

# Ecometrics in SyMSpace

SyMSpace Days

September 18<sup>th</sup>, 2024

# Ecometrics

## What are Ecometrics?

- Analysis results of environmental impacts of a product
- Environmental impacts caused by:
  - Production
  - Usage
  - Disposal
- Based on Life Cycle Assessments (LCA)

# Life Cycle Assessment (LCA)

## What is LCA?

- Categorical analysis of environmental impacts
  - Global Warming Potential
  - Ozone Depletion Potential
  - Acidification
  - Abiotic Depletion Potential
  - ...
- Methodical application of these categories
  - CML (**C**entre for **M**ileukunde, **L**eiden)
  - EPD (**E**nvironmental **P**roduct **D**eclaration)
  - TRACI (**T**ool for **R**eduction and **A**ssessment of **C**hemicals and other environmental **I**mpacts)
  - ...

# Ecometrics Workflow


## Start: Motor Project as Basis

Placeholder Expert Mode

EcoDemo\_2024-09-18

Component v1.0.8712 documentation »

### Ecometrics



Component to calculate environmental impacts based on materials and their masses provided by the GeoData parameter and based on used energy sources and the consumed energy provided by the EnData parameter of the SyMSpace project.

Currently, only data aggregated by one of the following two impact assessment methods can be evaluated.

### CML

*The CML method is an ecology-oriented information and decision-making tool for preparing a life cycle assessment in accordance with DIN EN ISO 14040. Its development can be traced back to the Centrum voor Milieukunde (CML) at Leiden University. It was published there in 1992 by Heijungs et al. (1992) and underwent a fundamental revision in 2000.*

(Source: <https://de.wikipedia.org/wiki/CML-Methode>)

The CML method comprises eleven impact assessment categories:

- ADPE: Abiotic Depletion Potential - Elements [kg Sb eq.]
- ADPF: Abiotic Depletion Potential - Fossil Fuel [MJ]
- AP: Acidification Potential [kg SO<sub>2</sub> eq.]
- FAE: Freshwater Aquatic Ecotoxicity [kg 1,4-DCB eq.]
- GWP: Global Warming Potential [kg CO<sub>2</sub> eq.]

# Ecometrics Workflow

## Ecometrics Main Component

The screenshot displays the Ecometrics software interface. At the top, there is a navigation bar with a refresh icon, a 'Placeholder' toggle (checked), an 'Expert Mode' toggle (unchecked), and a breadcrumb path '< EcoDemo\_2024-09-18'. On the right side of the navigation bar, there are icons for save, a green circle with the number '1', play, list, search, and refresh.

The left sidebar shows a project tree structure:

- ProjectName (Motor Interior) - includes a 'Simulation' button.
- Geometry (Geometry PMSM Interior)
- PMSM (PMSM FEMM)
- Ecometrics (Ecometrics)** - This entire section is highlighted with a red box. It contains:
  - Material Consumption
  - Energy Consumption
  - Transportation of Goods
  - Optional
- Optional

The main workspace on the right is currently empty, with the text 'Wizard' and 'Free Search' visible at the top.

# Ecometrics Workflow

## MaterialConsumption

The screenshot displays the Ecometrics software interface for a project named "EcoDemo\_2024-09-18". The left sidebar shows a hierarchical tree of workflow steps: ProjectName (Motor Interior), Simulation, Geometry (Geometry PMSM Interior), PMSM (PMSM FEMM), Ecometrics (Ecometrics), and MaterialConsumption (Material Consumption). The MaterialConsumption step is highlighted with a red box and labeled as "Optional". Below it are other optional steps: Energy Consumption, Transportation of Goods, and another Optional step.

The main workspace shows the "MaterialConsumption" step selected. It displays a "Parameters" section with a table:

Material	Material Ecometrics
EcoMaterial	EcoMaterial.json

There are icons for adding and editing materials. To the right, a "Filter" panel is visible with three toggle switches: "Input" (off), "Results" (off), and "Editable" (off).

# Ecometrics Workflow

## EnergyConsumption

The screenshot displays the Ecometrics software interface. On the left is a project tree with the following items:

- ProjectName (Motor Interior)
- Simulation
- Geometry (Geometry PMSM Interior)
- PMSM (PMSM FEMM)
- Ecometrics (Ecometrics)
- MaterialConsumption (Material Consumption)
- EnergyConsumption (Energy Consumption)** - This item and its sub-items are highlighted with a red box.
  - Load Profile
  - Optional
- Transportation of Goods
- Optional
- Optional

The main workspace on the right shows a header with the date 'EcoDemo\_2024-09-18', a toolbar with icons for save, a green '1' indicator, play, settings, and refresh, and a search bar labeled 'Free Search'. Below the header, the word 'Wizard' is visible.

# Ecometrics Workflow

## Load Profile

The screenshot displays the Ecometrics software interface. On the left is a vertical menu with several items:

- LP\_NoLoad (PMSM NoLoad RBF)
- LP\_Nominal (PMSM Loadpoint Motor RBF)
- Loadpoint Motor
- Optional
- Ecometrics (Ecometrics) - highlighted with a red box and a yellow warning icon
- Transportation of Goods
- MaterialConsumption (Material Consumption)
- Optional
- EnergyConsumption (Energy Consumption) - highlighted with a red box and a yellow warning icon
- Load Profile - highlighted with a red box and a link icon
- Optional
- Optional

On the right is the main configuration area, titled "EcoDemo\_2024-09-18". It features a "Wizard" section with a "Free Search" input field. Below this, there are two load profile options:

- ConstantLoad (0.1) - represented by a bar chart with a warning icon and a "+" button.
- DistributedLoad (0.1) - represented by a bar chart with a warning icon and a "+" button.

At the bottom right, there is a pagination control showing "Items per page: 50" and "1 - 2 of 2".



# Ecometrics Workflow

## EnergySource

The screenshot displays the Ecometrics software interface. On the left, a workflow tree is visible with several components: 'LP\_NoLoad' (PMSM NoLoad RBF), 'LP\_Nominal' (PMSM Loadpoint Motor RBF), 'Loadpoint Motor', 'Optional', 'Ecometrics' (Ecometrics), 'Transportation of Goods', 'MaterialConsumption' (Material Consumption), 'Optional', 'EnergyConsumption' (Energy Consumption), 'Load Profile', 'StandbyLoad' (ConstantLoad), 'Energy Source' (highlighted with a red box), and 'Loadpoint Data'. On the right, a search results panel titled 'EcoDemo\_2024-09-18' shows a search bar and three results: 'ElectricityMix AT 0.1', 'ElectricityMix DE 0.1', and 'ElectricityMix PL 0.1'. Each result includes a lightning bolt icon, a question mark, and a plus sign. The bottom of the search panel shows 'Items per page: 50' and '1 - 3 of 3'.

# Ecometrics Workflow

## ConstantLoad Example 1

The screenshot displays the Ecometrics software interface. On the left, a workflow tree is visible, with the 'StandbyLoad' component highlighted by a red box. The main panel on the right shows the configuration for the 'StandbyLoad' component, including a 'Parameters' table and a 'Filter' section.

**Parameters**

Symbol	Parameter Name	Value	Unit	Actions
P	Nominal power	0.5	W	Refresh, Preview, Export
td	On-time per day	24.0	h	Refresh, Preview, Export
Nd	Number of operation days per year	365.0	day	Refresh, Preview, Export
Ny	Number of operation years	5.0	year	Refresh, Preview, Export
E	Energy demand	21.9	kWh	Refresh, Preview, Export
EnData	Energy data	[struct with 1 fields]		Refresh, Preview, Export
	Energy data file			Refresh, Preview, Export

**Filter**

- In
- Rn
- Et

# Ecometrics Workflow

## ConstantLoad Example 2

The screenshot displays the Ecometrics software interface. On the left, a workflow tree shows several components: LP\_NoLoad (PMSM NoLoad RBF), LP\_Nominal (PMSM Loadpoint Motor RBF), Ecometrics (Ecometrics), MaterialConsumption (Material Consumption), EnergyConsumption (Energy Consumption), StandbyLoad (ConstantLoad), ElectricityMix\_AT (ElectricityMix AT), and NominalLoad (ConstantLoad). The NominalLoad component is highlighted with a red box. On the right, a configuration window for 'EcoDemo\_2024-09-18' is open, showing the 'Parameters' section for the 'NominalLoad' component. The parameters are as follows:

Parameter	Value	Unit
Nominal power (P)	0.0	W
On-time per day (td)	8.0	h
Number of operation days per year (Nd)	200.0	day
Number of operation years (Ny)	5.0	year
Energy demand (E)	1425.1	kWh

The 'Energy data' section shows 'Energy data' as '[struct with 1 fields]' and 'Energy data file' as an empty field. A 'Filter' panel on the right contains three toggle switches: 'In', 'Rt', and 'Ec', all of which are currently turned off.

# Ecometrics Workflow

## Transportation

The screenshot displays the Ecometrics software interface. On the left, a vertical navigation pane shows a tree structure of workflow steps:

- Geometry (Geometry PMSM Interior)
- PMSM (PMSM FEMM)
- Ecometrics (Ecometrics)
- MaterialConsumption (Material Consumption)
- EnergyConsumption (Energy Consumption)
- Transportation (Transportation)** - This entire section is highlighted with a red rectangular box.
  - Air Transport
  - Land Transport
  - Water Transport
  - Optional
- Optional
- Optional

The main workspace on the right shows a header with the project name "EcoDemo\_2024-09-18" and a toolbar with icons for save, a green circle with the number "1", play, list, refresh, and undo. Below the header, the word "Wizard" is centered, and a search bar labeled "Free Search" is positioned on the right side.

# Ecometrics Workflow

## Additional Parts

The screenshot displays the Ecometrics software interface. On the left, a vertical workflow tree shows various components: ProjectName (Motor Interior), Geometry (Geometry PMSM Interior), Stator (Stator Interior C010), Rotor (Rotor Interior IPM010), Part (Ecometrics Part), S235JR (S235JR), PMSM (PMSM FEMM), Ecometrics (Ecometrics), MaterialConsumption (Material Consumption), and EnergyConsumption (Energy Consumption). The 'Part' component is highlighted with a red box. On the right, the detailed view for the 'Part' component is shown, including a title bar with the project name 'EcoDemo\_2024-09-18' and a toolbar. Below the title bar, the 'Part' component is selected, and its parameters are displayed in a table. A 'Filter' panel on the right side of the parameters table allows for filtering the data.

Parameter	Value	Units	Actions
Mass	1.0	kg	Refresh, View, Edit
GeoData	[struct with 1 fields]		Refresh, View, Edit
MaterialName	'S235JR'		Refresh, View, Edit
Measurements	[struct with 6 fields]		Refresh, View, Edit

Filter:

- Input
- Results
- Editable

# Ecometrics Results

## Preview

- PMSM NoLoad RBF
- LP\_Nominal  
PMSM Loadpoint Motor RBF
- Ecometrics**  
Ecometrics
- MaterialConsumption  
Material Consumption
- EnergyConsumption  
Energy Consumption
- StandbyLoad  
ConstantLoad
- NominalLoad  
ConstantLoad
- Transportation  
Transportation
- AirTransport  
AirTransport
- LandTransport  
LandTransport
- WaterTransport  
WaterTransport

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Ecometrics
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Previews ⌵

fae	adpf	adpe	tae	gwp						
Freshwater aquatic ecotoxicity (C)	Abiotic depletion potential - fossil	Abiotic depletion potential - eleme	Terrestrial aquatic ecotoxicity (CMI)	Global warming potential (CML)						
ap	htp	odp	mae	pcop						
Acidification potential (CML)	Human toxicity (CML)	Ozone depletion potential (CML)	Marine aquatic ecotoxicity (CML)	Photochemical ozone creation pote						
np	Overview									
Eutrophication potential (CML)	Impact Assessment Results									
	Impact Assessment Method: CML									
	<table border="1" style="font-size: 8px; border-collapse: collapse;"> <thead> <tr> <th>Impact Category</th> <th>Value</th> <th>Unit</th> </tr> </thead> <tbody> <tr> <td>Freshwater aquatic ecotoxicity</td> <td>132.3</td> <td>kg</td> </tr> </tbody> </table>				Impact Category	Value	Unit	Freshwater aquatic ecotoxicity	132.3	kg
Impact Category	Value	Unit								
Freshwater aquatic ecotoxicity	132.3	kg								

# Ecometrics Results

## Overview

### Impact Assessment Results

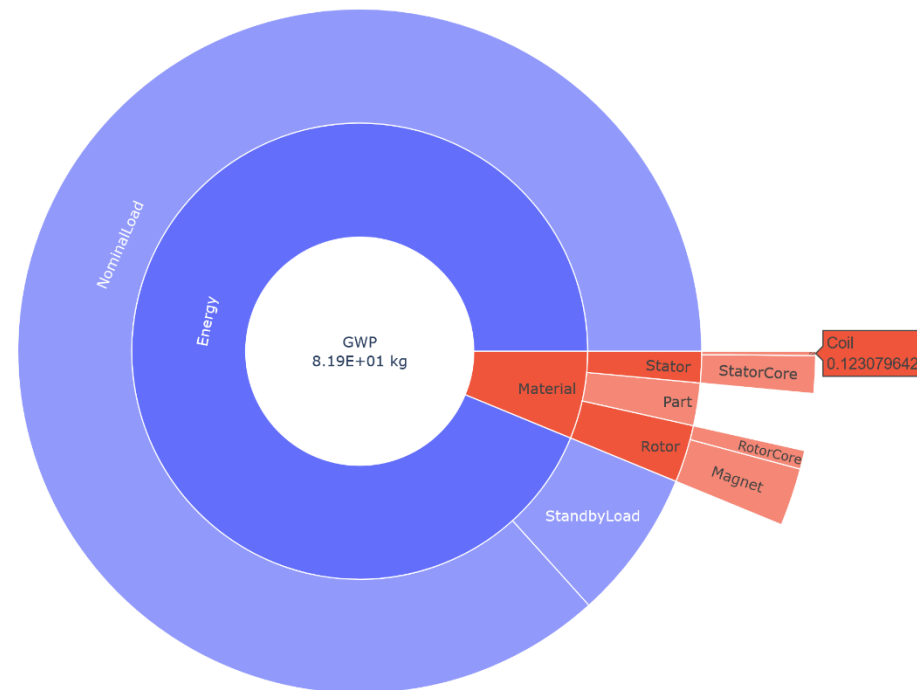
#### Impact Assessment Method: CML

Impact Category	Value	Unit
Freshwater aquatic ecotoxicity	132.3	kg
Abiotic depletion potential - fossil fuel	927.7	MJ
Abiotic depletion potential - elements	0.001309	kg
Terrestrial aquatic ecotoxicity	0.5083	kg
Global warming potential	81.88	kg
Acidification potential	0.4347	kg
Human toxicity	166.4	kg
Ozone depletion potential	1.78E-06	kg
Marine aquatic ecotoxicity	2.562E+05	kg
Photochemical ozone creation potential	0.02492	kg
Eutrophication potential	0.284	kg

# Ecometrics Results

## Detail (example)

Global warming potential (CML)





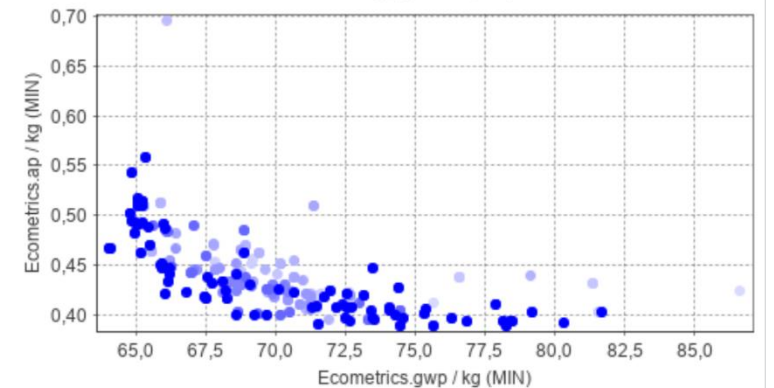
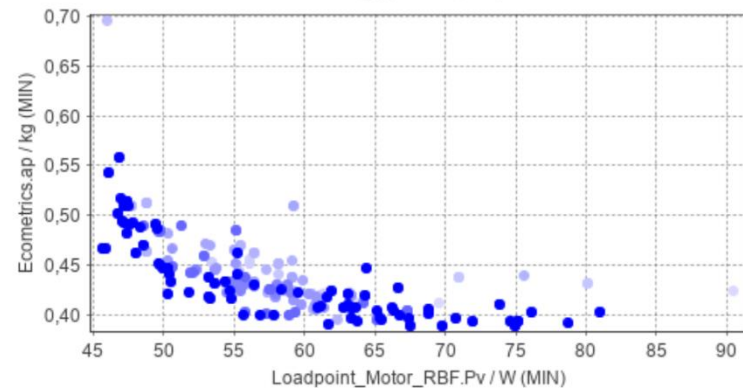
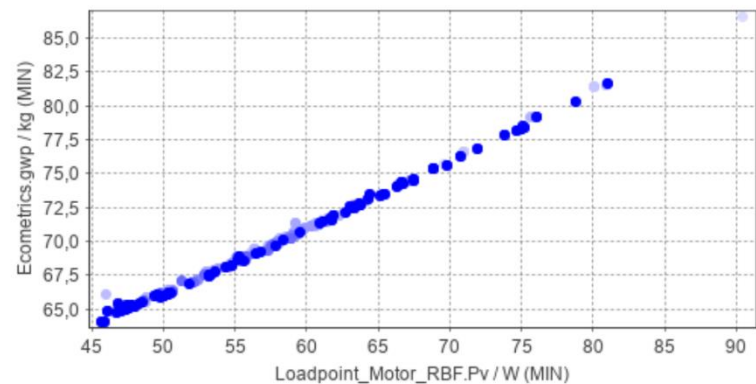
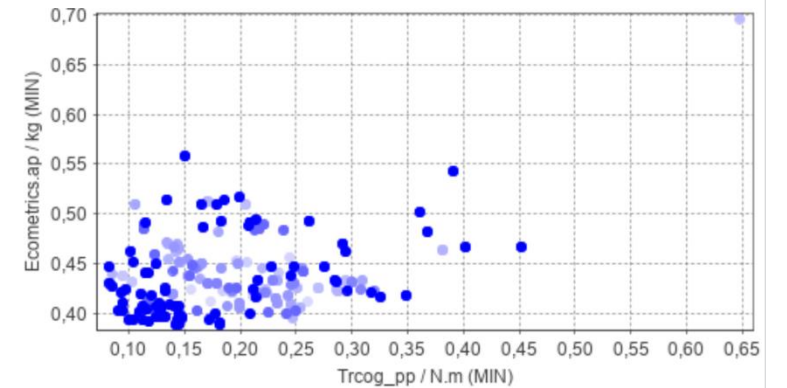
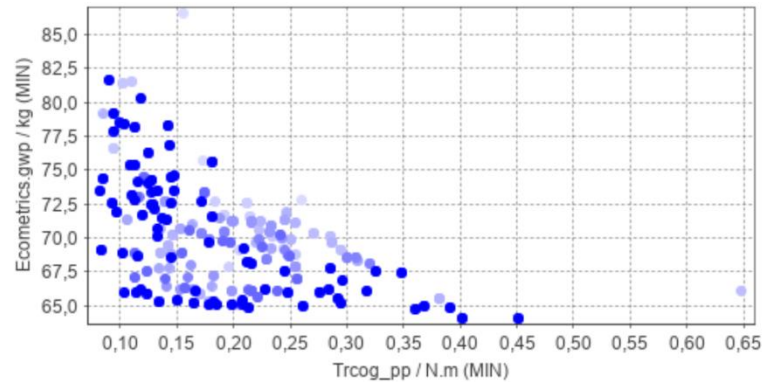
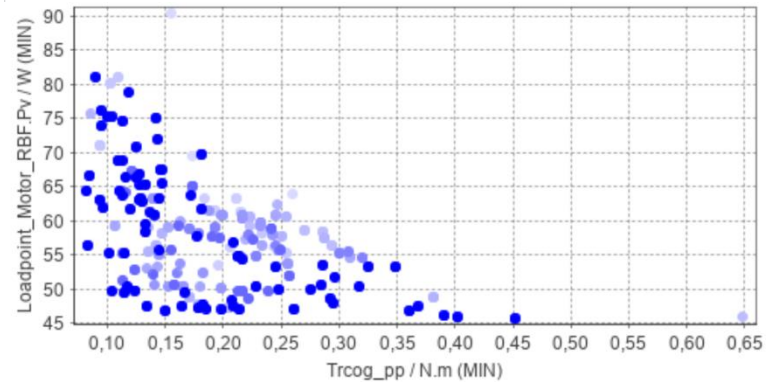
# Optimization

## Objectives

- Optimization in respect to environmental impacts
- Each impact category can be selected as objective
- Examples for CML:
  - ADPE: Abiotic Depletion Potential - Elements [kg Sb eq.]
  - ADPF: Abiotic Depletion Potential - Fossil Fuel [MJ]
  - AP: Acidification Potential [kg SO<sub>2</sub> eq.]
  - FAE: Freshwater Aquatic Ecotoxicity [kg 1,4-DCB eq.]
  - GWP: Global Warming Potential [kg CO<sub>2</sub> eq.]
  - HTP: Human Toxicity [1,4-DCB-Eq.]
  - MAE: Marine Aquatic Ecotoxicity [kg 1,4-DCB eq.]
  - NP: Nitrification Potential [kg PO<sub>4</sub> eq.]
  - ODP: Ozone Depletion Potential [kg CFC-11 eq.]
  - POCP: Photochemical Ozone Creation Potential [kg C<sub>2</sub>H<sub>4</sub> eq.]
  - TAE: Terrestrial Aquatic Ecotoxicity [kg 1,4-DCB eq.]

# Optimization

## Exemplary Results



# Summary

## Benefits

- Estimation of environmental impacts of product caused by
  - Materials
    - Data automatically aggregated from (motor) project
    - Additional parts/materials can be added
  - Energy consumption
    - Load scenarios are user definable
    - Load profiles can be linked to load points
  - Transportation (in development)
    - User definable transportation of goods
- Enables product (motor) optimization in respect to environmental impact category

# Summary

## Outlook

- Finalization of transportation components
- Expansion of energy sources
- Adding of Ecometrics data to all available materials in SyMSpace
- Automized update of Ecometrics source data
- Support of standardized drive cycles
- ...

Science becomes  
**reality**