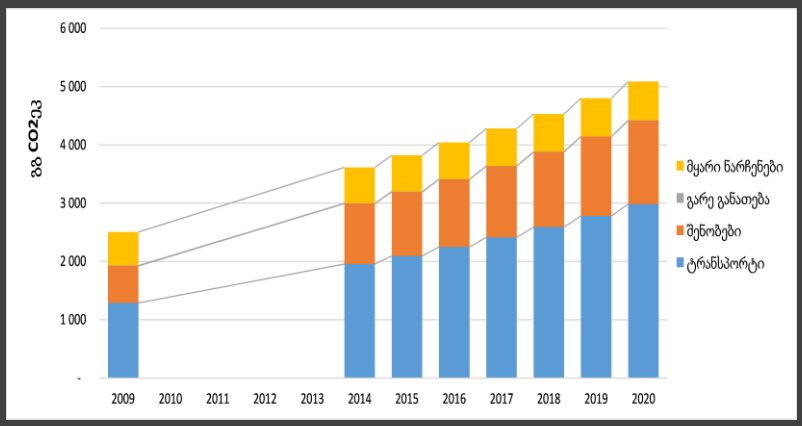
ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS) CLEAN ENERGY PROGRAM

COOPERATIVE AGREEMENT NO. 114-A-13-00008

Municipal Emission Inventory, Projection and Mitigation Planning Tool (muni-EIPMP)



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MUNICIPAL EMISSION INVENTORY, PROJECTION AND MITIGATION PLANNING TOOL (MUNI-EIPMP)

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The author appreciates the dedication of time and expertise provided by DecisionWare Group in testing the tool and providing valuable insights about its improvement.

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ACRONYMS

BAU	Business AS Usual (scenario)
BEI	Baseline Emission Inventory
CoM	Covenant of Mayors
EU	European Union
GHG	GreenHouse Gasses
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
MEI	Monitoring Emission Inventory
muni-EIPMP	Municipal Emission Inventory, Projection and Mitigation Planning Tool
NCV	Net Calorific Value
SEAP	Sustainable Energy Action Plan

EXECUTIVE SUMMARY

Tbilisi, the capital of Georgia and its largest city, was the first to join the Covenant of Mayors (CoM) and submit a Sustainable Energy Action Plan (SEAP). Tbilisi's SEAP was prepared by the Sustainable Development Centre Remissia with the financial support from USAID/Winrock. For Tbilisi's SEAP, a new methodology was developed and used, which differs from the methodology applied by the EU cities. In particular, a Business as Usual (BAU) scenario approach was offered instead of fixed base year approach applied by Annex I cities from the EU and former Soviet countries (Ukraine, Belarus). Such approach encloses a city's development perspective and potential of increase in greenhouse gasses (GHG) because of development needs and demonstrates perspective of development with lower emission pathway. The LEAP (Long-Term Energy Alternative Planning) model was applied for the preparation of a BAU (Business As Usual) scenario by 2020 for the Transport, Building and public lighting sectors. While LEAP was developed at the city level, it drew many assumptions (such as elasticity and penetration rates) from the national MARKAL-Georgia model.

Once the BAU scenario was established GHGs emission reduction till 2020 was calculated below the BAU scenario and not against a fixed base year approach. This approach was appraised and approved later by Joint Research Institute (JRC) from EU, which is responsible to review the SEAPs. Based on this approach JRC developed a methodology for preparation of SEAP for Eastern Neighborhood and Central Asia countries [1] which allows the use of BAU scenario as reference for reductions, and included the comprehensive energy sector modeling effort from Tbilisi's SEAP as an example of how to use the BAU approach.

However, such comprehensive modeling effort is often out of the human, technical and financial capacities of municipality, since this approach requires more statistics and better technical capacity than are generally available at municipality level and thus cities are forced to seek outside support. As a response to removing this barrier, the JRC also introduced another, optional approach for COM Eastern Countries to project BAU scenario. Coefficients were developed at the Institute for Environment and Sustainability of the Joint Research Centre that are simply applied to a base year to project likely future emission levels. While, this approach is easier to apply at municipal level, it has several drawbacks: the growth rates are national thus they cannot incorporate the municipal growth rates which may differ; the differences of sectoral growth rates are not accounted for; the possible changes in economic and demographic projections at national level are not reflected. In addition, JRC has compared the national factors for 2005-2010 (result of the first five years projection) with the current IEA energy consumption data for the same period and significant discrepancies for Georgia have been observed in their projections [2].

Due to the above reasons, EC_LEDS proposed to develop a simpler inventory and projection tool for municipalities which would draw information from national MARKAL-Georgia model, such as Georgia-specific sector-specific emission elasticities rather than using generic JRC emission growth coefficients. In addition, the municipalities would be provided with other necessary information such as national emission factors, including projected carbon intensity factor for electricity, which will capture the impact of planned national actions as well as plans from other municipalities or regions. Finally, specific SEAP measures that are common to many municipalities can be evaluated at the national level to identify the most attractive collective measures/programs, and so that basic cost and mitigation data can be provided to the municipalities to avoid duplication of effort and improve the consistency of the SEAPs. On the other hand municipal level data on building stocks, transport requirements along with expected mitigation measures and performance improvements would be aggregated in the enhanced MARKAL-Georgia model to increase the accuracy and validity of analyses performed at the national level. This approach ensures that actions and decisions taken at the national level will be properly incorporated in the municipal SEAPs, and that the cumulative influence of actions by the municipalities are properly accounted for in the national context.

This new tool has the following advantages: 1) It is simple enough to be successfully used at municipal level, but comprehensive enough to give the planners at municipal level the insights they require. 2) It is linked with national MARKAL-Georgia model (from Component 3) and obtains many necessary inputs from it to assess the GHG projections and mitigation potentials. 3) Linking with national model the consistency between different assumptions at municipal level that rely on national

data (for emission factors, net calorific values, etc) and data-sharing between different municipal models is achieved.
During the first year of EC-LEDS project, the modules for transport, buildings and public lighting were developed, which include submodules for data gathering, emission inventory calculations and BAU projections for these sectors up to 2020. Public lighting module also includes the sheets for evaluating impact of mitigation measure – substitution of existing sodium lamps with LEDS lamps.

During the second year the following enhancements were made to the model:
1.The initial year for BEI was made to be flexible, so the users can choose the starting year of their analysis or create additional inventories for monitoring.
2. The last year of BAU scenario was also made to be flexible, so that emission projections can be evaluated for the years after 2020 as well. This was done because 2020 is fast approaching and new municipalities have very small time to implement their mitigation action during remaining period. Thus the longer time scale for BAU is more appropriate for them.
3. The options for BAU methodologies were added. User can choose from MARKAL projections, JRC projections or any other national projections that are available.
4. The module for wastewater was added. For solid waste the IPCC software [8] can be used and integrated into muni-EIPMP. Modules include estimation of savings from mitigation measures.
5. The sheets for estimating mitigation effects and costs for different mitigation measures were also added. Sheets need to be populated with data form MARKAL analysis, or any other source.

SECTION ONE: METHODOLOGY

1.0 Introduction

The CoM process in Georgia started in 2010, when Tbilisi joined it. Later seven more cities have joined the process and stated to work on the development of SEAPs. The experience of working with them and lessons learned in the process make the foundation of the requirements and specifications for muni-EIPMP.
The needs of municipalities for support in the CoM process fall into four categories as discussed below:

1. **Support in data gathering**. Data gathering is the initial critical step in the SEAP preparation and implementation process, as it is needed to gain a proper understanding of emission sources and amounts from the territory of municipality. It remains an important component of the process even after submitting the SEAP, because municipalities should continue gathering such data to monitor the success of its implementation activities. Not all the data necessary to develop the Baseline inventory and assess the mitigation measures at municipal level is readily available. Only very few is currently collected for the assessment of economic activities. Some data valuable for the SEAP preparation and monitoring are collected by the private sector for their own purposes and belong to private sector (such as distribution companies, etc), who are not always willing to share them. Often the municipalities don't know all the sources of data, and even when a municipality is successful in obtaining some data, it is not usually in the format and structure that is required by the SEAP. Data from different sources can contradict and require strong validation. Some required data (e.g. transport mileage) has not been accurately quantified and must be estimated. The municipalities don't have the capacity and knowledge to develop such data if it is not readily provided by some external entity. The experts from abroad who provide support to municipalities in many cases are not aware of such difficulties and don't know how to face them. This was the main reason why Tbilisi was not able to develop its baseline inventory (despite support from GIZ and INOGATE) for SEAP. It is also the reason other cities, like Rustavi and Gori couldn't produce complete inventory. So the tool which will allow making necessary adjustments to data accompanied with detailed instructions on data gathering procedures and training on the use of the data collection workbooks will help municipalities to develop their baseline inventory.
2. The second most important aspect of a successful SEAP process is **developing mitigation measures and project proposals,** which will lead the municipality towards their mitigation target. Even if the SEAP is developed and given to a municipality, without the specific actions and projects it is just paperwork. The level of understanding among the municipal planners of energy issues, emissions, energy efficiency and renewable energy options, mitigation activities in non-energy sectors is very low. Where some understanding exists, there is no knowledge of how to translate it into information to guide decision-making. During many workshops some municipal staff have gathered information on possible measures, but without hands-on experience developing projects they are not able to apply them. So municipalities need on-the-job training for developing specific project proposals for their SEAP and technically and financially assessing them.
3. **The tool for emission inventory compilation, development of Business As Usual (BAU) Scenario and quick assessment of mitigation options for SEAP**. Georgian cities have the possibility to calculate mitigation target against a BAU scenario, and not against some base year for European cities. This ensures that CoM commitment doesn't act as a barrier to economic development of city, rather it facilitates sustainable development. Municipalities need both a simple tool, which it can successfully apply and sustain, and a tool that has more Georgia-specific data. The tool should be in familiar format (preferable Excel), make possible to adjust the emission growth projections using municipalities economic and demographic growth parameters, but shouldn't concentrate deeply in development of BAU.

The tool should also help them to prioritize different mitigation options applicable to Georgia and quickly assess their mitigation potential and costs. As already said, it is important that municipalities concentrate on data gathering and development of specific mitigation measures and proposals, and not comprehensive modeling efforts, which need significant time and skill. In best case the tool should cover all emission sectors, including energy and non-energy sectors.

4. **Targeted capacity building**. Despite many capacity building workshops organized by different organizations and donors for municipalities, the capacity of municipal staff is still very low. We believe that the main reason behind this unsuccessful capacity building activities is misunderstanding of municipal needs and unrealistic judgment of their real capabilities. So all capacity building workshops and trainings should be targeted to particular needs and aim to develop specific capacities in municipal staff.

To address the above discussed needs of municipalities and make the efforts successful and sustainable, it was decided to develop the special tool, the Municipal GHG Emission Inventory, Projection and Mitigation Planning Tool (muni – EIPMP). It is in Excel (software already familiar to the municipal staff and easily maintainable), and it is designed to guide the municipal staff to directly fill in the CoM SEAP templates, used by municipalities for CoM reporting.

Muni –EIPMP includes three features:

- The methods for activity data calculation and establishment of baseline inventory (BEI) or Monitoring Emission Inventory (MEI)
- Calculation of Business as Usual Scenario (BAU) projections
- Assessment of different mitigation options

Among these the inventory and BAU modules (first two features) for transport, building and public lighting have been developed during year 1, and module for the assessment of mitigation measures - during year 2. In addition, during year 2 the flexibility of choosing the starting and ending years of analysis, choosing of methodology for BAU development and waste modules were added.

1.1. Description of Methodology

1.1.1. Baseline Emission Inventory (BEI)

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) 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.
The methodology that muni-EIPMP uses to calculate emission from fuel combustion is based on Revised 1996 IPCC guidelines [3], which is used for countries to report their GHG inventory to the UNFCCC and completely in line with the CoM guidelines.
Greenhouse gas emissions are calculated with formula adapted for intergovernmental council's (IPCC) methodology level 1 sector approach for local level which is based on actual fuel consumption data.

Formula 1

Carbon Dioxide emissions $_j$ ($GgCO_2$)=
$\square_i${Actual fuel consumption $_{ji}$ (unit)x Net Caloric Value of fuel$_i$(MWh[1]/per unit)
x carbon emissions factor (tC/MWh)/1000x oxidation factor i}x 44/12,

Where lower index j *r*efers to sector and lower index *i* - type of fuel.
Emissions for other gases with sector approach were calculated via following formula:

Formula 2

[1]Basic energy unit in IPCC methodology is Terajoule, while according to the SEAP methodology it is MW/h, that is why MWh is used here everywhere

Greenhouse gas emissions $_j$ (GgGas)=
$\square_i${Actual fuel consumption $_{ji}$ (unit)
x Net Caloric Value of fuel$_i$(MW.h/per unit)
x Gas emissions factor $_{ji}$(t Gas/MW.h)/1000].

The approach ensures that emission factors and converters (Net Calorific Values) that have been used in MARKAL-Georgia and muni-EIPMP are the same and are taken from latest national GHG inventory developed under Third National Communication of Georgia to the UNFCCC. The tables 1,3, and 4 indicate these numbers.

Table 1. Converters and Carbon Emission Factors for Different Types of Fuel

Type of Fuel	Unit	Transfer Coefficient (MW/h unit)	Carbon Emission Factor (Ton C/ MW.h)
Gasoline	1000 liters	0.01	0.247
Diesel	1000 tons	0.011	0.267
Liquid Gas	1000 tons	0.013	0.227
Natural Gas	1 millionm^3	0.009	0.202
Firewood	1000 m^3	0.002	--

The Average emission factor of grid electricity was used in 2012 - 0. 136 kg CO_2/kWh for the electric power. It is obtained by dividing CO2 eq. emissions from national power sector in 2012 by generated electricity.

A small portion of carbon in fuel is not oxidized during combustion and are accounted for in formula 1. Typical values of oxidized carbon recommended by IPCC and used in 2006-2011 national inventory are given below. (Table 2). These are used in MARKAL-Georgia and muni-EIPMP as well.

Table 2. Oxidation factors for Different Fuels

Fuel	Share of Oxidized Carbon
Oil and Oil Products	0.990
Natural Gas	0.995

Other GHG emission factors for transport and buildings sectors are given in Table 3 and Table 4.

Table 3. Methane and Nitrous Oxide Emission Factors for Transport Sector (kg/MWh)

Greenhouse Gas	Gasoline	Diesel	Natural Gas
CH_4	0.072	0.018	0.18
N_2O	0.002	0.002	0.0004

Table 4. Methane and Nitrous Oxide Emission Factors for Buildings (kg/MW/h)

Greenhouse Gas	Natural Gas	Oil Products	Firewood
CH_4	0.018	0.036	1.08
N_2O	0.00036	0.002	0.014

Global warming potential values (GWP) of mentioned gases are used for converting methane and nitrous oxide into carbon dioxide equivalent.

Table 5. Global Warming Potential of Methane and Nitrous Oxide

Gas	Life Expectancy, Years	100-year GWP
CH_4	12±3	21
N_2O	120	310

1.1.2. Development of BAU

Guidance document [1] has been developed by the Joint Research Centre (JRC) specially for the Eastern Partnership member cities, according to which these cities are given a choice to determine mandatory reductions of emissions through three alternative approaches:

- Reduction of absolute emissions against fixed base year;
- Reduction of absolute per capita emissions against fixed base year;
- Reduction against prospective emissions of 2020 according Business As Usual (BAU) scenario.

Abovementioned guidance describes two possible versions of scenario construction:

- The city can develop its own methodology, which later will be evaluated by the JRC.
- The city may use national coefficients indicated in the guidance. These coefficients have been developed for the Global Atmosphere Research (EDGAR) project CIRCE[4] employing emissions database. There has also been used POLES (Prospective Outlook for the Long-term Energy Systems) [5,6] method, considering growth of energy consumption due to population and economic growth. According to the baseline year, the BAU scenario calculates level of emissions for 2020 assuming that current trends of population, economy, technologies and human behavior will continue and no national measures will be taken towards reduction of emissions. The coefficients are indicated in Table 6:

Table 6. JRC National Coefficients for Buildings and Transport Sectors

BAU projections	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

The emissions in 2020 are calculated as:

Formula 3

$$\text{Emissions}_{2020} = \text{=Emissions}_{BY} \times \text{Coefficient}_{BY}$$

Where Emissions $_{2020}$ are emissions in 2020, BY is base year, and Coefficient$_{BY}$ is coefficient from Table 6 for corresponding base year.
While, this approach is easier to apply at municipal level, it has several drawbacks: the growth rates are national thus they cannot incorporate the municipal growth rates which may differ; the differences of sectoral growth rates are not accounted for; the possible changes in economic and demographic projections at national level are not reflected. In addition, JRC has compared the national factors for 2005-2010 (result of the first five years projection) with the current IEA energy consumption data for the same period and significant discrepancies for Georgia have been observed in their projections.
Muni-EIPMP has flexibility of choosing the approach for development of BAU. The user can choose to develop BAU projections based on JRC coefficients[2] or based upon national projections existing within the country. The projections can be from MARKAL-Georgia or any other source but it is important that they should be given for each sector (and/or subsector) individually.
If the national coefficients are applied, they can be downscaled to the municipal level. To do this the user has to include the local level projections of population and GDP.
This approach has the following advantages: 1) It is simple enough to be successfully used at municipal level, 2) It gives projections at sectoral level that gives the planners at municipal level the insights they require. 3) It is linked with national projections (from Component 3 or INDC or MARKAL) and thus the national policy and BAU are properly accounted for at municipal level. 4) If there exists projections of main demand drivers (population growth and GDP growth) at municipal level they can be incorporated to adjust national coefficients to local level.

The emissions are calculated as:

Formula 4

$$\text{Emissions}_{s,t} = \text{Emissions}_{s,BY} \times \text{Coefficient}_{s,t} \times \text{population\_correction\_factor}_{t} \times \text{GDP\_correction\_factor}_{t}$$

Where s represents the sector, t represents the year for which emissions are calculated, BY is base year, and Population_correction_factor and GDP_correction factor represent the ratio of projected municipal growth rates (population and GDP corrspondingly) with the national growth rates. If the local projections don't exist, these factors equal to 1.
The description of methods for calculating emission reductions and costs for mitigation measures are presented within the descriptions of sectoral modules of muni-EIPMP.

SECTION TWO: Description of muni-EIPMP

2.1. Overall description of muni-EIPMP

Municipal GHG Emission Inventory, Projection and Mitigation Planning Tool (muni – EIPMP) is developed in the environment of Excel (software already familiar to the municipal staff and easily maintainable), and is designed to guide the municipal staff to directly fill in the CoM SEAP templates, used by municipalities for CoM reporting.
Current version of muni-EIPMP has 7 interlinked modules (workbooks) discussed below. Each workbook includes instruction of use on the first "MAIN" worksheet and sometimes on other sheets as well.

- Muni-EIPMP_Start is the starting module which includes Visual basic code for creating new inventory or opening existing one. The code also enables to set up the initial year of analysis,

[2] Note that JRC coefficients are available only until 2020.

end year of analysis and select the methodology for BAU modeling. It also creates sectoral modules for newly created inventory.

- Muni-EIPMP_MAIN – the main workbook is were inventory for base year (BEI or MEI) and and BAU projection are assembled. It reads the fuel consumption values and emission data for different sectors from sectorial modules and gives total values and tables for all sectors together. The structure of fuel consumption and inventory sheets are identical with CoM SEAP templates.
- Muni_EIPMP_Buildings is a sectoral workbook, which includes data entry sheets required for inventory and mitigation planning in this sector, as considered under SEAP. This workbook also include a BAU scenario worksheet, which takes emissions for the base year and calculates emissions for the BAU scenario based on selected methodology using parameters taken from the BAUInput workbook. The module includes sheet for evaluation of typical mitigation measures applicable to Georgian municipalities.
- Muni_EIPMP_Transport is a sectoral workbook, which include a data entry sheet (Transport data) required for inventory and mitigation planning in this sector, as considered under SEAP. This sheet requires data on vehicle numberss and fuel efficiency by fuel type and vehicle type, and mode, and calculates final energy use. The BAU scenario worksheet, takes emissions for the base year and calculates emissions for the BAU scenario based on on selected methodology using parameters taken from the BAUInput. The module includes sheet for evaluation of mitigation measures for typical transport "soft" measures considered in most of SEAPS of Georgian municipalities.
- workbook.Muni_EIPMP_Public Lighting is a sectoral workbook, which include sheets for data entry required for inventory and mitigation planning in this sector, as considered under SEAP. The public lighting enables to input the number of light fixtures of different kind as well as their energy consumption and projections in future both for BAU scenario and under mitigation scenario. The module supports two types of analysis: simple and detailed. In simple case projections are made only by type of fixtures (sodium, LED, etc) and in detailed case all fixtures can be listed by type and wattage and projected into the future.
- Muni_EIPMP_waste is a sectoral workbook, which estimates emissions from wastewater and landfills. All calculations necessary for estimated wastewater emissions are incorporated into the workbook, while landfill emissions should come from somewhere else. For example they can come from the IPCC spreadsheet for solid waste inventories. The workbook includes also the calculation for mitigation measures from both wastewater and landfills, which assumes the collection of methane at some rate and either flaring it or venting.

- The "Muni_EIPMP_BAUInput" is the workbook which holds external national coefficients used for inventory development and BAU projections. It includes the NCV end emission factors for different fuels that are used for calculating emission inventories, as well as coefficients for different methodologies for estimating BAU projections. It includes national level emission tables, and municipalities should not make any changes to it. If there are changes to the BAU scenario in MARKAL-Georgia, this workbook can be automatically filled by VedaBE software (part of MARKAL platform) and sent to each municipality, which will then update links in other muni-EIPMP workbooks (by open each and saving after replacing the MarkalInput workbook) to get updated BAU projections for their municipalities.

Each workbook includes instruction of use on the first "MAIN" worksheet and sometimes on other sheets as well. The sections bellow give descriptions of each workbook in more detain

2.2. Starting muni-EIPMP

The initial set-up of muni-EIPMP consists of one workbook called "START" and a folder that holds all other workbooks. To start working with muni-EIPMP, the user has to open START module[3]. The following window appears:

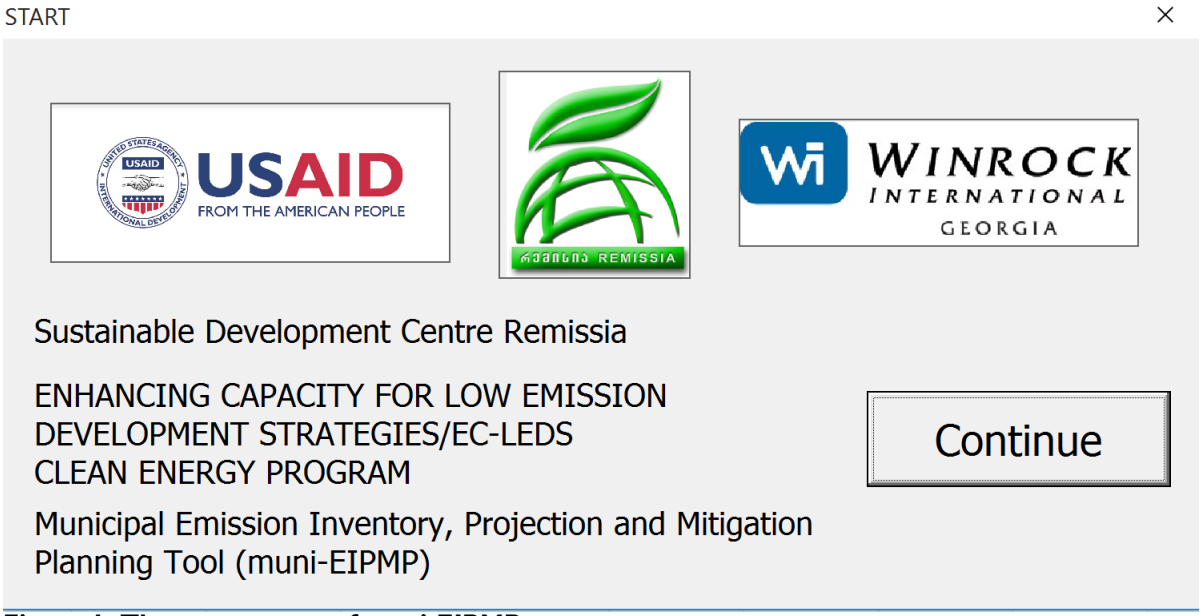

Figure 1. The start screen of muni-EIPMP

After pressing "continue" the user is prompted to either create new inventory or open existing one. If user chooses "new", new window appears where the user has to enter the name of municipality and starting end end years of analysis.

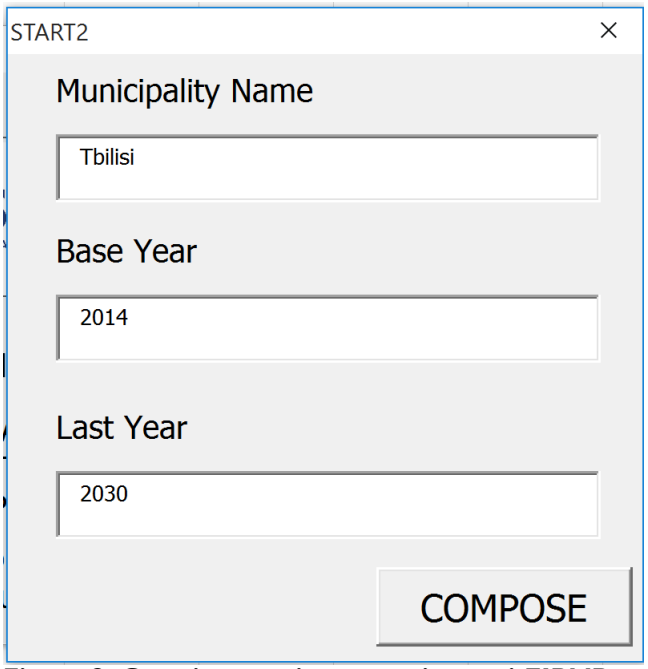

Figure 2. Creating new inventory in muni-EIPMP

After pressing "Compose" the new folder will be created, the name of which consists from municipality name and start year of analysis. It will hold all modules for this analysis in it. Later the user will be able to open it by pressing the "open" button instead of "new".

[3] If macros are not automatically enabled, the user has to enable them manually.

After the new inventory is created (or existing one is opened) the start workbook will present the selection of different sectoral modules, which can be opened by pressing the correcponding buttons. The buttons will open the sectoral modules, where the user can input the data and view the results.

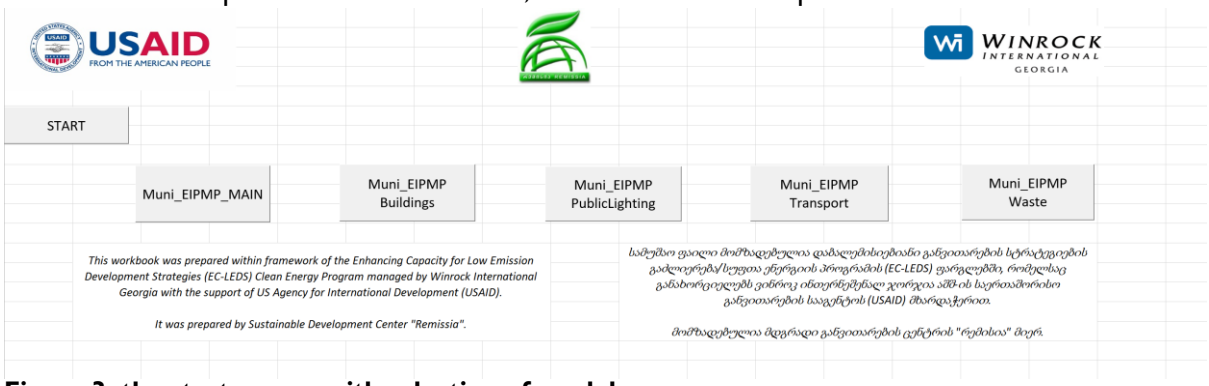

Figure 3. the start screen with selection of modules
The modules are described bellow in more detail.

2.3. Main Workbook

The "Muni_EIPMP_MAIN" is the main workbook and is used to assemble the complete inventory from all workbooks. It includes "MAIN" sheet which gives description of workbook and 5 other sheets.

- Sheet "Final energy (b.year)" contains 3 tables:
  - 1. "A. Final energy consumption" in which is energy consumption in natural units (KWh, kg, litre, etc.) by categories. These values are coming from Buildings, Transport, Public Lighting and Waste files;
  - 2. "A. Final energy consumption (TJ)' where fuel consumption from natural units is converted to TJ;
  - 3. A. Final energy consumption (MWh) where fuel consumption from natural units is converted to MWh.
- Sheet "CO2,CH4,N2O emissions (b.year)" contains 4 tables:
  - 1. "B. CO2 or CO2 equivalent emissions" in which CO2 emissions are calculated ;
  - 2. "B. CH4 emissions" in which CH4 emissions are calculated ;
  - 3. "B. N2O emissions" in which N2O emissions are calculated;
  - 4. "B. All emissions" in which CH4 and N2O are converted to CO2 using GWP values and all emissions are summed up in CO2 equivalent emissions.

  None of the above tables should be edited as all values are calculated automatically.
- Sheet "BAU" shows the increase of emissions in different sectors. Values are taken from the corresponding sectoral workbooks. But the methodology which is used to calculate should be selected in this sheet from BAU -> Option Control (A1:A2). There's 3 type of methodology - MARKAL, JRC, National whose growth rates are taken from a BAU_Input file.
- Sheet "Graphs" has tables and graphs that shows total fuel consumption, emissions and emission reductions that can be readily used in SEAP document.
- Sheet "Actions" includes a list of actions from Sustainable Energy Action Plan in different sectors.

2.4. Transport Workbook

The "Muni_EIPMP_Transport" is the workbook for Transport sector. It includes "MAIN" sheet which gives description of workbook and 4 sheets other sheets, described bellow:

- The first sheet, "Transport_data," is the main sheet and is used to enter the requested transport statistics, which includes vehicle numbers by fuel, vehicle efficiencies and mileage. Based on this the fuel consumption for each fuel and vehicle type is calculated toegther with corresponding emissions. The goal is to fill yellow fields and based on them other fields will be automatically calculated.
- Sheet "BAU" is "Business As Usual" scenario for Transport sector until the end year. In the cell A2 the chosen methodology for BAU is shown. The sheet also includes the graph for BAU projections.
- Sheet "tables and graphs for SEAP" has ready to use tables to use for SEAP document.
- Sheet "measures" lists the typical measures for transport sector and helps evaluate their impact. To do so, the user must enter the percentage of reductions expected from these measures (both for energy and emissions) in columns H and I. These values can come from feasibility studies or any other assessment, for example the assessment of similar measures through MARKAL-Georgia. It is expected that these numbers will be entered into muni-EIPMP after MARKAL assessment of mitigation measures is done under component 3 of EC-LEDS project.

2.5. Buildings Workbook

The "Muni_EIPMP_Buildings" is the workbook for Buildings sector. It includes "MAIN" sheet which gives description of workbook and 6 sheets not including current sheet.

- Sheet "Energy Consumption" contains 3 tables:
    - "A. Final energy consumption" in which energy consumption in natural units (KWh, kg, litre, etc.) by categories is filled in based on values form "input data" sheet.
    - "A. Final energy consumption (TJ)' where fuel consumption from natural units is converted to TJ;
    - A. Final energy consumption (MWh) where fuel consumption from natural units is converted to MWh.
- Sheet "CO2,CH4,N2O emissions" contains 4 tables:
    - "B. CO2 or CO2 equivalent emissions" in which CO2 emissions are calculated ;
    - "B. CH4 emissions" in which CH4 emissions are calculated ;
    - "B. N2O emissions" in which N2O emissions are calculated;
    - "B. All emissions" in which CH4 and N2O are converted to CO2 using GWP values and all emissions are summed up in CO2 equivalent emissions.

  None of the above tables should be edited as all values are calculated automatically.
- Sheet "BAU" is "Business As Usual" scenario for Buildings sector until the end year of analysis. In the cell A2 the chosen methodology for BAU is shown. The sheet also includes the graph for BAU projections.
- Sheet "Actions" lists the typical measures for buildings sector and helps evaluate their impact. To do so, the user must enter the percentage of reductions expected from these measures (both for energy and emissions) in columns F and G, as well as the penetration rate of these measures. These values can come from energy audits or any other assessment, for example the assessment of similar measures through MARKAL-Georgia. It is expected that these numbers will be entered into muni-EIPMP after MARKAL assessment of mitigation measures is done under component 3 of EC-LEDS project.
- In the sheet "input data" user should fill detailed information on fuel consumption in buildings sub-sectors and after this other sheets will automatically update.
- Sheet "Tables for SEAP" contains ready to use tables for SEAP document.
- Additional sheets can be added as necessary to hold any additional information.

2.6. Public Lighting Workbook

- The “Muni_EIPMP_PublicLighting” is the workbook for Public Lighting sector. It includes “MAIN” sheet which gives description of workbook and 5 other sheets.
- Sheet "Energy Consumption" is used to enter the data on electricity consumption of fountains and traffic lights. The "Street Lighting" base year and last year's values are filled automatically from "Public Lightings(BAU)" sheet.
- Sheet "BAU" is "Business As Usual" scenario for Public Lighting sector until 2030. The user has two options, he can either calculate BAU by more complicated way – indicated the growth and change of numbers of fixtures in last ears, or by directly modifying the energy consumption depending on the percentage of the streets that are lighted in base year and the percentage that is expected to be lighted in the last year. Thus it has a switch called "Use percentage (Y/N)?", which if set as “Y” will use percentage rates, otherwise will take values from detailed calculations from other sheets. The first table bellow shows the percentage of streets that are lighted, if this needs to be applied. The percentages should be written only in the baseline and last year, percentages placed among them are automatically calculated. The results of energy consumption are shown in the second table. If the use of percentage rates is off (N) it means that the results of energy consumption calculated in Public Lightings(BAU) sheet will be written in this second table. Also if we use "Use corresponding Electricity EF in the next years (Y/N)?" (Y) then for emissions calculations corresponding emission factors that are given in Public Lightings(BAU) -> CX2, will be used.
- Sheet "Public Lightings(BAU)" gives the possibility to calculate energy consumption and emissions based on fixture numbers and types, It has 2 tables:
    - In the first table user has to input the fixture types, electricity consumption for one fixture and also fixture quantity and working hours (per day) from baseline year till the last year. If we fill the yellow cells that is below baseline year's "working hours" cell then this value will appear in the other years's "working hours" cells. At the end Energy consumption and Emissions by years are calculated.
    - In the second table (cell CV11) user enters the percentage of Electricity losses by years.
- Sheet "Public Lightings(SEAP)" has similar tables as "Public Lightings(BAU)" and here the user can enter the alterbative projection of fixture numbers, giving preference to more efficient fixtures. It has one additional table which is the first table's simplified “averaged” version. With this table we can easily replace equally non-efficient lamps with efficient ones by years.
- There are 2 tables in "tables and graphs for SEAP" sheet: in the first there are calculated electricity consumption by years and in the second there are emissions. Both tables are calculated for BAU and SEAP scenarios.

2.7. Waste Workbook

waste Lighting sector. It includes “MAIN” sheet which gives description of workbook and 7 other sheets, 5 them are intended for wastewater modelings and remaining two for solid waste

- The worksheet "Input_wastewater" has three tables. In the first one the user shall enter population numbers muand the share of population who are connected to sewage systems in base year and projections. The number of population connected to sewage is then calculated based on this data. In the second table the user must enter the information on industrial wastewater. the third table includes additional parameters by year (if user doesn't enter them, then default values will be used).
- The sheet "Wastewater_mitigation" calculates the emission reductions from mitigation measure for wastewater. The user has to indicate what percentage of methane will be collected and whether it will be flared or vented.
- The sheet "Domestic wastewater" takes data from the sheet"Input_wastewater", makes calculations and presents net methane emissions from base year until the end year.
- The sheet "Industrial wastewater" calculates the total organic waste water from industry by years.

- The sheet "Wastewater_BAU" sums the domestic and industrial wastewater and presents the total by year. It also shows the difference between BAU scenario and mitigation case.
- The last two sheets are intended for calculating methane emissions from landfills. The sheet includes information about opening and closing year of landfill, as well as base year. The user has to input the data on population numbers, the share of population that is served by landfill and other parameterf for all years from the opening year of the landfill. For some parameters (i.e. waste composition) default values are used if the user doesn't fill the information. The information enetered in this sheet is then processed by "IPCC_Waste_Model" which calculates emissions for the landfill, shown in the sheet "Landfill BAU".
- The sheet "Waste_BAU" shows the total emissions from both wastewater and solid waste.
- The sheet "Landfill_mitigation" calculates the emission reductions from mitigation measure on landfills. The user has to indicate what percentage of methane will be collected and whether it will be flared or vented.

2.8. BAU Input Workbook

The "Muni_EIPMP_BAUInput" is the workbook which holds external national coefficients used for inventory development and BAU projections. It includes the NCV end emission factors for different fuels that are used for calculating emission inventories, as well as coefficients for different methodologies for estimating BAU projections.
There are 6 sheets in the workbook:

- "MAIN" sheet gives description of workbook in English and Georgian.
- Sheet "MARKAL" contains tables with MARKAL-Georgia projections for different sectors. Projections include emission projections from fossil fuel consumption and electricity consumption to assess indirect emissions from electricity. It also has information on current MARKAL-Georgia BAU scenario's assumptions on GDP and population growth rates which are used to compare with local projections.
  Whenever the name of the MARKAL BAU scenario changes, the button in MAIN sheet labeled "ScenAll" takes the name of new MARKAL BAU scenario (cell B7) and changes all the scenario name references in the other sheets to allow proper updating of the values. In such an event, this workbook can be automatically updated using the VEDA-BE software by the EC-LEDS team and provided to municipalities, which can then update the links to their other workbooks to get updated BAU projections for their municipalities.
- The sheet "JRC" has national emission coefficients for BAU from JRC, which are applied if JRC methodology is selected for BAU.
- The sheet "National" has national emission coefficients for BAU from some other research or study, which are applied if national methodology is selected for BAU. This is reserved for cases when the user doesn't want to use neither JRC nor MARKAL projections and has some other projections to be applied for BAU development.
- The sheet "local projections" includes local projections for GDP and population which can be used to downscale national projections to local level.
- The sheet "Coeffs" includes convertors (NCVs) and emission factors used for calculating emission inventory. It also includes grid emission factor and its projections for electricity.

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