

Practical Guidance of  
*Estimation Tool of Environmental Burden from Palm Oil Production Process*  
(Version 1.0)

March 2014

## **What is Environmental burden estimation tool?**

### <Objective>

Estimate environmental burden from Palm oil production by focusing three process (CPO production, waste water treatment, and solid waste management). And evaluate the effect of installing waste water treatment /Solid waste management option.

### <System Boundary>

“CPO production  
process” “Waste water  
treatment” “Solid waste  
management”

### < System format >

Microsoft Excel

### <Intended Environmental burden>

- Global warming
- Acidification
- Eutrophication

### < Future applications>

This tool will make a use for...

- Estimating an Inventory of Emission sources
- Supporting for making an action plan for climate change mitigation and other environmental burdens control.

### **Composition of the worksheets**

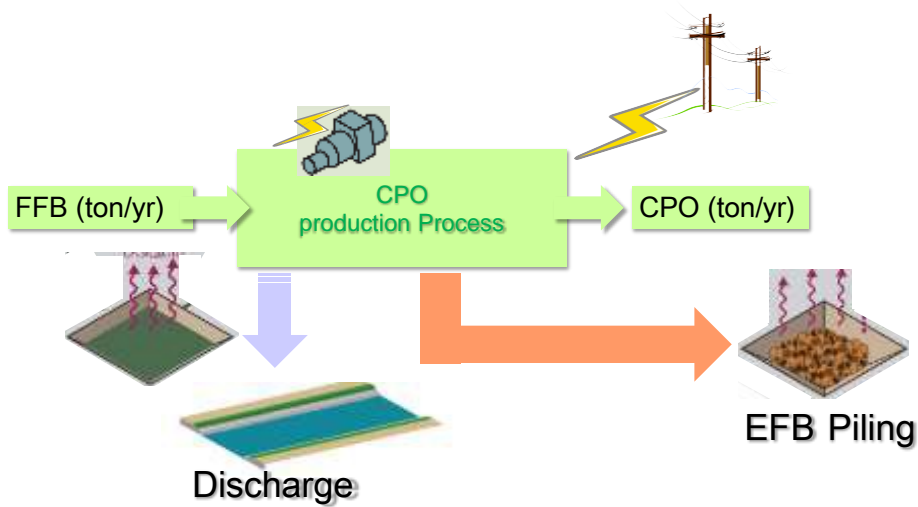
This tool has 7 (seven) tools in order to show the result of estimation by using input data that user may enter to the sheet.

| <b>Sheet Name</b>     | <b>functions</b>  |
|-----------------------|---|
| Questionnaire         | The user shall enter the actual data of its production process to this sheet.   |
| Data                  | Summarize all the information/data that is entered in “Questionnaire” sheet in order to use them in the “Cal” sheet.                |
| Cal                   | Calculate the environmental burden of each process by using the data of “Data” sheet and fixed value in “Default” sheet.            |
| Results               | Show us the estimation result quantitatively. Value results of the environmental burden are automatically created.                  |
| Results of fertilizer | Show us the estimation results of GHG emission reduction by substitution of chemical fertilizer. Results are automatically created. |
| Graphs                | Show us the estimation result visually. Graphs of the environmental burden are automatically created.                               |
| Default               | Provides fixed data necessary for Estimation of emissions, etc.   |

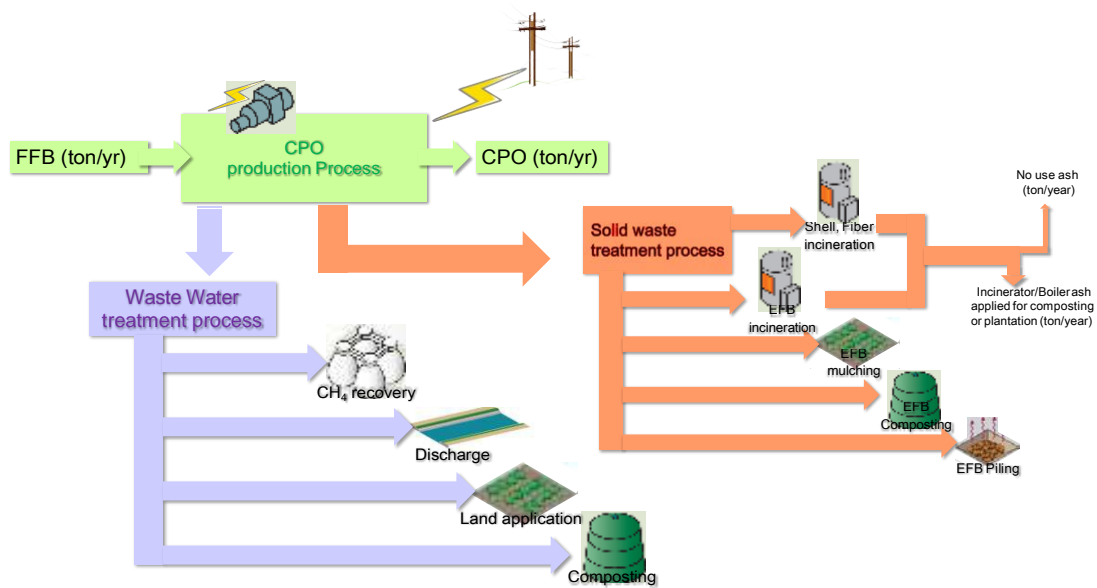
**Estimation Scenarios**

This tool compare two scenarios, “NO TREATMENT process” and “ACTUAL process”. No treatment process has no treatment options/methods. Hence, all the waste waters would not be treated at all and be discharged into water body without treatment. Besides, all the solid wastes were piled up in untidy heaps without treatment.

<No TREATMENT process>



<ACTUAL process>



Ex) Comparison of two scenario in “Data” sheet

| Ringkasan data terinput untuk inventory analysis dan uji dampak       |                      |              |           |
|---|----------------------|--------------|-----------|
| <b>Proses produksi minyak CPO</b>                                     |                      |              |           |
|   | Unit                 | No treatment | Actual    |
| Input tandan buah segar (TBS)   | tonnes/year          | 250,231      | 250,231   |
| Penggunaan minyak solar   | kL/year              | 92.59        | 150.137   |
| Penggunaan batu bara  | tonnes/year          | 0            | 0         |
| Penggunaan listrik (dari grid)  | kWh/year             | 8,337,696.92 | 0         |
| Penggunaan listrik (dari boiler)                                      | kWh/year             |              | 4,512,364 |
| Produksi CPO  | tonnes/year          | 38,193       | 38,193    |
| <b>Pengolahan limbah cair</b>   |                      |              |           |
|   | Unit                 | No treatment | Actual    |
| Jumlah POME ke kolam (lagoon)   | m <sup>3</sup> /year | 150,139      | 119,430   |
| Konsentrasi COD pada POME ke kolam (lagoon)                           | g/m <sup>3</sup>     | 50,000       | 50,000    |
| Jumlah POME pada inlet sistem pengolahan limbah cair                  | m <sup>3</sup> /year | 150,139      | 119,430   |
| Konsentrasi COD pada POME di inlet sistem pengolahan limbah cair      | g/m <sup>3</sup>     | 0            | 50,000    |
| Penggunaan listrik (dari grid)  | kWh/year             | 0            | 0         |
| Jumlah biogas yang tertangkap   | m <sup>3</sup> /year | 0            | 0         |
| Listrik yang dijual (ke grid)   | kWh/year             | 0            | 263,746   |
| POME yang dialirkan ke badan air (setelah pengolahan)                 | m <sup>3</sup> /year | 180,166      | 0         |
| POME untuk land application   | m <sup>3</sup> /year | 0            | 103,250   |
| POME untuk pengomposan  | m <sup>3</sup> /year | 0            | 77,689    |
| Konsentrasi COD pada POME untuk land application (setelah pengolahan) | g/m <sup>3</sup>     | 0            | 5,000     |
| Konsentrasi COD pada POME untuk dialirkan (setelah pengolahan)        | g/m <sup>3</sup>     | 5,000        | 150       |
| Konsentrasi N pada POME untuk land application (setelah pengolahan)   | g-N/m <sup>3</sup>   | 0            | 387.5     |
| Konsentrasi P pada POME untuk land application (setelah pengolahan)   | g-P/m <sup>3</sup>   | 0            | 73.5      |
| Konsentrasi N pada POME untuk dialirkan (setelah pengolahan)          | g-N/m <sup>3</sup>   | 387.5        | 450       |
| Konsentrasi P pada POME untuk dialirkan (setelah pengolahan)          | g-P/m <sup>3</sup>   | 73.5         | 70        |
| <b>Pengolahan limbah padat</b>  |                      |              |           |
|   | Unit                 | No treatment | Actual    |
| <b>Tandan kosong sawit (EFB)</b>                                      |                      |              |           |
| Pembakaran (incineration)   | tonnes/year          | 0            | 0         |
| Mulching  | tonnes/year          | 0            | 320       |
| Untuk bahan bakar boiler  | tonnes/year          | 0            | 0         |
| Pengomposan (open wind row)   | tonnes/year          | 0            | 32,148    |
| Pengomposan (close system)  | tonnes/year          | 0            | 0         |
| Pengomposan (mature)  | tonnes/year          | 0            | 0         |
| Penumpukan (piling)   | tonnes/year          | 52,549       | 0         |
| <b>Cangkang (shell)</b>   |                      |              |           |
| Disimpan untuk kemudian dijual ke pihak lain                          | tonnes/year          | 15,014       | 3,177     |
| Untuk bahan bakar boiler  | tonnes/year          |              | 10,586    |
| <b>Sabut (fiber)</b>  |                      |              |           |
| Disimpan untuk kemudian dijual ke pihak lain                          | tonnes/year          | 32,530       | 0         |
| Untuk bahan bakar boiler  | tonnes/year          |              | 32,530    |
| <b>Gas buang pembakaran (incinerator)</b>                             |                      |              |           |
| Laju gas buang  | m <sup>3</sup> /sec  | 0            | 0         |
| Konsentrasi NOx   | g/m <sup>3</sup>     | 0            | 70        |
| Konsentrasi SOx   | g/m <sup>3</sup>     | 0            | 1         |
| <b>Gas buang boiler</b>   |                      |              |           |
| Laju gas buang  | m <sup>3</sup> /sec  |              | 613       |
| Konsentrasi NOx   | g/m <sup>3</sup>     |              | 70        |
| Konsentrasi SOx   | g/m <sup>3</sup>     |              | 1         |
| <b>Abu</b>  |                      |              |           |
| Abu pembakaran tanpa aplikasi   | tonnes/year          |              | 0         |
| Abu boiler tanpa aplikasi   | tonnes/year          |              | 0         |
| Abu pembakaran dan boiler untuk pengomposan atau perkebunan           | m <sup>3</sup> /year |              | 1,572     |
| <b>Solid decanter</b>   |                      |              |           |
| Untuk land application  | tonnes/year          |              | 0         |
| Konsentrasi N   | g-N/m <sup>3</sup>   |              | 0         |
| Konsentrasi P   | g-P/m <sup>3</sup>   |              | 0         |
| Potensi kompos yang dihasilkan dari EFB (row angin opem)              | ton-compost/year     |              | 51,438    |
| Potensi kompos yang dihasilkan dari EFB (Close system)                | ton-compost/year     |              | 0         |
| Potensi kompos yang dihasilkan dari EFB (mature)                      | ton-compost/year     |              | 0         |

## How to use the tool?

The user shall entered all the data which “Questionnaire” sheet requests. Data will be separately entered by each process.

| Lokasi pabrik kelapa sawit (pilih salah satu di bawah ini)                                      |   | Sebenarnya |        |
|---|---|------------|--------|
| Sumatra   |   |            |        |
| Proses produksi minyak sawit mentah (CPO)   |   |            |        |
| Catatan: Mohon masukkan angka tahunan untuk setiap parameter, misal: rata-rata 3 tahun terakhir |   |            |        |
| Jumlah tandan buah segar (TBS) yg dibutuhkan untuk produksi minyak CPO (ton/tahun)              |   | Actual     |        |
| Jumlah minyak solar yg dibutuhkan untuk produksi minyak CPO (kilo liter/tahun)                  | e.g. an average of past 3 years.  |            |        |
| Jumlah batu bara yg dibutuhkan untuk produksi minyak CPO (m <sup>3</sup> /tahun)                | methane recovery system (cubic meters (m <sup>3</sup> ) per year)   | 119430     |        |
| Jumlah listrik (dari PLN) yg dibutuhkan untuk produksi minyak CPO (MWh/tahun)                   | ethylene recovery system (grams per cubic meters)   | 50000      |        |
| Jumlah listrik dari boiler yg dibutuhkan untuk pemrosesan (MWh/tahun)                           | flame system (cubic meters (m <sup>3</sup> ) per year) (not for)  |            |        |
| Jumlah produksi CPO (ton/tahun)   | COD concentration of POMME (g/l) (MWh/year)   |            | Actual |
|   | The amount of electricity sold to the grid, if any (MWh/year)   |            |        |
|   | The amount of CH <sub>4</sub> recovery in cubic meters (m <sup>3</sup> ) per year, if already installed.  |            |        |
|   | The amount of POMME discharged to water body after treatment (cubic meters (m <sup>3</sup> ) per year)  |            |        |
|   | The amount of POMME for land application (cubic meters (m <sup>3</sup> ) per year)  |            |        |
|   | The amount of POMME (raw / fresh POMME) for composting (cubic meters (m <sup>3</sup> ) per year)  |            |        |
|   | COD of POMME for land application (grams per cubic meters (g/m <sup>3</sup> ))  |            |        |
|   | N concentration for land application (grams of N per cubic meters (g N/m <sup>3</sup> ))  |            |        |
|   | P concentration for land application (grams of P per cubic meters (g P/m <sup>3</sup> ))  |            |        |
|   | COD of POMME discharged to water body after treatment (grams per cubic meters (g/m <sup>3</sup> ))  |            |        |
|   | N concentration of POMME discharged to water body after treatment (grams per cubic meters (g N/m <sup>3</sup> ))                                    |            |        |
|   | P concentration of POMME discharged to water body after treatment (grams per cubic meters (g P/m <sup>3</sup> ))                                    |            |        |
|   | SO <sub>2</sub> concentration (that gas stack of incinerator) (g SO <sub>2</sub> /m <sup>3</sup> ) (can use default value 6 g SO <sub>2</sub> /CPO) |            |        |
|   | SO <sub>2</sub> concentration (that gas stack of boiler) (g SO <sub>2</sub> /m <sup>3</sup> ) (can use default value 6 g SO <sub>2</sub> /CPO)      |            |        |
|   | SO <sub>2</sub> concentration (that gas stack of boiler) (g SO <sub>2</sub> /m <sup>3</sup> ) (can use default value 6 g SO <sub>2</sub> /CPO)      |            |        |
|   | The amount of boiler ash for no application (tonnes per year) (not for calculation)   |            |        |
|   | The amount of ash of incinerator and boiler applied for composting or plantation (tonnes per year)  |            |        |
|   | The amount of solid decanter for land application (tonnes per year)_Dosage 27 ton/tahun)  |            |        |
|   | N concentration of solid decanter (g N/m <sup>3</sup> )   |            |        |
|   | P concentration of solid decanter (g P/m <sup>3</sup> )   |            |        |

Questionnaire about CPO production process

Questionnaire about Waste Water treatment process

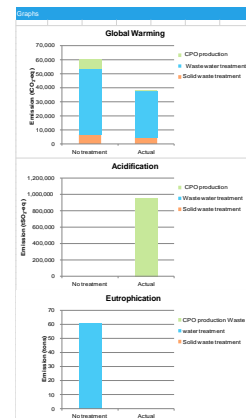
Questionnaire about Solid Waste treatment process

After the user enter all the data into “Questionnaire” sheet, all the rest estimation proceed AUTOMATICALLY.

1. Summarize entered data in “data” sheet

2. Calculate environmental burdens by using “Cal” & “Default” sheet

3. Summarize entered data in “data” sheet



Lokasi pabrik kelapa sawit (pilih salah satu di bawah ini)

Sumatra

Chose your location from a pull-down menu



Proses produksi minyak sawit mentah (CPO)

Sebenarnya

Catatan: Mohon masukkan angka tahunan untuk setiap parameter, misal: rata-rata 3 tahun terakhir

|  |  |
|--|--|
| Jumlah tandan buah segar (TBS) yg dibutuhkan untuk produksi minyak CPO (ton/tahun) |  |
| Jumlah minyak solar yg dibutuhkan untuk produksi minyak CPO (kilo liter/tahun)     |  |
| Jumlah batu bara yg dibutuhkan untuk produksi minyak CPO (m3/tahun)                |  |
| Jumlah listrik (dari PLN) yg dibutuhkan untuk produksi minyak CPO (kWh/tahun)      |  |
| Jumlah listrik dari boiler yg dibutuhkan untuk pemrosesan (kWh/tahun)              |  |
| Jumlah produksi CPO (ton/tahun)  |  |

Enter the requested data colored cells according to the questions!

Questionnaire about

### CPO production process

Pengolahan limbah cair

Sebenarnya

Catatan: Mohon masukkan angka tahunan untuk setiap parameter, misal: rata-rata 3 tahun terakhir

|  |  |
|--|--|
| Jumlah POME ke dalam kolam terbuka (open lagoon) tanpa sistem penangkap metana (m3/tahun) (bukan untuk dihitung) |  |
| Konsentrasi COD pada POME ke dalam kolam terbuka (open lagoon) tanpa sistem penangkap metana (gram/m3)           |  |
| Jumlah POME pada inlet sistem pengolahan limbah cair (m3/tahun) (bukan untuk dihitung)                           |  |
| Konsentrasi COD pada POME di inlet sistem pengolahan limbah cair (gram/m3)                                       |  |
| Jumlah listrik dari jaringan (PLN), jika ada (kWh/tahun)   |  |
| Jumlah listrik yg dijual ke jaringan (grid), jika ada (kWh/tahun)  |  |
| Jumlah metana yang tertangkap dalam m3/tahun, jika sistem sudah terpasang. Jika belum, masukkan nol              |  |
| Jumlah POME yang dialirkan ke badan air setelah diolah (m3/tahun)  |  |

|  |  |
|--|--|
| Jumlah POME untuk land application (pupuk) (m3/tahun)  |  |
| Jumlah POME murni (belum diolah) untuk kompos (m3/tahun)   |  |
| COD pada POME untuk land application (gram/m3)   |  |
| Konsentrasi N untuk land application (gram-N/m3)   |  |
| (a) jika nilai BOD 2000-3500 mg/liter, maka gunakan 387.5 (nilai N 325 - 450 mg/liter); (b) jika nilai BOD 3500 - 5000 mg/liter, maka gunakan 587.5 (nilai N 500 - 675 mg/liter) |  |
| Konsentrasi P untuk land application (gram-P/m3)   |  |
| (a) jika nilai BOD 2000-3500 mg/liter, maka gunakan 73.5 (nilai P 62 - 85 mg/liter); (b) jika nilai BOD 3500 - 5000 mg/liter, maka gunakan 100 (nilai P 90 - 110 mg/liter)       |  |
| COD pada POME yang dialirkan ke badan air setelah diolah (gram/m3)   |  |
| Konsentrasi N pada POME yang dialirkan ke badan air setelah diolah (gram/m3) (BOD < 100 mg/liter: 50, 100 < BOD < 150 mg/liter: 450)   |  |
| Konsentrasi P pada POME yang dialirkan ke badan air setelah diolah (gram/m3) (BOD < 100 mg/liter: 12, 100 < BOD < 150 mg/liter: 70)  |  |

Questionnaire about

### Waste Water treatment process

Pengolahan limbah padat Sebenarnya

Catatan: Mohon masukkan angka tahunan untuk setiap parameter, misal: rata-rata 3 tahun terakhir

|   |  |
|---|--|
| Jumlah tandan kosong sawit (EFB) untuk pembakaran (incineration) (ton/tahun)                          |  |
| TJumlah tandan kosong sawit (EFB) untuk pembakaran (incineration) (ton/tahun) _Dosage 40 ton/Ha/tahun |  |
| Jumlah tandan kosong sawit (EFB) untuk bahan bakar boiler (ton/tahun)                                 |  |
| Jumlah tandan kosong sawit (EFB) untuk pengomposan (open wind row) (ton/tahun)_Dosage 28 ton/Ha/tahun |  |
| Jumlah tandan kosong sawit (EFB) untuk pengomposan (close system) (ton/tahun)_Dosage 18 ton/Ha/tahun  |  |
| Jumlah tandan kosong sawit (EFB) untuk pengomposan (mature) (ton/tahun)                               |  |
| Jumlah tandan kosong sawit (EFB) untuk penumpukan (piling) (ton/tahun)                                |  |
| Jumlah cangkang (shell) yang disimpan (ton/tahun) (untuk kemudian dijual ke pihak lain)               |  |
| Jumlah cangkang (shell) untuk bahan bakar boiler (ton/tahun)  |  |
| Jumlah serat (fiber) yang disimpan (ton/tahun) (untuk kemudian dijual ke pihak lain)                  |  |
| Jumlah serat (fiber) untuk bahan bakar boiler (ton/tahun)   |  |



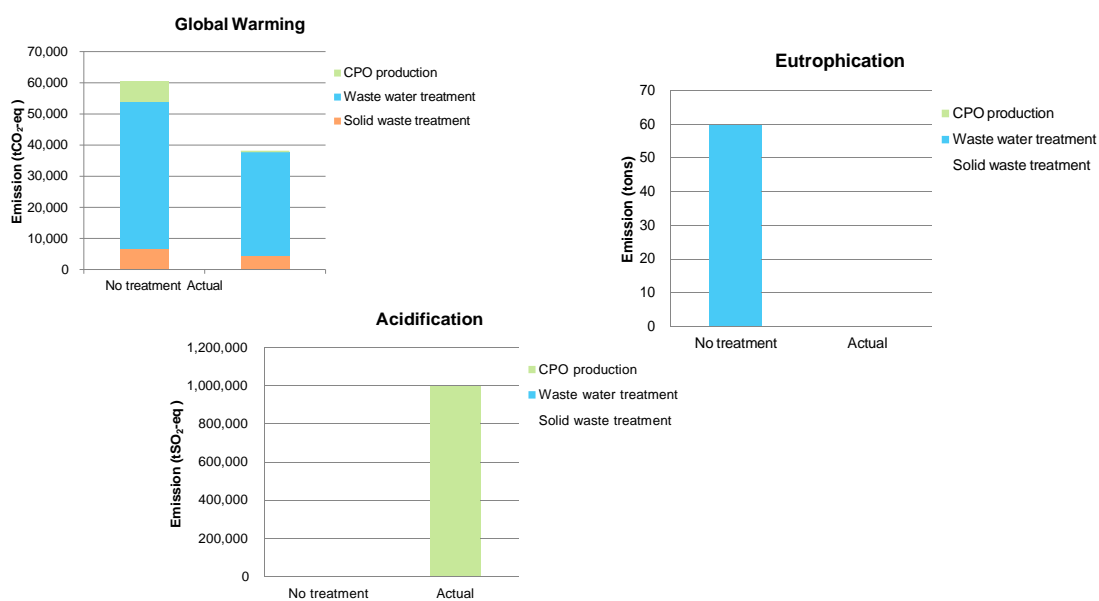
|  |  |
|--|--|
| Laju gas buang pembakaran (incinerator) (m3/detik)   |  |
| Konsentrasi NOx pada gas buang pembakaran (g-N/m3) (bisa memakai nilai default 70 gram-N/ton-CPO)  |  |
| Konsentrasi SOx pada gas buang pembakaran (g-N/m3) (bisa memakai nilai default 0.6 gram-N/ton-CPO) |  |
| Laju gas buang boiler (m3/detik)   |  |
| Konsentrasi NOx pada gas buang boiler (g-N/m3) (bisa memakai nilai default 70 gram-N/ton-CPO)      |  |
| Konsentrasi SOx pada gas buang boiler (g-N/m3) (bisa memakai nilai default 70 gram-N/ton-CPO)      |  |
| Jumlah abu pembakaran (incinerator) tanpa aplikasi (ton/tahun) (bukan untuk dihitung)              |  |
| Jumlah abu boiler tanpa aplikasi (ton/tahun) (bukan untuk dihitung)                                |  |
| Jumlah abu pembakaran dan boiler untuk aplikasi kompos atau perkebunan (ton/tahun)                 |  |
| Jumlah solid decanter untuk land application (ton/tahun)_Dosage 27 ton/Ha/tahun                    |  |
| Konsentrasi N pada solid decanter (gram-N/m3)  |  |
| Konsentrasi P pada solid decanter (gram-N/m3)  |  |

Questionnaire about

### Solid Waste treatment process

### Estimation Result

“Result” sheet show effects of global warming, acidification, eutrophication caused by the emission of following substances



■ Global warming

| Substances | Emission source                               |   |   |
|------------|---|---|---|
|            | CPO production                                | Waste water treatment   | Solid Waste treatment   |
| CO2        | Diesel oil use<br>Coal use<br>Electricity use | Electricity use<br>Electricity sold (credit)<br>Anaerobic digester emission   | Incineration of EFB<br>Boiler fuel of shell<br>Boiler fuel of fiber               |
| CH4        | Diesel oil use<br>Coal use                    | CH4 from POME (without recovery, runoff river)<br>Anaerobic digester emission | Incineration of EFB<br>Boiler fuel of shell<br>Boiler fuel of fiber<br>Stock pile |
| N2O        | Diesel oil use<br>Coal use                    | -   | Incineration of EFB<br>Boiler fuel of shell<br>Boiler fuel of fiber<br>Stock pile |

■ Acidification

| Substances | Emission source      |                       |                       |
|------------|----------------------|-----------------------|-----------------------|
|            | CPO production       | Waste water treatment | Solid Waste treatment |
| SO2        | Flow gas from boiler | -                     | SO2, NOx incineration |
| NOx        | Flow gas from boiler | -                     | SO2, NOx incineration |

■ Eutrophication

| Substances | Emission source |                                  |                       |
|------------|-----------------|----------------------------------|-----------------------|
|            | CPO production  | Waste water treatment            | Solid Waste treatment |
| N          | -               | N emission to the water system   | Leached               |
| P          | -               | P emission to the water system   | Leached               |
| COD        | -               | COD emission to the water system | Leached               |

And this tool also shows the result of GHG emission reduction by substitution of chemical fertilizers.

Ex) Example of estimation

**Results of GHG emission reduction by substitution of chemical fertilizer**

| Potential CO2-offset by substitution of fertilizer by compost utilizing (ton-CO2e) |                            |                           |                     |                |          | (tonCO2e) |
|--|----------------------------|---------------------------|---------------------|----------------|----------|-----------|
|  | composting (open wind row) | composting (close system) | composting (mature) | solid decantor | Mulching | POME (LA) |
| Substitution of Urea utilization   | 742                        | 0                         | 0                   | 0              | 5        | 135       |
| Substitution of RP utilization   | 55                         | 0                         | 0                   | 0              | 0        | 15        |
| Substitution of MOP utilization  | 32                         | 0                         | 0                   | 0              | 0        | 0         |

**Interpretation of result**

The user can assess visually how much emission-reduction efforts have been achieved already, and how many reduction chances he/she still has in each process.

