A developed tool allowing the South-Mediterranean cities to establish their sustainable energy plans

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Abstract. In the framework of the Covenant of Mayors for mitigation and Green House Gas emissions reduction toward a sustainable future, proposed tools used in the South-Mediterranean countries have not always been sufficient. To quantify the territory emissions (Baseline Emission Inventory BEI), local authorities had to rely on inaccurate data that generated inaccurate results. Furthermore, classical tools would not allow any authority wishing to join without any technical assistance from CES-MED to identify and determine the performance of each measure in order to elaborate a feasible Sustainable Energy and Climate Action Plan (SECAP).

A new tool is necessary to fill the gaps and lead to a more developed approach, more generalized and adapted to the regional context. The first part developed of this tool can assess the basic situation of a municipality in terms of calculating emissions. A second part of this tool is to identify priority energy efficiency measures, determine the performance of each measure and the related investment costs, in order to develop the SECAP for any authority in Lebanon and in the region.

This operational, reliable and effective tool called SECAP-SSP includes a specific database for Lebanon and the region to help municipalities calculate baseline emissions and assess the impacts of different SEAP measures. The new tool takes into account most of sectors contributing to the environmental impacts, to study their environmental performance, to succeed by modelling the determination of Optimum Energy Performance / Environmental Benefit / Costs of energy efficiency measures in the various sectors of the municipality. Depending on the magnitude of the contribution of each sector, the municipality will have the choice to decide on the measures to be implemented. A methodology for the elaboration of the “Budget Allocation Chart” is proposed.

This paper presents the results of application of this tool for the development of the SECAP’s of municipalities in Lebanon.

1. Introduction

The growing accumulation of greenhouse gases (GHG) in the atmosphere produced by the use of fossil fuels due to human activities seems to have the pivotal role for the climate change and the pollution that threatens the human health. Climatic changes are estimated to cause over 150,000 deaths annually worldwide [1]. Between the worldwide movements for climate and energy actions, the Covenant of Mayors (COM) is the world's largest for a local sustainable vision. Launched in Europe, the COM aims not only to gather local governments voluntarily committed to achieving and exceeding the EU climate and energy targets but also to support the transition towards sustainable, low-carbon and climate-resilient development in eight South Mediterranean countries through the CES-MED program. The plan will feature a Baseline Emission Inventory (BEI) to track mitigation actions in a Sustainable Energy and Climate Action Plan (SECAP). Several limitations obstruct the establishment of the SECAP with the tools proposed by CES-MED such as the absence of values regarding the emission factors in the baseline carbon footprint specified to each country, the relying on inaccurate data that generated inaccurate
results. Furthermore, the methodology would not allow any authority wishing to join without any technical assistance from CES-MED to identify and determine the performance of each measure clearly listed by its Energy Efficiency priority and its related investment cost [2]. Therefore, a developed tool called SECAP-SSP allowing the South-Mediterranean cities to establish their sustainable energy plans is necessary. It shall include a specific database for the region to calculate the BEI and assess the impacts of the most applicable SEAP measures taking into account all the sectors contributing to the environmental impacts on the territory (buildings, infrastructure, transport, local production of energy / electricity, public market, industries ...), to study their environmental performance to succeed by modelling the determination of Optimum Energy Performance / Environmental Benefit / Costs of energy efficiency measures in the various sectors of the municipality. That tool will give the municipality-user-the choice to decide on the measures to be implemented depending on many criteria. SECAP-SSP is a visual studio 2010 application using ASP.net language with SQL server 2012. This paper is a complete case study of a Lebanese municipality called Hammana. The SEAC was established using SECAP-SSP, and it can be generalised for any other municipality in Lebanon. An additional work will allow that tool to involve all the South-Mediterranean cities.

2. Case study
The Municipality of Hammana is a Lebanese local authority which is located in Baabda District, an administrative division of Mount Lebanon Governorate, about 26km East of Beirut. The municipality is member of Federation of High Metn Municipalities. It lies on an altitude ranging from 800 meters to 1600 meters and the municipal building is 1120 meters above sea level with coordinates (33.8252494, 35.7332926). With 800 inhabitants distributed in 300 households occupied all around the year and 3000 inhabitants over 900 households for summer only. In addition, there are 1500 Syrian refugees who live in the territory in all seasons. The yearly population increase is 2.6% per year. The human activity for the baseline year, chosen 2016, is distributed between electricity consumption, gas for cooking and diesel or wood for space heating for municipal, residential and non-residential buildings, diesel or gasoline consumed for the transportation sector, electricity consumption for the public street lighting and diesel consumption for private and common electrical generators. With a previous experience of hard data collection [3], a new methodology is used in this case study and is explained in the methodology section. As BEI result, SECAP-SSP reported per sectors and sub-sectors a total GHG emissions are of 24566 tCO2-eq per the baseline year with a preponderant contribution from the building sector (55%) followed by the Common Electrical Generators (25%). Expected GHG emissions by 2030 are quantified 29234 tCO2-eq [4]. Similarly, a total energy consumption for the territory is evaluated by 74540 MWh per baseline year. Using SECAP-SSP, an optimisation leads to list a set of measures by priority that, once implemented, will reduce 41.5 % of those emissions by 2030. The whole methodology of calculations, assessment, optimization and evaluation is detailed in this paper.

3. Methodology
3.1. Applying
In the beginning, the user can choose the language (English or French). To be registered, he entered the main ID data of the municipality such as its name, contact person with phone number and email, as well as he has to point for his location so the tool will save the municipality its coordinates (longitude and latitude). A user can apply for once and only but he can modify information as much as he is entering data and did not run the simulation.

3.2. Entering Data
To facilitate entering data, SECAP-SSP requires to print out a survey double A4 sheet available in 3 languages (Arabic, French and English), choose a sample of residential and tertiary buildings to distribute it to their owners. Noting that the sample must represent all types of buildings (Residential
RB: villas, apartments, small and medium houses….; Tertiary TB: all kinds of shops, restaurants, hotels, offices, hospitals, church, mosques, logistics warehouses, gas stations, schools…). That survey must be filled also for all the municipal buildings MB and public lighting PLB. Those data covers all the types of human energy activities such as national grid electrical consumption, private and common electrical generators supply, green electricity production or purchase, cooking, heating/cooling, water heaters, transportations, household waste and garden waste. Furthermore, this survey will give an idea about the awareness level of the citizens. From the other side, once SECAP-SSP points the location of the municipality, it identifies all related climate data and renewable energy potential due to the existing files linked to the tool referring to the Lebanese Agricultural Research Institute (LARI) [5]. Covering all inventory categories, sectors and sub-sectors, the user will accomplish his job by simply pushing on the run button.

3.3. Simulating

The simulating run button is the only way to consider all the data entered by the user as saved and unchangeable. SECAP-SSP will calculate immediately the municipality overall energy consumption for the baseline year chosen and so the amount of CO2 emissions resulting from the human activity occurring in the territory of the local authority by multiplying the conversion factor with corresponding activity data. The conversion factors are already existed as specific fixed data in the tool and can only be change by the administrator. Calculating all these values will able the tool to post on the SECAP report all the output tables recommended as well as to fill the BEI which is the instrument allowing the local authority to quantify its existing situation in the beginning (baseline year) and then to measure the impact of its actions related to climate change.

The magnitude of the contribution of each sector (generating the greatest energy consumption and the largest emissions) will be directly shown in graphs, and will show the main sectors where action should be focused and in which projects that reduce emissions should be developed. Specific indicators will guide the simulation to list a set of sustainable actions that the municipality should implement to succeed in reducing the 40%, at least, of GHG emissions by 2030.

SECAP-SSP includes a large number of sustainable actions for mitigation, climate adaptation and renewable energy production. Each action was studied and it has its number code, title, description, concerned sector, type of intervention, main objectives, economic indicators (estimated cost, lifetime, discounted payback period, project profitability…), environmental indicators (Estimated saved energy, renewable energy produced, estimated reduced emissions …), potential indicators, duration of implementation and stakeholders. This tool will identify the priority energy efficiency measures, determine the performance of each measure and the investment costs by a simple usage. This modelling will determine the Optimum Energy Performance / Environmental Benefit / Costs of energy efficiency measures. A "Budget Allocation Chart" is elaborated. The municipality will have the choice to decide on the measures to be implemented and on the criteria to be chosen for optimization. Otherwise, a list of actions will be given by priority.

3.4. Resulting

As result, a template of SECAP report will be immediately filled by SECAP-SSP for this particular case study, as well as the BEI and the SECAP official template of the COM will be filled. Then, a complete folder can be uploaded online by the municipality on the COM website https://www.eumayors.eu after joining as a signatory. Once approved and granted, the actions can be implemented.

4. Case Study Results with SECAP-SSP application

A case study applied as a first member in SECAP-SSP will allow an impartial evaluation of this tool and will show its gaps, weakness and even errors, as well as it will highlight on the advantages that offers SECAP-SSP.
4.1. Applying
As mentioned before, Hammana is the municipality first member that applied to SECAP-SSP. Applying requires main information as authority name, contact person with phone number and email address and a simple sharing for its location will give the coordinates of the municipality on the world map.

4.2. Entering Data
A survey sheet was distributed arbitrarily to a sample of 21 residential buildings. The residential building sample represents 7% of the population of households (300 houses) that are inhabited during the whole year (summer + winter), 2.33% of the population of households (900 houses) that are inhabited during the summer only. As for the tertiary sample, it represents 5.5% from the existing buildings. This statistic will give an approximately representation of the real case study.

While for the municipal buildings, the survey must be filled for all the buildings owned by the municipality. In this case study, the buildings are: the main municipal building, the public garden, the public library, the waste water treatment plant, the potable water purification plant, a building consisting of 3 schools (elementary, secondary and technical institute), sporting centre and 2 storage warehouses. Electricity consumption from the national grid (MWh/month), the backup generators (private or common), the green local generation or the purchased (not available in this case), was collected with the top-bottom method by referring to the main generation supply sources of the municipality. Noting that in case of unavailability of such data, the bottom-top collection method from the onsite statistics will give approximately the closest estimation to the real values. Kitchen gas consumption, heating and water heating are collected from this survey as well as the street lighting, the waste generation, the transportation consumption, agriculture, forestry and other activities on the territory. All these data represent the overall authority energy consumption per baseline year. The conversion factors inserted in this tool are considered suitable for Lebanon referring to the ministry of environment and to the Lebanese Association for Energy Saving and for Environment ALMEE. As for the other applicable countries, another set of conversion factors must be adopted.

4.3. Simulating
The magnitude of the contribution of each sector (generating the greatest energy consumption and the largest emissions) is automatically generated after running the simulation and calculating the BEI and gives the chart of contribution. A set of actions will be given from an existing list of measures according to the criteria selected. The economic criteria enable cities to showcase the cost-effectiveness of their good practices through a number of useful indicators that include the present value of financial savings $E_{ci}(1)$ ($/kWh saved or produced), the net present value of investment $E_{ci}(2)$ ($/action$), the discounted payback period $E_{ci}(3)$ (year) and the annual return on investment over the years $E_{ci}(4)$ (>10% to be profitable), noting that $E_{ci}$ is the abbreviation of Economic Indicator. The environmental criteria are the CO2 reduction of 1 kWh saved or produced $E_{ni}(1)$ (kgCO2-eq/kWh saved or produced) and the CO2 reduction of 1 $S$ invested $E_{ni}(2)$ (kgCO2-eq/$S$), noting that $E_{ni}$ is the abbreviation of Environmental Indicator. The territory potential is the third criteria that counts on the mitigation potential (MWh that could be saved/action) and the renewable resources valid in the territory (MWh that could be produced/action). A sample of 10 actions almost covering all sectors is listed in the table 1 and their indicators are listed in table 2. Knowing the approximate costs (investment and maintenance expenses) of each measure and its discounted cash flow as well as the cost of 1 kWh saved or produced all over the lifetime of the project, allows us to make informed decisions and choices that will lead to sustainable mission and financial success. A simple selection for one of these criteria by the user will allow the tool to go to the chosen column of that table and to announce the set of these actions by priority with a Budget Allocation Chart. If the end user chooses a default optimisation (over all indicators), it will give the action having the indicators descending to the last. SECAP-SSP will post in our sample the table 3 as well as its Budget Allocation Chart as shown in the figure 1. With this simple method the municipality will have a budget idea about the actions that could be implemented by ascending cost as well as its carbon footprint reduction relatively to the amount of energy savings per action.
Table 1. List of actions suggested by SECAP-SSP with the corresponding potential.

| Title                                                      | Sector       | Type of Intervention | Potential saved or produced [MWh/year] |
|------------------------------------------------------------|--------------|----------------------|----------------------------------------|
| Improvement of the building envelope                       | RB,TB,MB     | EE                   | 2623.5                                 |
| Replacement of Sodium bulbs by LED                         | RB,TB,MB     | EE                   | 3631.3                                 |
| More efficient heating system                              | RB,TB,MB     | EE                   | 4212.9                                 |
| Solar heaters                                              | RB,TB,MB     | RE                   | 9669.1                                 |
| Intelligent street lighting                                | PLB          | EE                   | 2960.2                                 |
| PV per household                                           | RB,TB,MB     | RE                   | 10085.3                                |
| Solar streetlight                                          | PLB          | RE                   | 7365.5                                 |
| PV Plant                                                   | RB,TB,MB,PLB | RE                   | 5180.9                                 |
| Solar streetlight                                          | PLB          | RE                   | 533                                    |
| Water treatment plant supplied by solar PV instead of private electric generators | MB           | RE                   | 212.8                                  |

Table 2. List of indicators calculated by SECAP-SSP for the actions suggested.

| Title                                                      | Ecl (1): [$/kWh saved or produced per year] | Ecl (2): [$/action] | Ecl (3): [%] | Ecl (4): [kgCO2-eq/kWh saved or produced] | Enl (1): [kgCO2-eq$/kWh saved or produced] | Enl (2): [kgCO2-eq$/] |
|------------------------------------------------------------|---------------------------------------------|---------------------|-------------|---------------------------------------------|---------------------------------------------|---------------------|
| Improvement of the building envelope                       | 0.014                                       | 822980              | 5.90        | 24.50%                                      | 0.2775                                       | 20                  |
| Replacement of Sodium bulbs by LED                         | 0.0152                                      | 339690              | 2.00        | 60.00%                                      | 0.247                                        | 17                  |
| More efficient heating system                              | 0.0148                                      | 1399625             | 7.10        | 21.40%                                      | 0.1329                                       | 9                   |
| Solar heaters                                              | 0.0157                                      | 1216404             | 5.00        | 27.90%                                      | 0.1774                                       | 12                  |
| Intelligent street lighting                                | 0.0534                                      | 997800              | 12.08       | 17.80%                                      | 0.2529                                       | 5                   |
| PV per household                                           | 0.1483                                      | 5054000             | 12          | 14.20%                                      | 0.3208                                       | 3                   |
| Solar streetlight                                          | 0.0892                                      | 2494500             | 10          | 16.00%                                      | 0.2538                                       | 3                   |
| PV Plant                                                   | 0.1484                                      | 3168000             | 11          | 16.40%                                      | 0.4218                                       | 3                   |
| Public Pool solar heating                                  | 0.0084                                      | 819000              | 3.55        | 36.00%                                      | 0.2777                                       | 3                   |
| Water treatment plant supplied by solar PV instead of private electric generators | 0.1228                                      | 90000               | 7           | 19.20%                                      | 0.341                                        | 3                   |

Table 3. Actions listed by priority for a default optimisation.

| Actions                                                   |
|-----------------------------------------------------------|
| 1 Public Pool solar heating- SBEMP1                       |
| 2 Replacement of Sodium bulbs by LED- SBEM1               |
| 3 Solar heaters- SBEM3                                     |
| 4 Improvement of the building envelope- SBE1              |
| 5 More efficient heating system- SBEM2                    |
| 6 Water treatment plant supplied by solar PV instead of private electric generators- SBGE7 |
| 7 PV per household- SBGE2                                 |
| 8 Solar streetlight-SBGE3                                 |
| 9 Intelligent street lighting-SBEM5                       |
| 10 PV Plant- SBGE5                                        |
5. Evaluation of SECAP-SSP
SECAP-SSP is such a simple tool developed by the team concerted in this paper and it can be used by any person chosen by the municipality willing to establish their SECAP without any previous acknowledgement in such field. It elaborates a complete study of a municipality SECAP from the data entering, to the simulation till the reporting. SECAP-SSP is a multiple language program (English and French), its technical words are translated to Arabic and all the application’s buttons are explicated in a popup window. It is able to be updated with new actions and measures as well as with local energy pricing. SECAP-SSP is an innovative tool that rounds up all indicators leading to an unprecedented optimization while covering environmental, economic and territory potential at the same time. Moreover, it will reduce the charge costed by COM service offices that had the task to formulate and implement more sustainable local policies.

6. Conclusion and recommendations
SECAP-SSP is a capable to determine the carbon footprint of any authority in Lebanon and to elaborate the most suitable policy to reduce it. Depending on the municipality vision and its priorities, the end user of SECAP-SSP can select first the criteria. If pointed on economic priority, the pricing or the investment may represent the most important challenge as well as the return on investment. If pointed on the environmental priority, it will be clear that the territory is facing a high level of pollution. If the pointed on optimizing by default, the tool will list the actions after optimizing referring to indicators. More specific database shall be collected to extend this tool to cover all the region of CES-MED. Moreover, some of the specific data that are not fixed shall be entered in a way to be updated automatically with every changes in values. In addition, a regulation study must be done for the region to evaluate the existing environmental protection laws and energy conservation laws at both local and national levels to develop an overall regulation that supports the SECAP implementation.

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