1.49	1.57
Moldova, Republic of	6.48	1.59	1.41	1.92	1.67	1.51	1.54
India	0.8	0.9	1	1.1	1.3	1.4	1.5
Albania	1.94	0.66	1.07	1.51	1.37	1.38	1.47
Bolivia	0.97	1.29	1.05	1.16	1.28	1.28	1.34
El Salvador	0.49	0.9	0.98	1.08	1.15	1.15	1.23
Kyrgyzstan	5.47	1.07	1	1.13	1.27	1.13	1.15
Georgia	5.5	1.48	1.05	1.04	1.21	1.09	1.13
Congo	0.95	0.91	1.33	1.18	1.07	1.05	1.1
Tajikistan	2.46	1.02	0.79	1.01	1.16	1.03	1.05
Pakistan	0.56	0.66	0.71	0.83	0.95	0.94	0.99
Zimbabwe	1.64	1.38	1.13	0.92	0.87	0.88	0.93
Angola	1.07	1	1.11	0.96	0.9	0.89	0.92
Nicaragua	0.47	0.58	0.74	0.81	0.81	0.81	0.86
Tonga	0.47	0.74	0.97	0.72	0.64	0.64	0.68
Bhutan	0.33	0.59	0.62	0.51	0.61	0.6	0.64
Nigeria	0.71	0.71	0.73	0.67	0.58	0.57	0.59
Western Sahara	0.73	0.63	0.69	0.51	0.49	0.48	0.5
Cameroon	0.62	0.41	0.41	0.36	0.34	0.34	0.35
Bangladesh	0.13	0.17	0.2	0.25	0.3	0.3	0.32
Kenya	0.31	0.3	0.31	0.29	0.3	0.3	0.31
Sudan	0.21	0.15	0.16	0.26	0.29	0.28	0.29
Haiti	0.16	0.14	0.19	0.24	0.24	0.24	0.25
Mozambique	0.09	0.08	0.09	0.13	0.15	0.15	0.16
Eritrea	0.07	0.25	0.18	0.14	0.14	0.14	0.15
Nepal	0.06	0.09	0.14	0.12	0.13	0.13	0.13
Laos	0.05	0.09	0.1	0.1	0.12	0.12	0.13
Madagascar	0.07	0.08	0.1	0.1	0.1	0.1	0.11
Cambodia	0.05	0.05	0.07	0.24	0.1	0.1	0.1

[a] Including other countries of the former Soviet Union and Turkey.
[b] Other large developing countries: Brazil, India, Iran, Mexico, Saudi Arabia and South Africa.

Table B. CO_2-eq. emissions per capita ([22])

	1990	1995	2000	2005	2008	2009	2010
	Tonnes CO_2-eq./cap	Tonnes CO_2-eq./cap	Tonnes CO_2-eq./cap	Tonnes CO_2-eq./cap	Tonnes CO_2-eq./cap	Tonnes CO_2-eq./cap	Tonnes CO_2-eq./cap
Iceland	85.36	78	75.81	72.74	72.89	72.07	71.63
Australia	28.19	26.98	31.55	30.67	29.65	30.47	28.24
Luxembourg	34.37	26.33	23.59	29.42	26.1	24.81	25.69
Mongolia	26.47	25.64	26.61	24.75	25.62	25.97	25.38
Finland	25.57	25.21	24.44	24.23	24.26	23.52	25.18
Estonia	35.35	21.95	21.16	22.5	23.42	21.03	23.87
Guinea	11.32	8.27	6.93	7.17	27.44	58.08	23
USA	24.14	23.81	24.72	23.86	22.7	21.17	21.63
Canada	21.82	28.33	23.99	24.31	22.19	21.05	21.41
Kazakhstan	22.51	15.52	12.95	17.35	19.69	17.5	19.82
New Zealand	19.3	18.9	20.18	20.88	19.98	18.53	18.29
Russian Federation	24.16	17.74	18.04	17.97	18.19	17.34	17.56
Turkmenistan	22.16	13.17	14.06	16.7	18.64	16.1	17.29
Ireland	18.45	18.8	20.2	18.92	18	16.71	16.47
Belarus	17.69	12.48	12.26	13.38	14.7	14.85	15.6
Bolivia	28.93	22.8	20.58	30.07	14.08	13.82	14.48
Czech Republic	19.01	14.52	15.82	14.48	13.93	13.29	13.98
Bahamas	14.03	12.62	11.1	12.12	13.21	13.56	13.91
Norway	15.74	15.96	16.01	15.68	15.04	13.93	13.76
Cambodia	2.05	1.86	1.79	4.55	12.43	9.86	13.55
Korea, Republic of	6.97	10.12	11.13	11.93	12.46	12.57	13.42
Netherlands	14.87	15.08	14.27	13.7	12.77	12.53	13.11
Bhutan	2.29	3.18	6.33	3.22	4.16	6.28	12.93
Belgium	13.76	14.33	14.28	13.16	12.97	12.34	12.93
Taiwan_Province of China	6.9	8.89	11.36	12.81	12.58	11.86	12.73
Denmark	14.04	15.15	13.36	12.47	12.35	11.9	11.96
Germany	15.85	13.8	12.72	12.28	12.41	11.92	11.9
Poland	12.4	11.88	10.81	11.41	11.63	11.21	11.76
Malaysia	10.88	12.15	10.86	12.88	12.14	12.74	11.62
Austria	10.36	10.17	10.29	11.88	11.37	10.67	11.25
Japan	10.65	11.4	11.23	11.42	10.98	10.42	10.9
Slovenia	10.37	9.6	10.63	11.26	11.6	10.68	10.87
Venezuela	10.65	10.3	10.4	10.16	10.88	10.37	10.7
Israel	8.78	9.96	10.91	10.82	10.62	10.28	10.62
Congo	26.6	21.21	18.74	15.01	10.49	10.25	10.23
Seychelles	5.14	5.38	6.8	8.24	9.42	9.81	10.22
UK	13.55	12.53	11.6	11.1	10.52	9.65	9.99
Singapore	10.79	12.78	12.31	11.19	10.52	9.6	9.91
Lithuania	14.57	7.93	7.51	8.66	9.75	9.13	9.88
Uruguay	8.4	9.43	9.18	9.85	10.19	10.11	9.85
Greece	9.45	9.27	10.34	10.73	10.38	9.99	9.47
Suriname	25.8	21.08	14.28	12.53	9.38	9.46	9.44
Slovakia	13.65	9.87	9.3	9.09	9.08	8.63	9.2
Sweden	10.67	10.91	10.35	9.84	9.13	8.53	9.15
Bulgaria	12.26	9.36	8.17	8.87	9.45	8.65	9.08
Bermuda	10.92	8.09	8.32	9.18	8.72	8.9	9.08
Ukraine	18.45	11.53	9.61	9.34	9.5	8.11	8.73
France	9.72	9.35	9.5	9.18	8.81	8.54	8.57
Solomon Islands	19.07	10.9	10.03	9.23	8.67	8.55	8.47
South Africa	9.45	8.93	8.82	9.53	9.31	8.8	8.41
Cote d'Ivoire	12.16	10.05	10.1	7.79	8.69	7.71	8.36
China	3.38	4.13	4	6.01	7.57	7.95	8.34
Equatorial Guinea	0.65	4.5	7.79	9.35	8.72	8.52	8.33
Latvia	12.61	7.53	6.72	7.64	8.09	7.82	8.33
Brazil	10.73	9.72	8.39	13.78	7.72	7.42	8.31
Bosnia and Herzegovina	7.27	1.97	5.15	5.58	6.49	8.1	8.23
Cyprus	6.69	7.71	8.34	8.63	8.51	8.38	8.14

[22] Source and complete database: JRC/PBL Netherlands Environmental Assessment Agency, 'Emission Database for Global Atmospheric Research (EDGAR)', release version 4.2, 2010. See http://edgar.jrc.ec.europe.eu online.

Indonesia	6.3	6.58	6.77	12.69	8.58	11.03	8.11
Italy	8.93	9.1	9.59	9.61	8.83	7.99	8.1
Argentina	8.16	7.89	8.09	8.21	8.46	7.77	7.79
Serbia and Montenegro	7.97	5.36	5.36	3.8	6.07	6.87	7.77
Spain	7.51	8.05	9.37	10.01	8.96	8.14	7.68
Switzerland	8.44	7.77	7.45	7.58	7.52	7.29	7.5
Hong Kong	6.43	6.61	6.68	6.82	7.5	7.93	7.23
Croatia	7.44	5.05	5.77	6.72	7.44	7.12	7.08
Hungary	9.32	7.46	7.35	7.56	7.21	6.67	6.73
Grenada	1.64	1.77	4.68	5.47	6.21	6.45	6.68
Uzbekistan	8.16	6.28	6.72	6.5	6.89	6.45	6.33
Portugal	5.84	6.82	8.03	8.33	6.99	6.9	6.32
Chile	4.14	4.6	5.74	6.13	6.47	6.09	6.27
Thailand	3.65	4.72	4.48	5.23	5.27	5.27	5.98
Mexico	5.81	5.54	5.69	5.95	5.87	5.74	5.83
Turkey	4.11	4.4	4.97	5.1	5.63	5.6	5.77
Botswana	9.67	7.66	5.51	6.52	5.49	5.53	5.73
Romania	10.55	7.61	5.99	6.46	6.35	5.6	5.54
Azerbaijan	10.83	5.48	5.22	5.52	6.01	5.47	5.44
Cuba	5.37	4.27	4.37	4.12	4.49	5.32	5.14
Malta	7.09	7.01	6.42	7.74	5.13	4.79	4.96
Algeria	4.19	4.37	4.34	4.43	4.65	4.76	4.76
Sudan	3.5	3.38	3.44	3.47	4.97	4.93	4.47
Jamaica	3.94	4.42	4.8	4.97	5.12	4.42	4.27
Colombia	5.25	4.91	4.51	3.79	4.23	4.31	4.03
Ecuador	3.01	3.42	3.13	3.58	3.4	3.63	3.71
Armenia	6.98	2.08	2.25	2.78	4.09	3.69	3.69
Tunisia	2.54	2.73	3.21	3.25	3.43	3.49	3.6
Vietnam	1.48	1.63	1.98	2.71	3.01	3.25	3.49
Egypt	2.32	2.35	2.71	3.28	3.44	3.36	3.4
Mali	3.55	3.2	2.72	2.74	3.89	3.34	3.27
Moldova, Republic of	8.71	3.84	2.63	3.39	3.05	3.06	3.17
Georgia	6.97	2.67	2.38	2.52	2.82	3.07	3.01
Albania	3.29	2.04	2.52	2.82	2.72	2.66	2.77
Nicaragua	2.49	2.32	2.57	2.64	2.59	2.6	2.63
Honduras	2.81	3.02	2.38	2.54	2.68	2.58	2.54
Kyrgyzstan	7.57	2.28	2.08	2.2	2.32	2.57	2.51
Morocco	1.49	1.54	1.75	2.3	2.32	2.26	2.43
Maldives	0.6	1.38	1.13	1.66	2.1	2.24	2.37
Costa Rica	2.78	2.88	2.51	2.34	2.39	2.31	2.36
Somalia	2.72	2.88	2.76	2.55	2.4	2.34	2.31
India	1.58	1.7	1.78	1.87	2.04	2.14	2.2
Tajikistan	4.06	2.2	1.63	1.89	2.13	2.08	2.14
Madagascar	4.29	3.54	3.42	3.44	2.12	2.1	2.07
Zimbabwe	3.34	2.59	2.42	2.22	1.96	2	2.06
Pakistan	1.54	1.62	1.7	1.88	2.02	2.02	1.96
Samoa	1.78	1.66	1.83	1.73	1.84	1.87	1.9
Senegal	1.52	1.44	1.57	1.61	1.76	1.75	1.86
Uganda	2.08	1.86	1.67	1.69	1.84	1.53	1.72
Yemen	1.08	1.18	1.36	1.58	1.63	1.61	1.54
Sri Lanka	1.06	1.13	1.24	1.37	1.37	1.33	1.43
Tonga	1.31	1.57	1.83	1.56	1.47	1.44	1.41
Kenya	1.66	1.52	1.42	1.41	1.42	1.42	1.39
Nigeria	1.67	1.67	1.64	1.49	1.65	1.39	1.36
Ethiopia	1.39	1.21	1.17	1.2	1.31	1.34	1.32
Mozambique	3.02	2.31	3.61	2.93	1.29	1.31	1.31
Nepal	1.32	1.25	1.18	1.11	1.09	1.1	1.09
Eritrea	1.06	1.17	1.29	0.99	0.95	0.94	0.92
Comoros	0.67	0.64	0.65	0.59	0.73	0.78	0.82
Haiti	0.75	0.76	0.83	0.85	0.85	0.85	0.8
Burundi	0.5	0.49	0.39	0.64	0.68	0.7	0.72
Malawi	0.91	0.82	0.7	0.69	0.64	0.63	0.65
Niger	0.89	0.89	0.86	0.67	0.64	0.62	0.64

Table Series C. Total CO_2 emission per country and sector breakdown ([23])

Table C1. Total CO_2 emissions and sector breakdown of Armenia

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	6 120.78	1 392.47	1 601.88	948.915	1 305.26
1A2	Manufacturing industries and construction	3 812.88	504.802	722.254	1 355.4	1 969.78
1A3b	Road transportation	3 013.97	116.058	580.29	559.98	2 754.45
1A4	Residential and other sectors	7 007.81	1 357.96	526.647	1 148.12	1 415.57
1B2	Fugitive emissions from oil and gas	0	0	0	0	0
2A (1,2)	Production of cement and lime	695.46	106.902	102.519	270.485	331.533
2B	Production of chemicals	0.06904	1.14782	0.057821	0.057821	0.057821
2C	Production of metals	0.012	0	0	0	0
2G	Non-energy use of lubricants/waxes (CO_2)	16.5904	1.84338	1.22892	7.37352	7.98798
3 (A,B,C,D)	Solvent and other product use	210.6256	191.7478	183.1332	179.2287	177.3981
4D4	Other direct soil emissions	40.92	11	11	24.64	49.885
5 (A,D)	Forest and peat fires, decay of drained peatland	116	124.056	132.111	140.167	145
	TOTAL	21 035.12	3 807.987	3 861.121	4 634.367	8 156.922

Table C2. Total CO_2 emissions and sector breakdown of Azerbaijan

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	26 124.9	14 443.7	15 385.4	13 944	16 188.9
1A1bc	Other energy industries	1 815.93	272.51	1 104.43	2 522.31	2 155.88
1A2	Manufacturing industries and construction	14 158.6	6 156.71	4 323.31	2 365.58	1 291.24
1A3a	Domestic aviation	0	0	0	11.723	33.7037
1A3b	Road transportation	3 226.69	2 953.42	2 018.88	5 006.16	4 879.68
1A3c	Rail transportation	0	39.8039	0	0	0
1A3d	Inland navigation	0	0	0	0	0
1A3e	Other transportation	286.553	93.9518	70.4636	0	0
1A4	Residential and other sectors	16 712.6	7 074.43	6 619.36	7 093.33	7 092.25
1B2	Fugitive emissions from oil and gas	34.2605	23.1354	277.081	315.574	943.09
2A (1,2)	Production of cement and lime	496.32	92.214	90.2	679.796	768
2B	Production of chemicals	203.432	82.514	105.809	103.801	103.801
2C	Production of metals	115.134	10.3059	10.1666	101.623	82.4222
2G	Non-energy use of lubricants/waxes (CO_2)	267.29	5.53014	30.1085	49.1568	30.1963
3 (A,B,C,D)	Solvent and other product use	141.4908	152.8625	159.7652	165.0173	168.2515
4D4	Other direct soil emissions	138.192	53.46	3.52	29.04	0.825
5 (A,D)	Forest and peat fires, decay of drained peatland	75	75	75	75	75
	TOTAL	63 796.39	31 529.55	30 273.49	32 462.11	33 813.24

[23] Source and complete database: JRC/PBL Netherlands Environmental Assessment Agency, 'Emission Database for Global Atmospheric Research (EDGAR)', release version 4.2, 2010. See http://edgar.jrc.ec.europe.eu online.

Table C3. Total CO_2 emissions and sector breakdown of Belarus

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	56 485.5	34 390.4	31 996.4	33 100.7	32 358.3
1A1bc	Other energy industries	2 477.11	1 143.31	764.304	1 149.53	1 378.1
1A2	Manufacturing industries and construction	9 533.91	4 187.15	5 468.95	6 183.34	7 103.43
1A3a	Domestic aviation	0	0	0	2 870.82	8 253.62
1A3b	Road transportation	8 372.81	4 536.89	4 338.92	4 060.53	5 011.63
1A3c	Rail transportation	1 610.15	1 118.92	738.179	1 486.06	1 296.42
1A3d	Inland navigation	99.2777	65.1508	3.10242	99.2777	99.2777
1A3e	Other transportation	164.039	100.278	302.994	3.10242	3.10242
1A4	Residential and other sectors	19 554.9	10 800.2	9 446.38	9 902.68	11 435.5
1B2	Fugitive emissions from oil and gas	11.1484	8.34331	7.08443	6.56334	6.29434
2A	Production of cement, lime and other minerals	1 862.629	927.5383	1 340.309	2 100.145	2 933.436
2B	Production of chemicals	2 265.34	1 538.47	1 563.07	1 386.27	1 388.82
2C	Production of metals	0	29.76	60.08	81.08	119.56
2G	Non-energy use of lubricants/waxes (CO_2)	0	4.30122	3.0723	0	0
3 (A,B,C,D)	Solvent and other product use	151.3138	62.54469	43.41206	44.35206	60.15863
4D4	Other direct soil emissions	2 509.7	1 950.99	1 506.06	1 115.68	871.482
5 (A,D)	Forest and peat fires, decay of drained peatland	41 515	41 515	41 515	41 515	41 515
	TOTAL	146 612.8	102 379.2	99 097.32	105 105.1	113 834.1

Table C4. Total CO_2 emissions and sector breakdown of Georgia

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	13 440.9	4 374	1 439.38	824.353	1 298.73
1A1bc	Other energy industries	0	0	0	377.166	189.943
1A2	Manufacturing industries and construction	6 465.96	906.079	653.121	297.081	489.002
1A3b	Road transportation	3 556.57	840.855	937.961	1 492.5	1 306.68
1A3c	Rail transportation	112.349	192.35	30.9738	31.6857	31.6857
1A3e	Other transportation	97.9208	0	0	36.8217	89.6988
1A4	Residential and other sectors	5 276.85	829.343	1 342.55	993.623	1 296.71
1B2	Fugitive emissions from oil and gas	8.62904	7.45902	7.61181	3.8345	3.79939
2A (1,2)	Production of cement and lime	244.2	48.9	159.198	220.425	214.5
2B	Production of chemicals	208.338	101.565	249.163	220.442	258.987
2C	Production of metals	363.587	58.8	46.24	36.44	30.3307
2G	Non-energy use of lubricants/waxes (CO_2)	73.7352	11.6747	2.45784	4.30122	4.91568
3 (A,B,C,D)	Solvent and other product use	97.0618	89.46335	83.90783	79.54096	77.15507
4D4	Other direct soil emissions	101.137	45.4772	23.6657	18.7	17.71
5 (A,D)	Forest and peat fires, decay of drained peatland	210	204.228	198.302	192.222	188.5
	TOTAL	30 257.24	7 710.194	5 174.532	4 829.136	5 498.347

Table C5. Total CO_2 emissions and sector breakdown of Kazakhstan

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	109 734	74 502.1	63 591.8	77 285.2	84 711.1
1A1bc	Other energy industries	5 554.33	5 150.97	4 483.68	8 122.28	11 923.5
1A2	Manufacturing industries and construction	78 117.4	54 473.5	27 963.2	38 529.9	44 214.7
1A3a	Domestic aviation	902.529	538.497	532.728	233.119	308.21
1A3b	Road transportation	12 294.3	7 770.77	4 246.25	8 296.8	11 294.1
1A3c	Rail transportation	1 445.73	1 002.08	822.142	1 709.44	1 757.13
1A3d	Inland navigation	21.7169	12.4097	9.30726	24.8194	23.656
1A3e	Other transportation	0	0	29.1652	0	0
1A4	Residential and other sectors	26 785.7	21 893.4	15 805.9	29 528.2	45 392.9
1B (1,2)	Fugitive emissions from solid fuels, oil and gas	6 132.023	5 757.81	13 531.7	16 206.66	15 279.08
2A (1,2,7)	Production of cement, lime and other minerals	6 085.65	2 257.885	1 872.245	4 234.1	4 932.94
2B	Production of chemicals	974.874	236.004	70.0208	111.954	93.1146
2C	Production of metals	7 087.35	7 250.13	6 520.07	7 198.03	7 472.99
3 (A,B,C,D)	Solvent and other product use	181.0798	174.1233	164.983	162.6984	162.213
4D4	Other direct soil emissions	366.96	99	44	59.84	47.465
5 (A,D)	Forest and peat fires, decay of drained peatland	15 657.8	3 936.99	357.649	224.181	96.64
	TOTAL	271 341.4	185 055.7	140 044.8	191 927.2	227 709.7

Table C6. Total CO_2 emissions and sector breakdown of Kyrgyzstan

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	3 922.81	2 199.39	2 009.39	1 521.89	1 991.24
1A2	Manufacturing industries and construction	8 446.9	557.531	913.639	1 612.64	1 693.34
1A3a	Domestic aviation	275.407	256.19	119.743	191.588	68.1035
1A3b	Road transportation	3 072.63	658.629	496.148	858.831	830.023
1A4	Residential and other sectors	7 447.03	1 001.45	1 085.42	1 047.95	1 400.51
1B2	Fugitive emissions from oil and gas	0.399488	0.223614	0.193322	0.18566	0.178098
2A (1,2)	Production of cement and lime	715.02	146.79	231.5	404.7	562.167
2B	Production of chemicals	0.05178	0.058684	0.058684	0.058684	0.058684
2G	Non-energy use of lubricants/waxes (CO_2)	0	6.75906	4.30122	13.5181	18.4338
3 (A,B,C,D)	Solvent and other product use	34.9228	36.45957	39.35337	41.8309	43.2598
4D4	Other direct soil emissions	135.96	34.32	43.56	7.92	1.485
5 (A,D)	Forest and peat fires, decay of drained peatland	498.5275	442.5483	418.332	410.001	405
	TOTAL	24 549.66	5 340.349	5 361.639	6 111.113	7 013.799

Table C7. Total CO_2 emissions and sector breakdown of Moldova Republic

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	13 676.6	5 301.62	4 037.46	3 971.07	3 946.82
1A1bc	Other energy industries	7.92561	0	0	0	0
1A2	Manufacturing industries and construction	2 052.7	986.188	491.287	687.184	566.733
1A3a	Domestic aviation	0	0	0	0	0
1A3b	Road transportation	2 418.85	841.255	399.966	672.379	24.3449
1A3c	Rail transportation	0	93.9312	27.8764	99.1666	185.213
1A3e	Other transportation	38.7488	136.23	81.0335	149.038	16.4149
1A4	Residential and other sectors	12 492.5	3 668.88	1 462.1	2 308.37	1 834.22
1B2	Fugitive emissions from oil and gas	0	0	0	0.012542	0.035118
2A (1,2)	Production of cement and lime	1 224.72	30.741	102.372	285.647	322.25
2B	Production of chemicals	0.30205	0.270982	0.270982	0.270982	0.270982
2C	Production of metals	40.276	26.52	36.32	40.64	35.4
2G	Non-energy use of lubricants/waxes (CO_2)	0	10.4538	4.30122	7.98798	5.44237
3 (A,B,C,D)	Solvent and other product use	95.678	95.1256	93.71996	92.20955	91.37946
4D4	Other direct soil emissions	115.029	104.437	2.95429	4.90285	4.40785
5 (A,D)	Forest and peat fires, decay of drained peatland	22.5	21.8056	21.1111	20.4167	20
6C	Waste incineration	2.29042	1.71969	1.72815	2.08526	2.22838
	TOTAL	34 178.12	13 314.18	8 762.501	10 346.38	9 063.16

Table C8. Total CO_2 emissions and sector breakdown of Tajikistan

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	1 533.76	807.986	629.476	589.549	786.623
1A2	Manufacturing industries and construction	0	5.61	5.61	5.61	5.61
1A3b	Road transportation	1 598.7	3 092.94	2 089.04	3 406.31	3 943.07
1A4	Residential and other sectors	8 734.61	1 461.61	1 564.53	1 642.43	2 239.31
1B2	Fugitive emissions from oil and gas	0.371849	0.067837	0.045152	0.055185	0.035118
2A (1,2)	Production of cement and lime	581.01	46.302	30.8	131.026	150.5
2B	Production of chemicals	108.438	27.1408	28.2403	86.057	43.5858
2C	Production of metals	438.4	371.2	430.72	608.001	542.399
3 (A,B,C,D)	Solvent and other product use	37.609	40.91746	43.67685	46.14625	47.72806
4D4	Other direct soil emissions	21.8114	62.1343	25.1114	32.8427	32.8427
	TOTAL	13 054.71	5 915.908	4 847.25	6 548.027	7 791.704

Table C9. Total CO_2 emissions and sector breakdown of Turkmenistan

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	10 069.3	9 169.71	8 920.72	11 619.5	15 561.7
1A1bc	Other energy industries	4 622.66	3 697.13	4 968.39	5 939.55	6 802.59
1A2	Manufacturing industries and construction	0	5.61	5.61	5.61	5.61
1A3b	Road transportation	2 483.65	1 401.4	1 993.3	2 312.46	2 829.09
1A4	Residential and other sectors	29 894.9	20 397	20 398.2	21 576.2	24 132.3
1B2	Fugitive emissions from oil and gas	884.87	674.75	2 003.17	2 632.45	2 928.55
2A (1,2)	Production of cement and lime	582.87	220.83	215.7	299.3	399
2B	Production of chemicals	77.71	114.906	137.02	430.05	532.85
3 (A,B,C,D)	Solvent and other product use	38.27	43.74	46.974388	50.42	52.54
4D4	Other direct soil emissions	212.52	165	136.08	196.08	196.08
5 (A,D)	Forest and peat fires, decay of drained peatland	315.14	295.45	283.333	275	270
	TOTAL	49 181.90	36 185.54	39 108.50	45 336.63	53 710.31

Table C10. Total CO_2 emissions and sector breakdown of Ukraine

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	325 607	180 740	131 487	116 466	124 413
1A1bc	Other energy industries	18 243.9	8 613.7	7 368.89	9 500.1	7 697.33
1A2	Manufacturing industries and construction	200 238	96 308.5	80 647.3	74 579.2	80 321.9
1A3a	Domestic aviation	0	8.79228	5.85201	92.7584	125.73
1A3b	Road transportation	48 279.8	24 838.4	19 668.9	21 369.8	24 704.4
1A3c	Rail transportation	2 485.04	1 151	774.345	1 083.57	962.83
1A3d	Inland navigation	0	0	0	408.854	334.517
1A3e	Other transportation	5 051.23	7 220.18	6 800.44	7 620.72	7 023.09
1A4	Residential and other sectors	81 534	60 320	47 127	49 688.6	45 938
1B (1,2)	Fugitive emissions from solid fuels, oil and gas	34 528.34	44 002.82	31 633.5	21 218.35	13 425.39
2A (1,2,7)	Production of cement, lime and other minerals	25 524.01	11 070.9	10 694.78	16 728.38	18 707.27
2B	Production of chemicals	10 476.6	6 480.29	6 598.68	6 839.93	6 152.48
2C	Production of metals	12 246.8	6 217.67	8 656.54	8 964.71	8 491.4
2G	Non-energy use of lubricants/waxes (CO_2)	318.905	140.097	178.193	145.013	181.88
3 (A,B,C,D)	Solvent and other product use	734.809	274.2862	197.5051	256.5967	276.3735
4D4	Other direct soil emissions	3 621.48	2 297.96	1 247.68	541.075	541.075
5 (A,D)	Forest and peat fires, decay of drained peatland	8 213	7 305.23	6 397.45	5489.66	4945
	TOTAL	777 102.9	456 989.8	359 484.1	340 993.3	344 241.7

Table C11. Total CO_2 emissions and sector breakdown of Uzbekistan

IPCC Code	IPCC Description	1990	1995	2000	2005	2008
		Gg	Gg	Gg	Gg	Gg
1A1a	Public electricity and heat production	43 837.9	33 915.5	36 134.5	34 755.2	38 487.7
1A1bc	Other energy industries	3 397.28	1 858.3	4 477.23	4 121.44	4 106.96
1A2	Manufacturing industries and construction	0	13 350.7	16 030.4	15 247	16 770.6
1A3a	Domestic aviation	242.478	1 008.52	905.388	699.23	624.513
1A3b	Road transportation	5 588.2	3 949.43	6 105.81	4 964.61	6 481.06
1A3c	Rail transportation	0	0	312.835	232.303	201.33
1A3e	Other transportation	0	2 400.47	3 107.1	2 975.78	3 257.18
1A4	Residential and other sectors	62 133	38 298	45 656.5	42 269.3	45 890.3
1B2	Fugitive emissions from oil and gas	1 762.79	1 958.57	2 270.93	4 571.79	4 529.06
2A (1,2)	Production of cement and lime	3 486.27	1 750.53	1 733.095	2 389.235	2 973.5
2B	Production of chemicals	2 843	1 706.3	1 440.3	1 505	1 735.16
2C	Production of metals	80.3393	53.8728	41.1145	63.3063	66.7426
2G	Non-energy use of lubricants/waxes (CO_2)	0	88.0098	82.9521	59.6027	53.4581
3 (A,B,C,D)	Solvent and other product use	146.2648	163.3983	176.268	189.5975	197.788
4D4	Other direct soil emissions	615.497	522.94	361.932	351.373	341.473
5 (A,D)	Forest and peat fires, decay of drained peatland	1 094.738	1 079.515	1 071.67	1 067.5	1 065
	TOTAL	125 227.8	102 104.1	119 908	115 462.3	126 781.8

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Abstract

In the process of extending the Covenant of Mayors action towards the East, the specificity of the economic situation of the countries involved in this programme was carefully analysed as well as the implications of using the methodology of the original Covenant of Mayors EU, as described in the Guidebook "How to develop a Sustainable Energy Action Plan (SEAP)".
The first aspect that was considered was the choice of the baseline year: choosing 1990 (as recommended for the EU countries) was not considered appropriate because of the drastic economic collapse that followed the fall of the Soviet Union, resulting in a CO2 emissions reduction of more than 50% in a few years. Therefore, a recent baseline year was the recommended choice. On the other side, since the countries covered by this project are recovering from the economic collapse of the 1990s, imposing a reduction of CO2 emissions in absolute terms was a questionable choice in terms of feasibility. Therefore it was considered necessary that, the opportunity to calculate a target based on a reference scenario, called business-as-usual (BAU) (defined as a continuation of the current trend) to 2020 should be given to signatories willing to do so (besides the absolute and the per capita reduction options). This option of using Business as Usual Scenarios would avoid a burden to the signatories in their economic aspiration and would allow social and economical progress after the economic collapse in the 1990s.
Based on these considerations, IES-JRC team developed a methodology according to which the 11 post-sovietic countries will be given the possibility to use a business-as-usual (BAU) scenario to estimate their emissions in 2020 and to calculate their emissions reduction accordingly.

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