Using LCA data to inform the decision making of the Belgium energy future.

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Brief presentation of the energy model

Importance of using of prospective data

Premise scenarios: year-2050

```
list_scenario = list(bd.databases)
list_scenario = [db for db in list_scenario if 'ecoinvent_' in db]
list_scenario
```

```
['ecoinvent_image_SSP2-RCP19_2050',
 'ecoinvent_remind_SSP2-PkBudg500_2050',
 'ecoinvent_image_SSP2-Base_2050',
 'ecoinvent_image_SSP2-RCP26_2050',
 'ecoinvent_remind_SSP2-Base_2050',
 'ecoinvent_remind_SSP2-NDC_2050',
 'ecoinvent_remind_SSP2-PkBudg1150_2050']
```

I-SSP2-RCP19	compliant with the hard targets of the Paris Agreement (increase of 1.5 C9
R-SSP2-PkBud 500	CO2 emissions peak at 500 Gt. Scenario compliant with the hard targets of the Paris Agreement
I-SSP2-Base	worst-case scenario
I-SSP2-RCP26	compliant with the soft targets of the Paris Agreement (1.8-2 C)
R-SSP2-Base	worst-case scenario
R-SSP2-NDC	Current Nationally-determined Contributions implemented by the parties of the Paris Agreement
R-SSP2-PkBudg1 150	CO2 emissions peak at 1150 Gt. Scenario compliant with the soft targets of the Paris Agreement

Add the transportation stage to the eMethane activity

Create a new database

Create a new activity

Create the exchanges: eMethane production and transport by pipeline considering the distance between Spain and Belgium

Evaluate the global warming potential including hydrogen (for the different Premise escenarios)

Add the transportation stage to the eMethane activity

```
#Function that creates new activties (eMethane transp to BE from ES) with scenarios as inputs

def create_activity(db_scenario):

    name_scenario = db_scenario.name

    new_act = mydb.new_activity(code = 'eMethane transported to Belgium from Spain by pipelines, ' + name_scenario,
        name = 'eMethane transported to Belgium from Spain by pipelines, '+ name_scenario,
        unit  = 'kg',
        amount = 1,
        type =  'process',
        comment = '',
        location = "BE",
        authors = 'our amazing group',
        scenario = name_scenario)

    new_act.save()
```

Create activities and exchanges

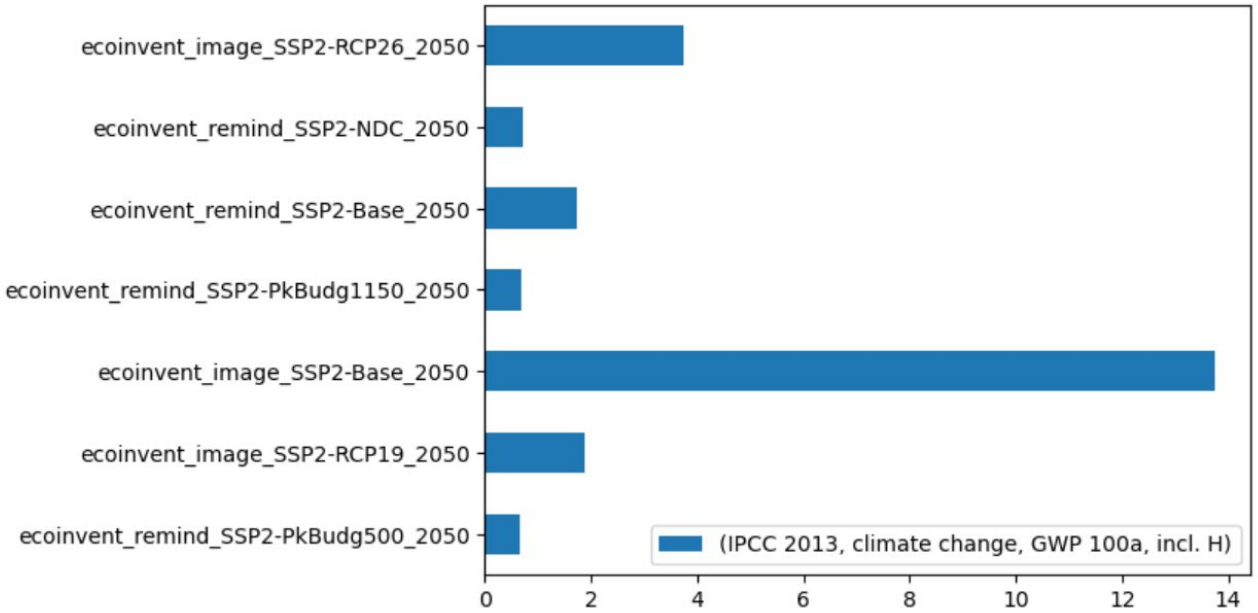
```
#output_1
new_act.new_exchange(type = 'production',
                         name = new_act['name'],
                         unit = new_act['unit'],
                         amount = new_act['amount'],
                         input = new_act.key,
                         output = new_act.key,
                         ).save()

#input_1
act_input = [act for act in db_scenario if "transport, pipeline, onshore" in act["name"]
                                        and "natural gas" in act["name"]
                                        and "RER" in act["location"]][0]

new_exc = new_act.new_exchange(type = 'technosphere',
                        name = act_input["name"],
                        amount = 2,
                        input = act_input.key,
                        output = new_act.key,
                        )
new_exc.save()
```

Add the transportation stage to the eMethane activity

```
# setting up my new MultiLCA for all the different databases with the 2 different methods
list_functional_units = [{act:1} for act in list_act]
list_methods = [pr_gwp]
bd.calculation_setups['ech4_prospective'] = {'inv':list_functional_units, 'ia':list_methods}
myMultiLCA = bc.MultiLCA('ech4_prospective')
df = pd.DataFrame(myMultiLCA.results, colums = list_method)
```



Regionalization

```
bwa.print_recursive_calculation(act, method_ipcc, cutoff= 0.01, max_level= 8)
```

```
Fraction of score | Absolute score | Amount | Activity
0001 | 1.972 |     1 | 'eMethane transported to Belgium from Spain by pipelines, ecoinvent_im
  0.0594 | 0.1172 |     2 | 'market for transport, pipeline, onshore, long distance, natural gas'
    0.0594 | 0.1172 |     2 | 'transport, pipeline, onshore, long distance, natural gas' (ton kilome
      0.05 | 0.09871 | 0.145 | 'natural gas, burned in gas turbine, for compressor station' (kilowatt
  0.941 | 1.855 |     1 | 'methane, from electrochemical methanation, with carbon from atmospher
    0.941 | 1.855 |     1 | 'methane, from electrochemical methanation, with carbon from atmospher
      0.13 | 0.257 | 2.768 | 'carbon dioxide, captured from atmosphere, with heat pump heat, and gr
        0.0176 | 0.0348 | 2.768 | 'carbon dioxide capture system' (unit, RER, None)
          0.0139 | 0.0274 | 3.032e-07 | 'adsorption and desorption unit, carbon dioxide capture process' (unit
            0.0135 | 0.02656 | 0.003942 | 'aluminium production, primary, ingot' (kilogram, IAI Area, EU27 & EFT
              0.0122 | 0.02412 | 0.003724 | 'aluminium production, primary, liquid, prebake' (kilogram, IAI Area,
        0.0139 | 0.02748 | 0.3936 | 'market group for electricity, low voltage' (kilowatt hour, WEU, None)
          0.013 | 0.02567 | 0.3742 | 'market group for electricity, medium voltage' (kilowatt hour, WEU, No
            0.0126 | 0.02489 | 0.3763 | 'market group for electricity, high voltage' (kilowatt hour, WEU, None
        0.0567 | 0.1117 |   1.6 | 'market group for electricity, low voltage' (kilowatt hour, WEU, None)
          0.0529 | 0.1044 | 1.521 | 'market group for electricity, medium voltage' (kilowatt hour, WEU, No
            0.0513 | 0.1012 |  1.53 | 'market group for electricity, high voltage' (kilowatt hour, WEU, None
      0.806 |  1.59 | 0.5078 | 'hydrogen production, gaseous, 25 bar, from electrolysis' (kilogram, W
        0.799 | 1.576 | 22.56 | 'market group for electricity, low voltage' (kilowatt hour, WEU, None)
          0.0127 | 0.0251 | 1.972e-06 | 'distribution network construction, electricity, low voltage' (kilomet
          0.746 | 1.472 | 21.46 | 'market group for electricity, medium voltage' (kilowatt hour, WEU, No
```

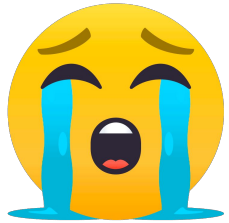
REGIONALISATION

Goal

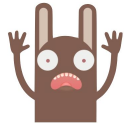
Change the electricity mix used for the electrolyzer from RER to ES using user-defined scenarios in Premise

- A new configuration file has been created
- A new scenario_data.csv file is created to estimate the future electricity mix in Spain assuming that it will be based on PV.

- Some errors related to the configuration file occurred when creating a new database including user-defined scenarios.



We tried good habits, but it didn't last long…



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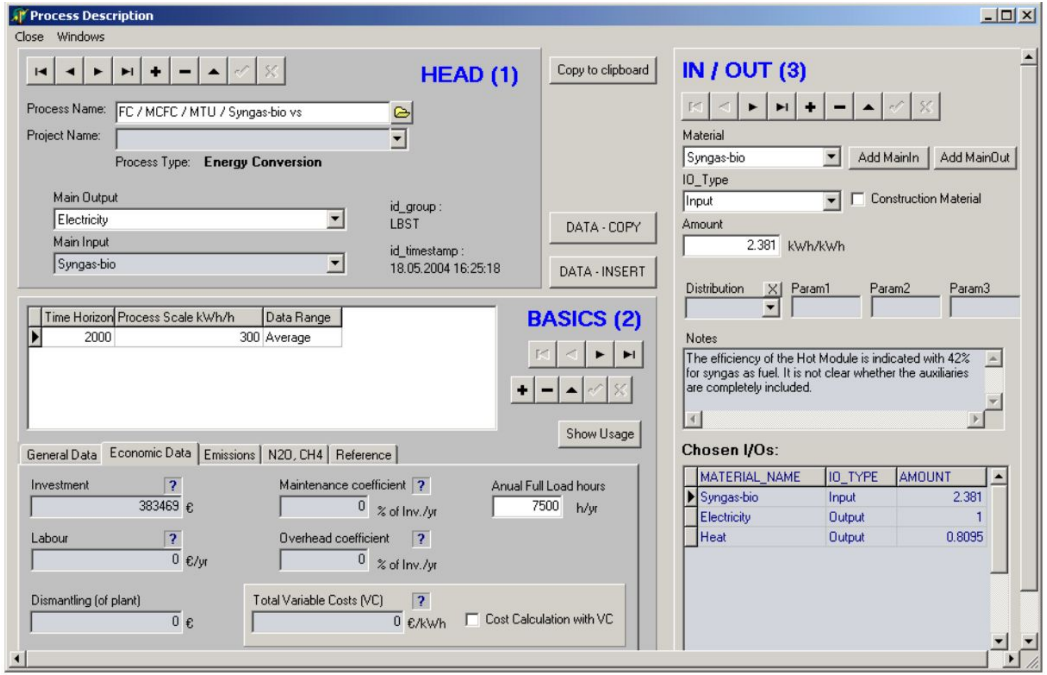
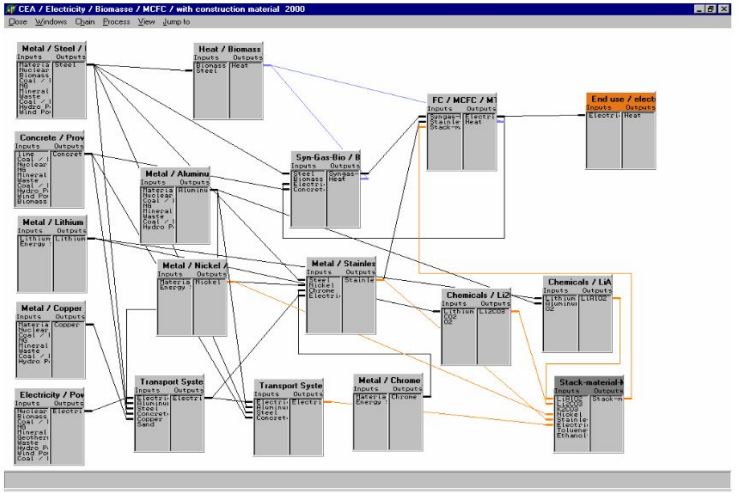
main 1 branch 0 tags Go to file Add file Code

Mahefa test	ee1aebc 13 hours ago	4 commits
.gitignore	Update .gitignore	2 days ago
LICENSE	Beerware license	2 days ago
README.md	Initial commit	2 days ago
Test.ipynb	test	13 hours ago

Try to use another external data source… the E3 database

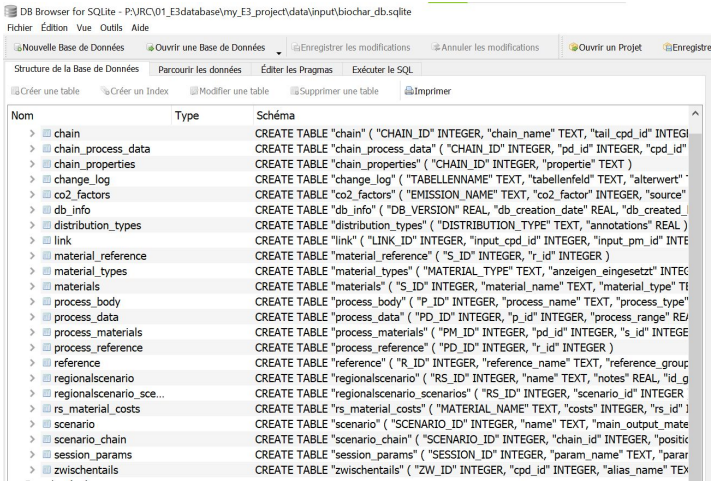
A very old tool containing a lot of data related to bioenergy pathways…





But unfortunately not open source, making it difficult to check and analyze the contained data…

We've won some battles, but not the war (yet)…



- We manage to import the database and manipulate the SQL database with peewee.
- Successful creation of 435 nodes for "material"
- Successful creation of >6000 nodes for "process" and 55311 egdes with the "material" and biosphere flows (took 90 minutes)
- Many duplicated data… Only after deleting duplicated: 1343 nodes remained and 9215 edges.
- Next step is to substitute edge with material to edge with the right "process".
- We've been able to analyze the inventories, and calculate direct impact only as processes are not chain connected yet…

Biomethane from microalgae

Inventories in Excel file

Inventories of the system in Excel file

FU: 1GWh of biomethane		For one kg biomethane	
Miroalgae culture infrastucture			
Activities	ecoinvent_act	Amount	Unit
LDPE	"market for packaging film, low density polyethylene","GLO"	3,30095E-06	kg
water_pipeline	"market for water supply network","GLO"	2,19454E-12	km
Glass_fibre_paddle_wheel	"market for glass fibre","GLO"	1,55903E-06	kg
steel_paddle_wheel	"market for steel, low-alloyed","GLO"	3,04949E-07	kg
steel pump paddle wheel	"market for steel, low-alloyed","GLO"	1,22071E-07	kg
CO2 pipeline	"market for pipeline, natural gas, low pressure distribution network","GLO"	8,00091E-12	km
Culture operation			
N-fertilizer	"market for inorganic nitrogen fertiliser, as N,"FR"	3,31881E-09	kg
P2O5-fertilizer	"nutrient supply from triple superphosphate, "RER"	7,06402E-10	kg
seawater	"Water, salt, ocean"	-5,05365E-08	m3
electricity co2 injection	"market for electricity, medium voltage,"FR"	1,32129E-09	kWh
electricity water supply	"market for electricity, medium voltage,"FR"	6,99508E-09	kWh
electricity cultivation	"market for electricity, medium voltage,"FR"	9,1439E-09	kWh
Culture emissions			
water evaporation	air', 'low population density, long-term'	1,68146E-08	m3
CO2 leak	'air', 'low population density, long-term'	1,61215E-08	kg
ammonia emissions	'air', 'low population density, long-term'	3,98257E-10	kg
N2O leak emissions	'air', 'low population density, long-term'	5,3101E-12	kg

Biomethane from microalgae

Use of Excel template to be imported in Brightway2

cutoff	14						
database	Microalgal biomethane						
Activity	Biomethane						
reference product	Biomethane						
code	biomethane_production						
location	SP						
amount	1						
unit	kg						
Exchanges							
name	reference product	location	amount	unit	database	type	categories
Biomethane	Biomethane	SP	1	kilogram	Microalgal biomethane	production	
Microalgae infrastucture	Microalgae infrastucture	SP	1	unit	Microalgal biomethane	technosphere	
Culture operation	Culture operation	SP	1	unit	Microalgal biomethane	technosphere	
Harvesting microalgae	Harvesting microalgae	SP	1	unit	Microalgal biomethane	technosphere	
Microalgae anaerobic digestion	Microalgae anaerobic digestion	SP	1	unit	Microalgal biomethane	technosphere	

Biomethane from microalgae

Import of the Excel file into Brightway2

```
del bd.databases['Microalgal biomethane']
```

```
# # === Import foreground databases ===
# # == Water database ==
if "Microalgal biomethane" in bd.databases:
    print("Microalgal biomethane database already exists")
else:
#     # 1. Specify filepath to your foreground inventories.
    biomethane_path = "biomethane.xlsx"
#     # 2. Create an instance of a class that contains basic methods for importing a database from an excel file.
    biomethane = bi.ExcelImporter(biomethane_path)
#     # 3. `apply_strategies` is one of such basic methods, it makes sure units, locations, etc are in correct format.
    biomethane.apply_strategies()
#     # 4. Next step is to link your foreground exchanges to existing databases by matching relevant exchanges fields.
    biomethane.match_database("biosphere3", fields=("name", "unit", "categories"))
    biomethane.match_database("ei 3.8 cutoff", fields=("name", "location", "unit"))
    biomethane.metadata.pop(None)  # Remove metadata None entry. TODO
#     # 5. If everything is linked, write database so that it is saved in your project.
    if len(list(biomethane.unlinked)) == 0 :
        biomethane.write_database()
```

cutoff	14						
database	Microalgal biomethane						
Activity	Biomethane						
reference product	Biomethane						
code	biomethane_production						
location	SP						
amount	1						
unit	kg						
Exchanges							
name	reference product	location	amount	unit	database	type	categories
Biomethane	Biomethane	SP	1	kilogram	Microalgal biomethane	production	
Microalgae infrastucture	Microalgae infrastucture	SP	1	unit	Microalgal biomethane	technosphere	
Culture operation	Culture operation	SP	1	unit	Microalgal biomethane	technosphere	
Harvesting microalgae	Harvesting microalgae	SP	1	unit	Microalgal biomethane	technosphere	
Microalgae anaerobic digestion	Microalgae anaerobic digestion	SP	1	unit	Microalgal biomethane	technosphere	

Biomethane from microalgae

Success import but…UNREALISTIC score of GWP

```
bd.databases
```

```
Databases dictionary with 12 object(s):
        Microalgal biomethane
        basic_premise
        biosphere3
        ecoinvent_image_SSP2-Base_2050
        ecoinvent_image_SSP2-RCP19_2050
        ecoinvent_image_SSP2-RCP26_2050
        ecoinvent_remind_SSP2-Base_2050
        ecoinvent_remind_SSP2-NDC_2050
        ecoinvent_remind_SSP2-PkBudg1150_2050
        ecoinvent_remind_SSP2-PkBudg500_2050
        ei 3.8 cutoff
        our own database
```

```
biomethane_act = [act for act in mdb if "Biomethane" in act["name"]][0]
biomethane_act
```

```
'Biomethane' (kilogram, SP, None)
```

```
myFirstLCA = bc.LCA({biomethane_act:1}, pr_gwp)
myFirstLCA.lci()
myFirstLCA.lcia()
myFirstLCA.score
```

```
503.21199168790935
```

Biomethane from microalgae

Looking for activities with the bigger share to the impact

```
ba.print_recursive_calculation(biomethane_act, pr_gwp, cutoff=0.025)
```

```
Fraction of score | Absolute score | Amount | Activity
0001 | 503.2 |      1 | 'Biomethane' (kilogram, SP, None)
 0.999 | 502.5 |      1 | 'Microalgae infrastucture' (unit, SP, None)
    0.644 | 323.9 | 104.3 | 'market for packaging film, low density polyethylene' (kilogram, GLO,
      00.2 | 100.8 | 34.48 | 'packaging film production, low density polyethylene' (kilogram, RER,
      0.427 | 214.9 | 69.82 | 'packaging film production, low density polyethylene' (kilogram, RoW,
    0.237 | 119.3 | 49.26 | 'market for glass fibre' (kilogram, GLO, None)
      0.0667 | 33.55 | 16.29 | 'glass fibre production' (kilogram, RER, None)
      0.163 | 82.02 | 32.98 | 'glass fibre production' (kilogram, RoW, None)
    0.0385 | 19.36 | 9.636 | 'market for steel, low-alloyed' (kilogram, GLO, None)
      0.0253 | 12.73 | 5.687 | 'steel production, converter, low-alloyed' (kilogram, RoW, None)
    0.0403 |  20.3 | 0.0002528 | 'market for pipeline, natural gas, low pressure distribution network'
      0.0402 | 20.25 | 0.0002521 | 'pipeline construction, natural gas, low pressure distribution network
```

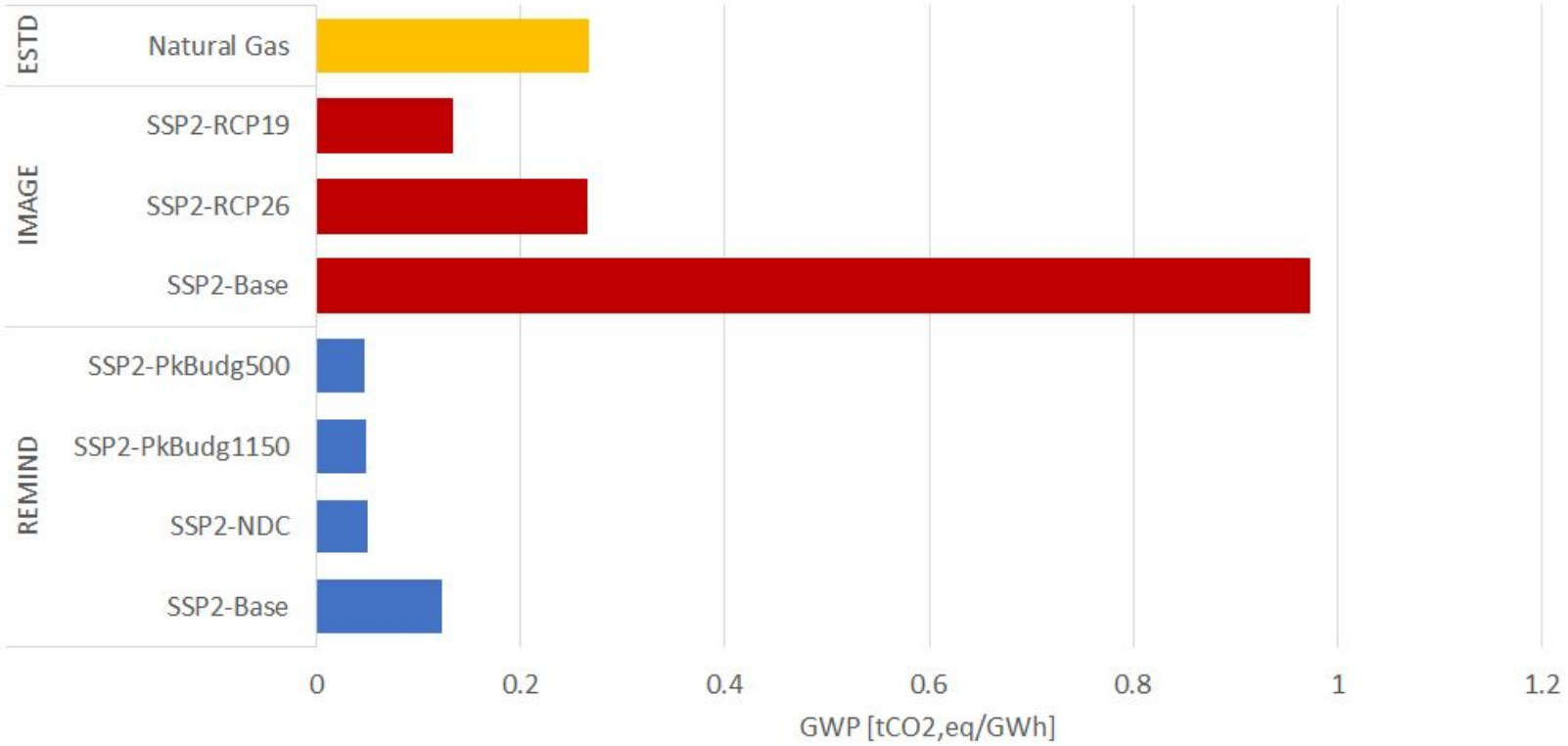
Soft-coupling with an Energy System Optimisation Model

Soft-coupling with EnergyScope TD

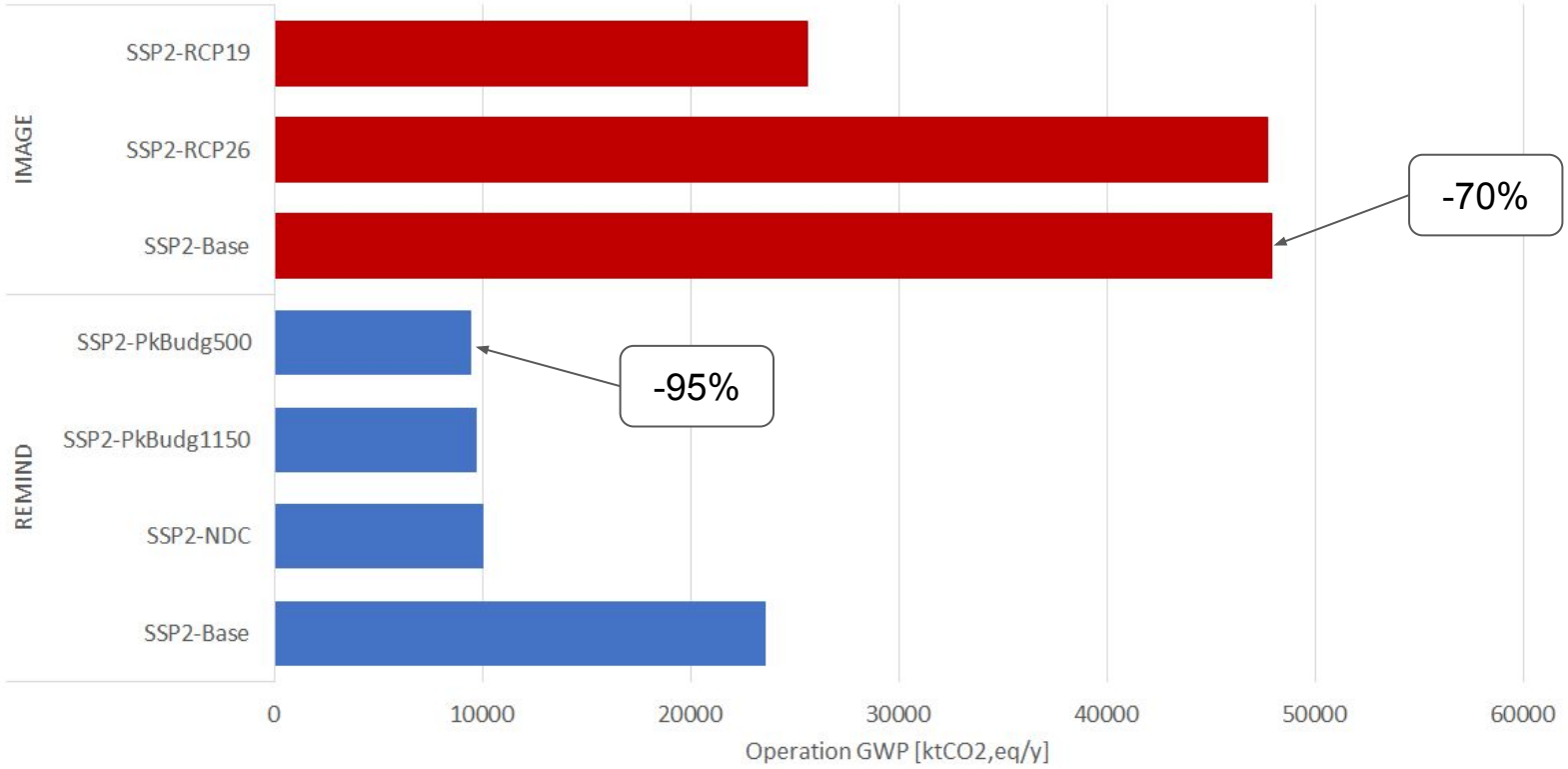
- EnergyScope TD is a regional whole-energy system optimisation model
  - Applied to 2050 Belgium energy system
  - Optimize the design and operation of the system to have minimal operational emissions
  - Upper bound on cost increase: 20%
  - The embodied emissions of the e-methane are given as an input to the energy model

- Results
  - Reachable reduction objectives
  - Energy (and technology) mixes

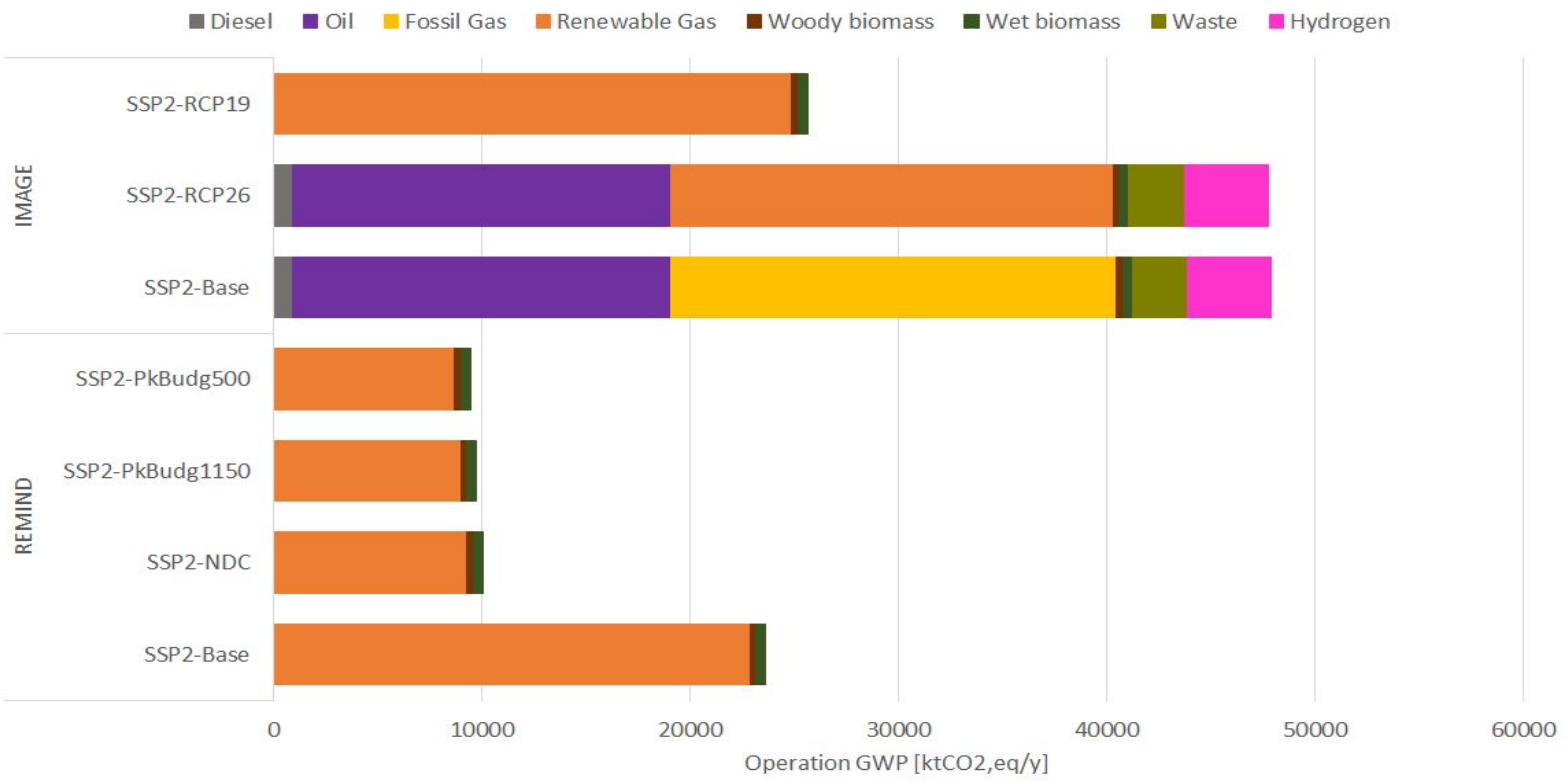
Input : embodied emissions of the e-methane



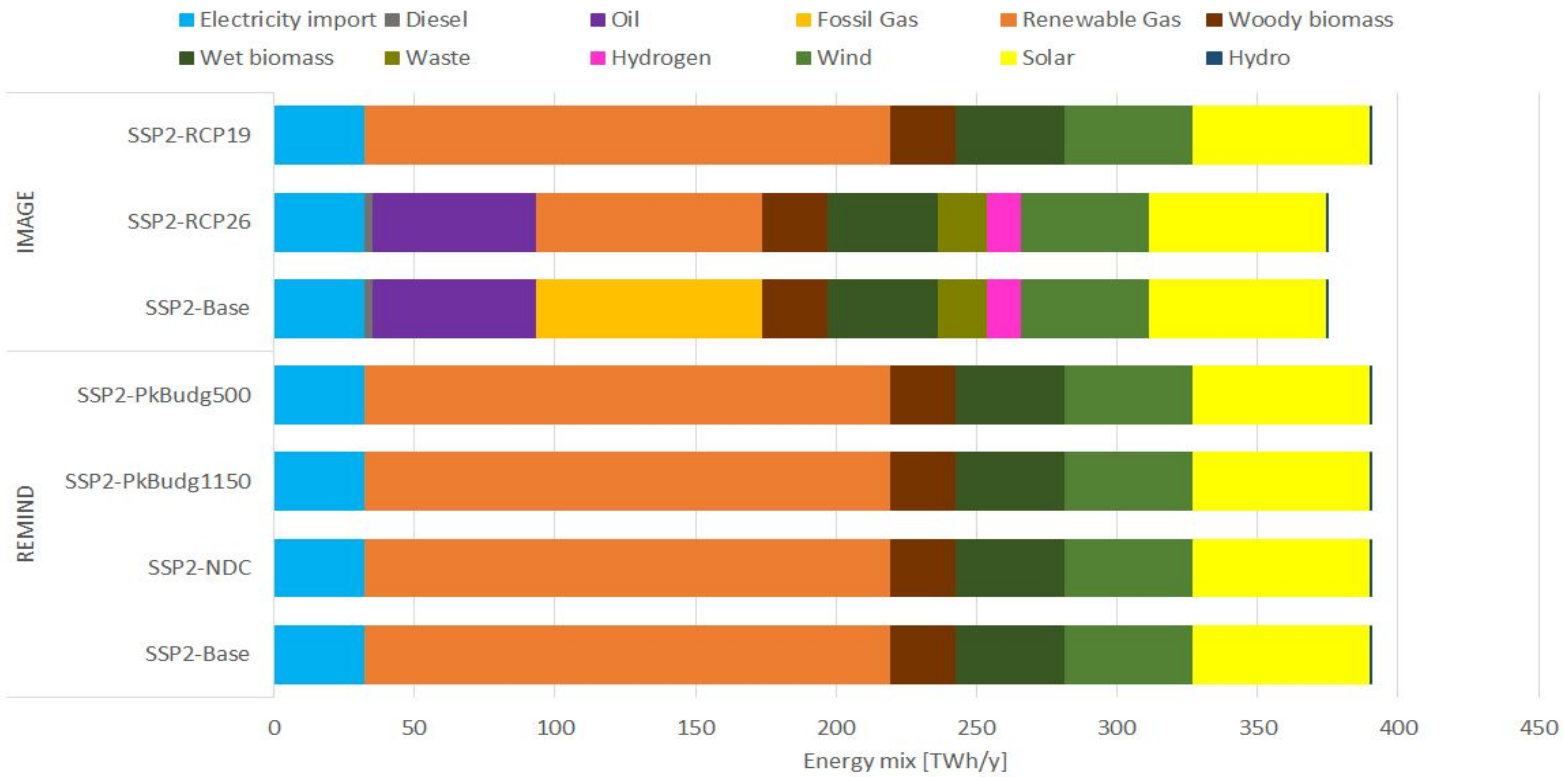
Optimal system emissions



Emission mix



Energy mix of the optimal energy system



Perspectives of the coupling

- Computing emissions of other renewable fuels
- Computing emissions of energy system infrastructures and assets

- Application on European energy system and feedback loop to regionalize :
  - Electricity mix in European countries
  - Heat mix
  - Vehicles fleets
  - …