# Indicators to derive from OSeMBE results for the REEEMgame

## List of abbreviations

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| --- | --- |
| **Abbreviation** | **Explanation** |
| *Subscript* d | Indicates OSeMBE input data |
| *Subscript* r | Indicates OSeMBE results |
| e | Emission type (e.g. CO2, NOx etc.) |
| m | Mode of operation (every technology in OSeMOSYS can work in more than one way) |
| t | Technology type (e.g. NGCC, Wind turbine, etc.) |
| y | Year |

We decided to display three main indicators (though still open to your inputs on the matter):

* CO2 emission intensity (by population): it acts as an **environmental indicator**; the intensity is represented per citizen, as it is not possible to represent it per GDP. In different scenarios, the GDP would be arguably different and would need to be calculated. This is out of the scope of OSeMOSYS models;
* Investment intensity (by population): it acts as an economic indicator; the intensity is represented per citizen for the same reasons as above;
* Average LCOE of the electricity mix: it acts as a sort of socio-economic indicator, where the LCOE can also give a proxy of the electricity costs and prices (tariff policy, subsidies etc. excluded). For the minute, there are no proper social indicators retrievable from OSeMBE.

The required calculations are described below.

## CO2 intensity per citizen

For Europe:

**With** : ‘In’ AS data, version=’DataV1’

In the above formula the CO2 emission are retrievable from the OseMBE results from the REEEMdb. I tried to indicate how to request them for the entire modelled region. However, the year and the pathway vary of course. Concerning the population, I sent a put an email to Roland. They should have the population in NEWAGE. By replacing changing ‘EU+CH+NO’ by a country and the population this formula can be used to calculate the CO2 intensity for a country. Since the ‘DataV2’ is just under way for now we need to test with version=’DataV1’.

The calculation needed to determine the CO2 emissions per capita in a country is indicated above. It needs to be noted that the AnnualTechnologyEmission are indicated by technology (t) and emission (e) in the OSeMOSYS results files. Therefore, the country would need to be determined. This can be done relatively easy, since the first two letters of the technology name indicate the country, e.g. in this technology name ATBF00I00 the first two letters indicate that the technology is part of the Austrian energy system. For all country codes see also the annex of this document. Furthermore, OSeMOSYS models do not contain the population of a country or modelled region. Therefore, it would be necessary to derive the population of all 30 countries per year. Other models in REEEM should contain this information.

## Discounted Investment per citizen

With:

* CapitalCost: ‘In’ AS data, ID: 69-135, region: should be calculated for each country, year: ‘XXXX’, pathway: ’CXTXEX’
* NewCapacity: ‘Out’ AS data, ID: 243-294 (the IDs in the EU sheet are currently lower by one, still in exchange with Ludwig for fixing this. Will let you know once I upload the data of the new runs)
* DiscountRate: ‘In’ AS data, ID: 136, region: ‘EU+CH+NO’

To derive the Discounted Investment per Capita per year information from several sources needs to be used. The CapitalCost can be derived from the OSeMBE input data by technology and year. As described already above, also in this case the country is not indicated but needs to be derived from the initial two letters of the technology names. The NewCapacity per technology and year needs to be multiplied to derive the undiscounted investment costs. The NewCapacity can be found in the results files. To get the discounted investment the result of the previous calculation needs to be divided by the discount factor which is: . The DiscountRate can be taken from the OSeMBE input, anyhow it is for the entire mode 0.05. Finally, all is divided by the number of citizens in the contemplated country, which needs to be taken from another REEEM model.

## Levelized Cost of Electricity (per country, resulting from the installed and used technologies)

The calculation of the Levelized Cost of Electricity is the most sophisticated one of the three suggested indicators. Therefore, the calculation is split into several formulas (marked in bold characters below).

**Capital Recovery Factor (CRF)**:

**With:**

* DiscountRate: ‘In’ AS data, version=’DataV1’, ID=136, region=’EU+CH+NO’, year=’2015’ (current year could be used since indicated for all years, but constant), NB: the discount rate is only indicated in the region ‘EU+CH+NO’
* OperationalLife: ‘In’ AS data, version=’DataV1’, region= selected country, the operational life is only indicated per country, ID = from 338 to 404, the countries do not have all the same technologies available, therefore not all the operational life times are indicated in each country, year = the operational life is indicated per year, but is always constant

The capital recovery factor is the ratio of a constant annuity to the present value or receiving that annuity for a given length of time. The length of time is in our case the OperationalLife time of the power plant, which is available in the data files. The DiscountRate is available in the data files as well.

**Capital Investment (CI)**:

With:

* CapitalCost: ‘In’ AS data, ID: 69-135, region: should be calculated for each country, year: ‘XXXX’, pathway: ’CXTXEX’
* NewCapacity: ‘Out’ AS data, ID: 243-294 (the IDs in the EU sheet in ‘DataV1’ are lower by one, however for the new runs I will correct that)

The CapitalInvestment is calculated by multiplying the CapitalCost – available in the input data file – by the NewCapacity of the technology – available in the results file.

**Annualized Investment Cost (AIC)**:

The Annualized Investment Cost indicates the annual investment cost when spreading the Capital Cost over the life time of the respective technology.

**Annual Fixed Operating Cost (AFOC)**:

With:

* Installed Capacities Public and Industrial Power and CHP Plants by Fuel and Technology: ‘Out’ AS data, ID: 24-75, region: per country/region, year: per year, pathway: per pathway
* FixedCost: ‘In’ AS data, ID: 271-337, region: per country (not given in ‘EU+CH+NO’), year: per year, pathway: per pathway

The Annual Fixed Operating Cost is calculated by multiplying the capacity of a technology that is installed per year (result) with the fixed cost of the technology (data). Building the sum over all technologies gives the Annual Fixed Operating Cost of the entire country.

**Annual Variable Operating Cost (AVOC):**

With:

NB: The variable cost of the fuels are reported to the db in a different unit than the variable cost of the power plants. Therefore, please note that these have a conversion factor (277.778) and the fuel cost not.

* Electricity Production from Public and Industrial Power and CHP Plants by Fuel and Technology: ‘Out’ AS data, ID: 76-127, region: per country, year: per year, pathway: per pathway
* VariableCost: ‘In’ AS data, ID: 674-740, region: per country (not given in ‘EU+CH+NO’), year: per year, pathway: per pathway
* Fuel Input to Public and Industrial Power and CHP Plants by Fuel and Technology: ‘Out’ AS data, ID: 128-179, region: per country, year: per year, pathway: per pathway

The Annual Variable Operating Cost is calculated by multiplying the capacity of a technology that is installed per year (result) with the RateOfActivity (result) and the variable cost of the technology (data). Building the sum over all technologies gives the Annual Variable Operating Cost of the entire country.

**Domestic Production of Electricity (DP)**:

With:

* Specified annual demand: ‘In’ AS data, ID: 472, region: per country, year: per year, pathway: per pathway
* Total net Imports: ‘Out’ AS data, ID: 210, region: per country, year: per year, pathway: per pathway

**Levelized Cost of domestic Electricity**:

The LCodE needs to be calculated for all countries to be able to proceed.

**Levelized Cost of Electricity:**

With:

* SpecifiedAnnualDemand: ‘In’ AS data, ID: 472, region: selected country, year: per year, pathway: per pathway
* Electricity Exchange – Net Imports (x,y): ‘Out’ AS data, ID: 180-209,

## Annex

### List of abbreviations

|  |  |
| --- | --- |
| **Country code** | **Country name** |
| AT | Austria |
| BE | Belgium |
| BG | Bulgaria |
| CH | Switzerland |
| CY | Cyprus |
| CZ | Czech Republic |
| DE | Germany |
| DK | Denmark |
| EE | Estonia |
| ES | Spain |
| FI | Finland |
| FR | France |
| GR | Greece |
| HR | Croatia |
| HU | Hungary |
| IE | Ireland |
| IT | Italy |
| LT | Lithuania |
| LU | Luxembourg |
| LV | Latvia |
| MT | Malta |
| NL | Netherlands |
| NO | Norway |
| PL | Poland |
| PT | Portugal |
| RO | Romania |
| SE | Sweden |
| SI | Slovenia |
| SK | Slovakia |
| UK | United Kingdom |