WP1 Shared modelling framework and learnings

Task 1.1 Methods for background life cycle inventory

D1.2 – Description of scientific methods

Tier 2. tutorial to generate background databases (for Windows)

Approach: Attributional, (compatibility: up to ecoinvent 3.9.1, premise 2.0.1)

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PROJECTS DETAILS			
Project title		Aligning Life Cycle Assessment methods and bio-based sectors for improved environmental performance.	
Project acronym	ALIGNED	**Start / Duration**	01/10/2022 – 36 months
Type of Action	RIA	**Website**	www.alignedproject.eu

Important: The Tutorial for Tier 2 analysis is adapted from Tier 1. The steps 1, 2, and 3 are identical to Tier 1, with few **adaptations in Steps 4 and 5**. Additionally, this Tutorial presents a Jupyter Notebook file which aims to speed up the process of linking foreground and background inventories, as further detailed **in Step 7**.

1) Install Miniconda

Go to https://docs.conda.io/en/latest/miniconda.html to download Miniconda. Follow the instructions to install it (in case you don't have Miniconda in your PC). In case you have Miniconda installed in your PC, you might need to update it.

2) Import ecoinvent database

You must have an active licence of ecoinvent. Get your ecoinvent database file at:
https://v391.ecoquery.ecoinvent.org/Account/LogOn

Type your username and login.

Go to Files (top menu)

Attributional premise (version 2.0.1) is compatible with ecoinvent 3.9.1

Download version ecoinvent 3.9.1_cut_off _ecoSpold02.7z

Choose the windows file path where you downloaded your ecoinvent database in your computer

Extract the zipped database into the folder you selected (you need 7-Zip software installed in your computer)

3) Installing Premise
On Windows, go to the bottom left "search" tool and type "cmd" and choose "Anaconda prompt (Miniconda)"
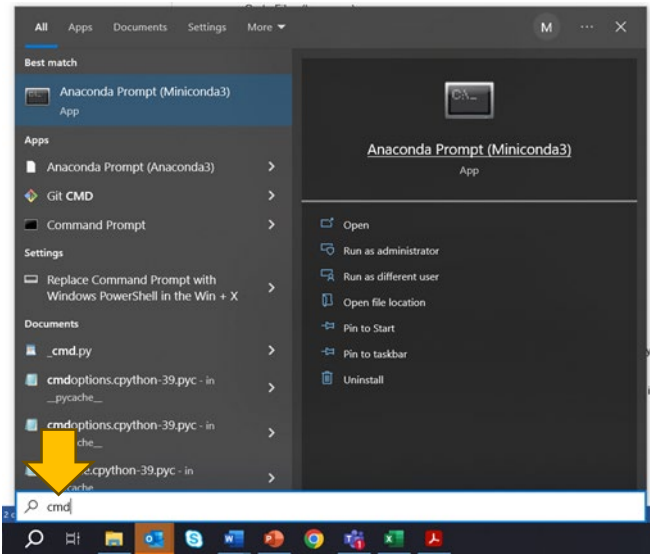
A black window will pop up

First, you need to create an environment. A conda environment is like a separate computer where software packages don't conflict with each other. An environment called '**aligned**' will be created**.** Follow the instructions below:

- Find the aligned.yml environment file in the ALIGNED repository. **Save this file in your C:\Users**username. Note that username refers to your own PCs username folder. In this example, the username is "marcosdb".

- After saving "aligned.yml" properly in your C:\Users\username, open a new command screen (i.e., type 'cmd' in the windows search bar and open a new Miniconda prompt)

- Type the following command and press enter:

```
conda env create --file aligned.yml
```
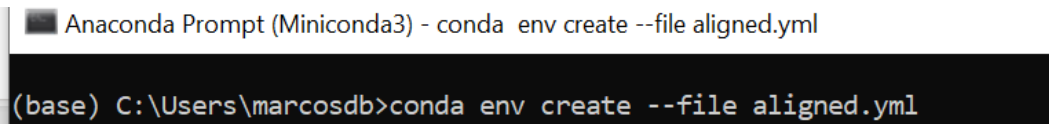

The command above will create an Anaconda environment called "aligned" based on the file you have just downloaded from ALIGNED repository.

- In your Anaconda prompt (black screen), activate your new environment by typing:

```
activate aligned
```

4) Using Premise database for SimaPro
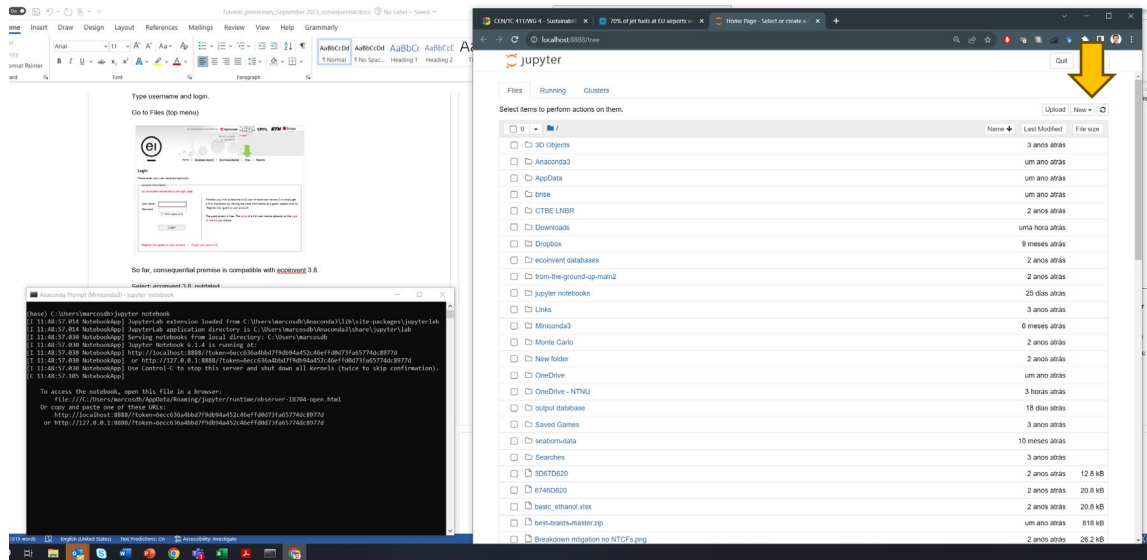
This part of the tutorial shows how to generate a CSV file using premise and how to load this file in SimaPro. In Tier 2 analysis, we exemplify how to generate multiple databases with a single run, considering different IAMs, years, and SSPs. See the modifications highlighted in green color.

- Still inside your prompt window (black pop-up screen) and using the same 'bw2' environment, type the code below

```
jupyter notebook
```

- A new window will pop up on your internet browser. After that:

    Go to the upper right corner of your screen and go to "New", and select "Python 3 (ipykernel)"

- A new window will pop up again on your internet browser. After that:

    Go to the upper left corner of your screen and go to "File", "Save as", and save this notebook with a new name.

Before using premise codes, some important information:

Each user should have your own 'decryption key'. You should contact the developer (romain.sacchi@psi.ch) and ask for the 'decryption key' before running the codes below.

Find the Windows File Path where the ecoinvent "datasets" folder was extracted into (using 7-Zip). In my case, I saved it in the following: C:\datasetecospold02\ecoinvent3.9.1_cut-off_ecoSpold02\datasets. Find your specific file path. Remember to select the file entire path which

---

will always end with "\datasets" subfolder. In the instructions below, you need to adapt the file pathway according to your case.

The codes below illustrate how to generate new background databases using the 'REMIND' and 'IMAGE' Integrated Assessment Models (IAMs), choosing different SSPs, Policy Scenarios and Years.

Finally, you need to define the folder you are going to send the premise/ecoinvent database to. In my case, it was "C:\Users\marcosdb\output database". Adapt the code according to your case.

- In the command line (ln []:), you should copy and paste the following commands. **Observe that the sentences in bold, initiated by #,** mean just comments made by us to help you to understand the command lines:

```
from premise import *

ndb = NewDatabase(

    scenarios = [

            {"model":"remind", "pathway":"SSP2-NDC", "year":2030},

            {"model":"remind", "pathway":"SSP2-NDC", "year":2040},

            {"model":"remind", "pathway":"SSP2-NDC", "year":2050},

            {"model":"image", "pathway":"SSP1-Base", "year":2030},

            {"model":"image", "pathway":"SSP1-Base", "year":2040},

            {"model":"image", "pathway":"SSP1-Base", "year":2050},

    ],

# In this example, we create 6 new databases at a time. But you can add as
many scenarios as you want. Change the name of the model to another IAM, or
choose different SSPs, and years. Before doing that, check the scenario
availability on the methodology description. Just remember that generating
multiple databases at a time will require more processing time from your PC.


    source_type="ecospold",

    source_file_path=r"C:\datasetecospold02\ecoinvent 3.9.1_cut-
off_ecoSpold02\datasets", # <-- you need to adapt this folder path to your
case

    source_version="3.9.1",

    key='xxxxxxxxxxxxxxxxxxxxx' # <-- insert your decryption key here

)
```

```
ndb.update()

ndb.write_db_to_simapro(filepath=r"C:\Users\marcosdb\output database") # <--
you need to choose your own output folder to store your database
```

After running the codes above, a CSV file will be created and sent to the folder that you selected (in my case, C:\Users\marcosdb\output database). DO NOT open the SimaPro CSV file in Excel before importing it to SimaPro. It may corrupt the file.

To run the premise CSV file in SimaPro, follow the steps below:

1. Open SimaPro and select the project where you would like to store the premise database into. For multi-user versions, you may need to be logged on as the Manager user.
2. Click on File/Import.
3. In the 'Import files' window, choose 'SimaPro CSV' for file format, click "Add" and browse for the CSV file and click 'Open,' choose 'try to link imported objects to existing objects first,' choose 'Semicolon' for the CSV format separator and keep all the other options unchecked.
4. Click 'OK' to the 'Import overview' (Important: In my case, importing data files took several hours, one entire working day. I had to adjust my 'Power and Energy' settings accordingly so that my PC did not turn off during the importing process).
5. Done! The premise database was imported to your Simapro project and it is ready to be used.

For more information about premise, check:
https://premise.readthedocs.io/en/latest/extract.html#current-iam-scenarios

https://github.com/romainsacchi/premise

5) Using premise in Brightway2

On Windows, go to the bottom left of your screen ("search button") and type "cmd" and choose "Anaconda prompt". In Tier 2 analysis, we exemplify how to generate multiple databases with a single run, considering different IAMs, years, and SSPs. See the modifications highlighted in green color.

A black window will pop up

- Activate your environment (aligned, previously created):

  ```
  activate aligned
  ```

  You will need to activate this environment every time you start a new terminal or command line shell.

- **Still in your prompt window (black pop-up screen) and in the same 'aligned' environment, type:**

  ```
  jupyter notebook
  ```

- **A new window will pop up on your internet browser. After that:**

  Go to the upper right corner of your screen and go to "New", and select "Python 3 (ipykernel)"

- **A new window will pop up again on your internet browser. After that:**

  Go to the upper left corner of your screen and go to "File", "Save as", and save this notebook with a new name.

Before using premise codes, some important information:

Each user should have your own 'decryption key'. You should contact the developer (romain.sacchi@psi.ch) and ask for the 'decryption key' before running the codes below.

Find the Windows File Path where the ecoinvent "datasets" folder was extracted into (using 7-Zip). In my case, I saved it in the following: C:\datasetecospold02\ecoinvent 3.9.1_cut-off_ecoSpold02\datasets. Find your specific file path. Remember to select the file entire path which will always end up with "\datasets" subfolder. In the instructions below, you need to adapt the file pathway according to your case.

The codes below illustrate how to generate new background databases using the 'REMIND' and 'IMAGE' Integrated Assessment Models (IAMs), choosing different SSPs, Policy Scenarios and Years.

Finally, you need to define the folder you are going to send your premise/ecoinvent database to. In my case, it was "C:\Users\marcosdb\output database". Adapt the code according to your case.

- In the command line (ln []:), you should copy and paste the following commands:

```
from premise import *

from brightway2 import *

import brightway2 as bw

bw.projects.set_current("ALIGNED") #Accessing the project and setting up
'Aligned' as project name, but you can change it

bw2setup()

#the codes below need to be adapted according to your file path

ei39 = SingleOutputEcospold2Importer(

    "C:/datasetecospold02/ecoinvent 3.9.1_cutoff_ecoSpold02/datasets",

    "ecoinvent_3.9.1_cutoff"

)#you need to change the folder path above

ei39.apply_strategies()
```

```
ei39.statistics()

ei39.write_database()
```

```python
from premise import *

ndb = NewDatabase(

    scenarios = [

            {"model":"remind", "pathway":"SSP2-NDC", "year":2030},

            {"model":"remind", "pathway":"SSP2-NDC", "year":2040},

            {"model":"remind", "pathway":"SSP2-NDC", "year":2050},

            {"model":"image", "pathway":"SSP1-Base", "year":2030},

            {"model":"image", "pathway":"SSP1-Base", "year":2040},

            {"model":"image", "pathway":"SSP1-Base", "year":2050},

    ],

# In this example, we create 6 new databases at a time. But you can add as
many scenarios as you want. Change the name of the model to another IAM, or
choose different SSPs, and years. Before doing that, check the scenario
availability on the methodology description. Just remember that generating
multiple databases at once will require more processing time from your PC.


    source_type="ecospold", #

    source_file_path=r"C:\datasetecospold02\ecoinvent3.9.1_cut-
off_ecoSpold02\datasets", # <-- you need to adapt this folder path to your
case

    source_version="3.9.1",

    key='xxxxxxxxxxxxxxxxxxxxx' # <-- insert your decryption key here

)


ndb.update()

ndb.write_db_to_brightway()
```

If you don't have Brightway2 installed in your PC, here you will find more information
https://docs.brightway.dev/en/latest/content/faq/brightway.html

6) Installing Activity Browser (optional)

The Activity Browser is an interface to use Brightway2, which can facilitate the process of exploring your BW2 projects, databases and running LCAs. To install it, go to the bottom left "search" button of your screen and type "cmd" and choose "Anaconda prompt"

A black window will pop up

- You can install and start the activity-browser in a new environment named "ab":
  ```
  conda create -n ab -c conda-forge activity-browser
  ```

- To open the activity browser, first activate your environment:
  ```
  activate ab
  ```

- And then:
  ```
  activity-browser
  ```

- Although AB is very user-friendly and easy to use, you can find more instructions on how to use it at: https://github.com/LCA-ActivityBrowser/activity-browser#installation

7) Linking foreground LCIs with new background databases

The more databases you create using premise the more time you will spend connecting them to your foreground inventory(ies).

The simplest (but more time-consuming method) is to manually link the databases to your foreground LCI(s). **If you are a SimaPro user**, this means you will have to manually select and drag each process from your new background activities, until all your foreground LCI is linked to the premise database.

If you are a Brightway2 user (or Activity Browser user), however, you can save time by following this tutorial based on a Jupyter Notebook script which will link your foreground inventory(ies) to one of your new background databases at a time. This tutorial is particularly timesaving if you have many foreground inventories to be linked to many background databases.

a) First, you need to re-create your foreground inventory(ies) according to the specific Excel File format in the repository, called "LCI_format.xlsx" and change it according to your case. See below one example of LCI made for a hypothetical activity and modify this file according to your case (i.e., modify activity names, description, exchanges, amounts, etc.). Here we describe just one foreground inventory, but you can have multiple foreground inventories (activities) in the same Excel file. You just need to copy and paste this inventory format (light green area) below the last line in blue color. Repeat this procedure until you insert all your inventories.

Database	aligned							
Activity	**Example activity**							
comment	This dataset represents an example of foreground LCI							
location	*Europe without Switzerland*							
production amount	1							
type	process							
unit	kilogram							
Exchanges								
name	reference product	amount	unit	database	categories	location	type	comment
Example activity	*Example activity*	*1*	*kilogram*	*aligned*		*Europe without Switzerland*	*production*	*reference product*
market for zeolite, powder	zeolite, powder	4.20E-05	kilogram	ecoinvent_3.9.1_cutoff		GLO	technosphere	
market for natural gas liquids	natural gas liquids	4.66E-04	kilogram	ecoinvent_3.9.1_cutoff		GLO	technosphere	
market for tap water	tap water	8.54E-03	kilogram	ecoinvent_3.9.1_cutoff		Europe without Switzerland	technosphere	
Water		1.32E-05	cubic meter	biosphere3	air		biosphere	
Carbon dioxide, non-fossil		1.98E-02	kilogram	biosphere3	air::low population density, long-term		biosphere	
Carbon dioxide, fossil		1.29E-04	kilogram	biosphere3	air		biosphere	

Figure 1. Example of Excel-format LCI for Brightway 2.

    b)   In your new inventory, replace the names of ecoinvent databases

In the example above, "Exchanges" are either linked to biosphere, ecoinvent, or your own Excel database. For exchanges connected to ecoinvent, you will need to replace names in the cells related to the database description. For instance, replace "ecoinvent_3.9.1_cutoff" by, for example, "ecoinvent_remind_SSP2-NDC_2050"). Just adapt the ecoinvent and premise database names according to the ones you have in your project. **Using the Activity Browser might help in this procedure**. Name substitutions need to be accurate, i.e., typos can generate errors when running the codes. You can make all replacements either manually or using the Excel "Find and Replace" tool.

Also, remember that **new locations, activities, and markets** are created by premise. For example, those related to transport or power generation that can be linked to "EUR" region, which is the representation of Europe in REMIND. This means that you can change your foreground inventory by replacing not only the database name, but also ecoinvent activities which now have a better representation in premise. More concrete examples are the use of new activities such as battery electric lorries, new hydrogen-based fuel systems, electricity generation associated with carbon capture and storage (CCS), and so on.

See in the example below how the exemplified LCI was modified to match the premise database (**highlighted in yellow**). In this example, it was not necessary to change the names of exchanges, reference products, or regions. Just a simple adaptation of database name was made:

Database	aligned						
Activity	**Example activity**						
comment	This dataset represents an example of foreground LCI						
location	*Europe without Switzerland*						
production amount	1						
type	process						
unit	kilogram						
Exchanges							
name	reference product	amount	unit	database	categories	location	type
Example activity	*Example activity*	*1*	*kilogram*	*aligned*		*Europe without Switzerland*	*production*
market for zeolite, powder	zeolite, powder	4.20E-05	kilogram	ecoinvent_3.9.1_remind_SSP2-NDC_2050		GLO	technosphere
market for natural gas liquids	natural gas liquids	4.66E-04	kilogram	ecoinvent_3.9.1_remind_SSP2-NDC_2050		GLO	technosphere
market for tap water	tap water	8.54E-03	kilogram	ecoinvent_3.9.1_remind_SSP2-NDC_2050		Europe without Switzerland	technosphere
Water		1.32E-05	cubic meter	biosphere3	air		biosphere
Carbon dioxide, non-fossil		1.98E-02	kilogram	biosphere3	air::low population density, long-term		biosphere
Carbon dioxide, fossil		1.29E-04	kilogram	biosphere3	air		biosphere

c) Link the foreground inventory to a new premise background database

Once all your LCI is properly represented in Excel format for Brightway2, copy and paste the codes below to a Jupyter Notebook and run it (after making the necessary adaptations in the code). This step will link all your foreground inventories from your Excel file to the premise database. In this example, we considered "**ecoinvent_3.9.1_remind_SSP2-NDC_2050**", but you can connect to your own premise databases. If you have many premise databases, repeat this procedure for all of them (one at a time).

```python
from brightway2 import *

import pandas as pd

import numpy as np

import bw2io

import bw2data


projects.set_current("ALIGNED") # choose your own project name.

bw2setup()

invent = ExcelImporter(r"C:/Users/marcosdb/LCI_format.xlsx") # change this
pathway to match your own Excel file with foreground inventory(ies)

invent.apply_strategies()

invent.match_database("ecoinvent_cutoff_3.9.1_remind_SSP2-NDC_2050",
fields=('name','unit','location','reference product')) #change the premise
database name according to your needs

invent.match_database(fields=('name','unit','location'))

invent.statistics()

invent.write_excel(only_unlinked=True)

list(invent.unlinked)

invent.write_database()

database = Database("---")
```

In case if you experience errors during the execution, it is very likely they might be related to typos when filling in/modifying the Excel file, such as wrong exchange/reference product names, errors in location, wrong/missing characters in Excel cells, etc. Make sure you had a thorough review of your Excel file so that there is a proper match with the names, regions, etc. from premise databases.