



# ENERGY BALANCE ASSESSMENT TOOL (EBAT):

## User introduction

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1	R Pheasant	Draft	December 2014
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## INTRODUCTION

The Energy Balance Assessment Tool (EBAT) was developed to provide policy makers and those providing water and wastewater services with a means of identifying where within the urban water cycle potential energy savings or opportunities for recovery exist. Microsoft Excel was chosen as the medium to support EBAT as it is the spreadsheet application common to the European Computer Driving License (ECDL) and therefore applicable across all EU member states. The rationale underpinning the development of the model was that it should be able to track water from the point of abstraction to the point at which it is returned to the natural environment. Specifically it was to include: energy and volumetric measures for abstraction, treatment, supply, use in Domestic Hot Water (DHW), pumping within the sewer system and wastewater treatment. The driving philosophy behind the design of the tool was that it should be simple to use, allow for user input variables to be entered, and show annual results for energy used and associated emissions produced, expressed as a measure of equivalent carbon dioxide (CO<sub>2e</sub>), for a specified catchment size.

The purpose of this document is to introduce the user to the main features of EBAT and to provide an overview of the user input parameters and their relationship with the results shown. For simplicity it follows the seven headings used on the Front Page tab of the spreadsheet that allow user selected input values or choices, to be entered. **THIS IS NOT A CARBON OR ENERGY REPORTING TOOL**

### 1. Control Parameters:

1.1 Row 27 allows the user to select, from a drop down list, the country that they want to use within the model. The list includes each of the partner States contributing to the INNERS project and links to the values contained on the hidden Country-Specific data tab. Additional countries could be added to the model as relevant national data becomes available.

### 2. Supply:

2.1 Row 30 allows the user to input the known or estimated percentage for the amount of potable water leaked from the supply system prior to delivery. This water has already used energy within the abstraction, treatment and supply process and therefore has an associated CO<sub>2e</sub> value.

2.2 Row 31 allows the user to input the average depth from which groundwater is abstracted and in Row 32 the percentage of groundwater being sourced can also be entered.

2.3 Row 33 allows the user to select the percentage of energy used in pumping within the whole of the supply process (abstraction to the point of delivery) and Row 34 uses this value to calculate the energy used in treating 'raw water'. The model's default position is to use a 60:40 pumping to treatment ratio as this is the most commonly given relationship within the literature. However, it has not been hard coded into the model as there is an acknowledgement that all catchments differ in their size, geographic characteristics and groundwater to surface water abstraction ratios.

2.4 Row 35 enables the user to input known values for renewable energy that is generated and used on-site. This value is then used to calculate the CO<sub>2e</sub> emissions resulting from the supply of potable water. Only energy generated on-site should be entered into row 35, as energy provided under a 'certified green tariff' is not permitted within carbon reporting by some EU Governments.

### 3. Households:

- 3.1 Rows 38 and 39 allow the user to input known or estimated temperature values for potable water entering a domestic property and for hot water used in the home for example: directly from the tap, in the shower or within a washing machine. The calculations within EBAT do not include the heating of water for space heating. The input values in particular are subject to regional and national variations. The temperature range identified by these user selected input values (or the default values) typically have the largest energy usage and CO<sub>2</sub>e emissions of the whole of the urban water cycle. Therefore, on the Results Summary tab graphs are shown that separate the results for DHW from other information, to enable the results for the services provided by the water industry to be viewed independently of DHW energy demands, that water utilities have no, or only limited influence over.
- 3.2 Row 40 allows the user to input a known or estimated value in litres, for the volume of potable water that is produced to meet the daily requirements of one individual in litres/person/day. The default value uses established per capita values for potable water consumption obtained from national statistics and the known or estimated leakage rates, to determine the volume required to meet the per capita potable water demands.
- 3.3 Row 41 allows the user to input known per-household occupancy values. These are obtainable from national and EU statistics.
- 3.4 Row 42 allows the user to input known or estimated percentages for the amount of supplied potable water that is not returned to sewer. This allows for the fact that some of the water supplied evaporates or is returned to the natural water cycle without directly entering the sewer system via household drains. Examples of where this may occur include when water is used for gardening which then permeates through the soil, or when water is drunk and a proportion of this is perspired and then evaporates.
- 3.5 Row 43 allows for the amount of rainfall and associated run-off into the sewer system. In this case the sewer system is assumed to be combined. Within the model this is input as a per-capita value in millilitres. These values can be obtained from regional or national sources or simply determined as part of a volumetric mass balance, i.e. the known volume of water reaching the treatment plant minus the known volume input from domestic and industrial sources, divided by the number of people in the catchment. This type of input represents rainfall runoff contribution to a combined sewer that discharges to the WwTP.
- 3.6 Row 44 is not operator selectable as it shows the calculated value for domestic wastewater entering the sewer. This is calculated using the volume of potable water produced, the number of inhabitants per household, the proportion of domestic water not returned to the sewer and the percentage of potable water that is leaked prior to supply to households.
- 3.7 Row 45 allows the user to input a known or estimated value for daily household usage of DHW. This can be obtained from national statistics or studies. The default value has been taken from the UK Energy Savings Trust and is set at 122 litres per household per day.
- 3.8 Row 46 allows the user to input a known or estimated per-capita value for domestic COD (Chemical Oxygen Demand). Although COD is the measure presented, the metric could be changed to Biological Oxygen Demand (BOD) provided that the known energy use per kg of BOD eliminated was entered in place of the COD elimination figures in the hidden Country-Specific data tab. Furthermore despite the fact that the input parameter is in grams per person per day (i.e. per-capita values) these can, if required, deviate from established Population Equivalent (PE) values such as the 60g/person/day listed in the Waste Water Treatment Directive. The current default

position is to use a mean per-capita value of 120g (COD) which has been obtained from the INNERS Benchmark study.

- 3.9 Row 47 is not operator selectable as it shows the national values for COD elimination (kWh/kg). These are stored on the hidden Country-Specific data tab and were taken from the INNERS Benchmark study.
- 3.10 Row 48 allows the user to input a known or estimated value for the number of households being serviced within the catchment.

#### **4. Industry:**

- 4.1 Row 51 allows the user to enter a known value for the average volume (m<sup>3</sup>/day) of industrial effluent being discharged to the sewer and Row 52 enables the user to input the known amount of industrial COD (kg/day) entering the system. These values should relate to industrial trade effluent consents and known or estimated volumes of wastewater entering a wastewater treatment plant by other means, for example unauthorised discharges or wastewater being brought in my tanker.

#### **5. Treatment:**

- 5.1 Row 55 allows the user to enter a known value for the Wastewater Treatment Plant's COD (or as stated above this could be changed to BOD) discharge consent limit. This will vary depending on the sensitivity of the receiving waters.
- 5.2 Row 56 allows the user to set a known or estimated value for the percentage of energy used in the transport and treatment of wastewater which is used specifically for 'pumping' wastewater within the sewer system. The remaining percentage of energy used in the management of wastewater is considered to fall under the heading of 'treatment', despite additional pumping actually taking place at the WwTP. EBAT's default position is to use a 20:80 pumping to treatment ratio, however, EBAT has been developed in the knowledge that no two catchments are the same so row 69 enables the user to alter this default pumping to treatment ratio. Row 57 uses the value from row 56 to calculate the proportion of energy used in the treatment process.
- 5.3 Row 58 enables the user to input a known value for the percentage of renewable energy that is generated and used on-site. This value is then deducted from the total CO<sub>2</sub>e emissions shown in the results section for pumping and treatment. Only energy that is generated and used on-site should be entered in row 58 as energy provided under a 'certified green tariff' is not permitted within carbon reporting by some EU Governments.

#### **6. Equipment Performance:**

- 6.1 Rows 61 – 65 allow the user to enter known or estimated values (percentages) that relate to the performance of various systems or processes. The default position is that all systems are performing in line with the average efficiency of these systems or processes and so a performance factor of 100% is the default value entry. However, if a system is known to be consuming half of the average amount of energy for this system, as given in the Benchmark study or process then 50% should be entered and where it is known to be using 50% more energy for example, 150% should be entered.

#### **7. Results**

The results are contained in Rows 68 -98 and are shown in the order that they are input, i.e. from water abstraction to discharge back into the natural water cycle.

- 7.1 Rows 68 and 70 show the combined energy demands for abstraction, treatment and pumping of potable water supplied to households and potable water that is leaked prior to supply, using figures from the hidden 'Calculations' tab. Row 72 combines the total of these energy demands.
- 7.2 Row 74 lifts the result of the calculation shown in row 106 on the hidden 'Calculations' tab, which uses the volume and input and output temperature range of Domestic Hot Water used per household, to determine the associated annual energy demands for heating of DHW for the catchment.
- 7.3 Row 76 lifts the result from row 76 in the hidden 'Calculations' tab, which uses the volume of rainwater received by combined sewers, and the proportion of the energy demands of wastewater pumping versus treatment, as shown in row 56 of the 'Front Sheet'. This shows the estimated energy demands of pumping rainwater within the sewer system.
- 7.4 Row 78 shows the energy demands of pumping domestic wastewater, based on a ratio defined in row 56 of the 'Front Sheet' for pumping and treatment. The volume of rainwater received by combined sewers is incorporated in the calculations for the energy demands of the treatment of domestic wastewater. This is based upon the amount of COD that needs to be eliminated from the combined domestic wastewater and rainwater to meet the discharge consent.
- 7.5 Row 80 shows the energy demands of removing sufficient COD from the domestic wastewater to meet the discharge consent. Again this is based on the ratio of pumping to treatment of wastewater with the proportion required for treatment shown in row 56 of the 'Front Sheet'.
- 7.6 Rows 82 and 84 present similar calculations for the pumping and treatment of industrial wastewater using this same ratio.
- 7.7 The energy demands for pumping and treatment of domestic wastewater and industrial wastewater have been presented separately to allow the user more visibility within this model of where energy demands occur. However, in practice the energy demands of domestic wastewater and industrial wastewater cannot be separated as it is possible that one wastewater input could dilute the COD of the combined wastewater, meaning that less COD needs to be removed to meet the discharge consent. As such row 86 presents a figure that enables an adjustment to be applied for any such dilution of wastewater. This is then incorporated in row 88 (which shows the total energy demands for pumping and treatment of all wastewater including rainwater).
- 7.8 Row 90 gives the combined total of rows 72, 74 and 88. Row 92 shows the combined total of rows 72 and 88 (i.e. this excludes the energy demands of heating Domestic Hot Water).
- 7.9 Rows 94, 96 and 98 show the breakdown of energy demands in kWh per m<sup>3</sup> for the whole of the urban water cycle.

## Limitations

This model is based on known values and assumptions that have been taken from an extensive range of academic, industry and government literature, including the INNERS Benchmarking study, and from experts within the INNERS team. Following recommendations from both internal and external partners it was agreed that COD eliminated would be a more robust measure of the energy consumed during wastewater treatment operations, than a purely volumetric measure of kWh/m<sup>3</sup>. The decision was also taken that the model should include domestic (residential) and industrial volumes of COD plus the volume of rainfall infiltration to combined sewers, and that the energy required to eliminate the COD of these combined volumes should be based upon the WwTP's legal limits for returning water to a receiving watercourse.

Another limitation of EBAT is the assumption that rainwater infiltration to combined sewers will have no implications on the energy demands of wastewater 'treatment' over and above pumping. However, it is possible that this may not be the case if the rainwater is polluted on route to the sewer.