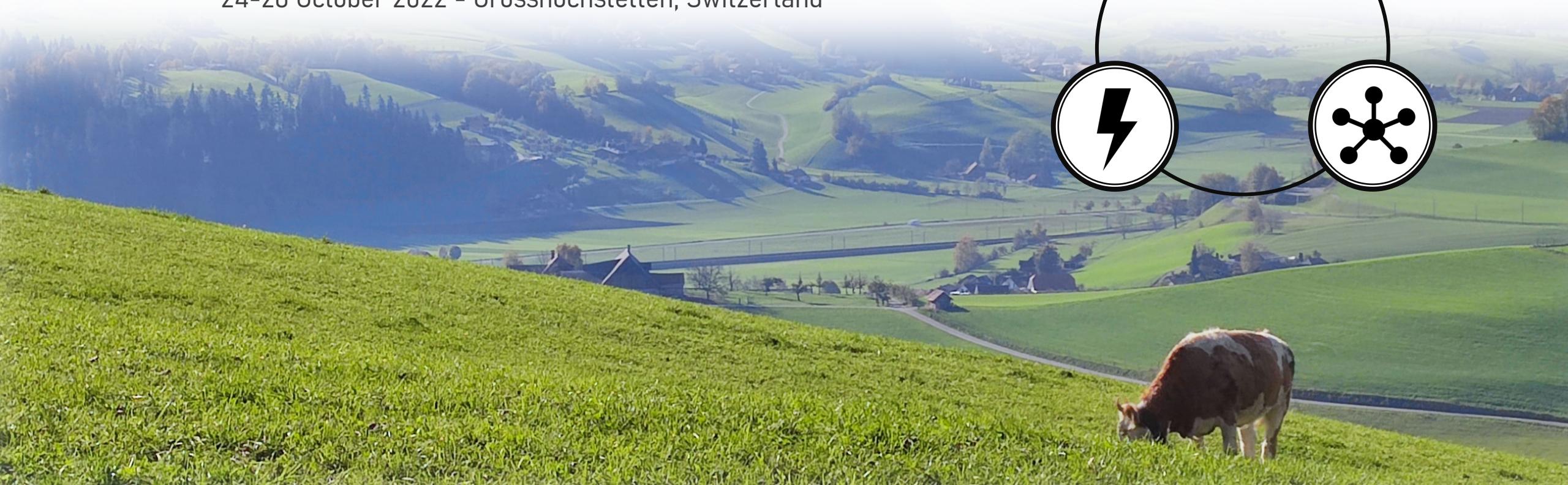
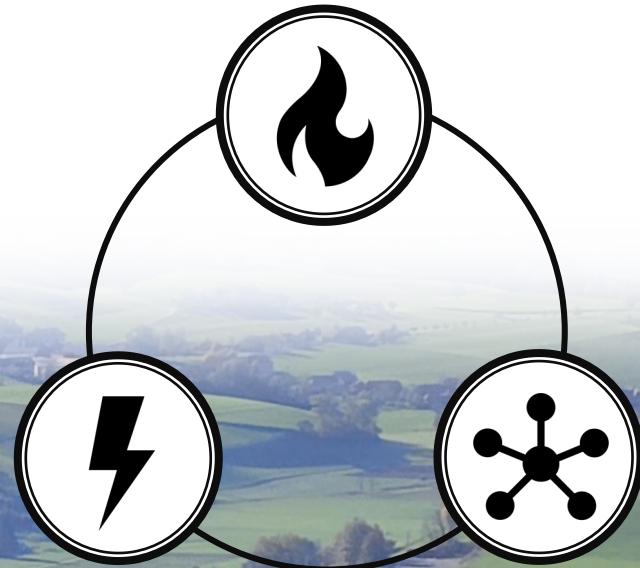


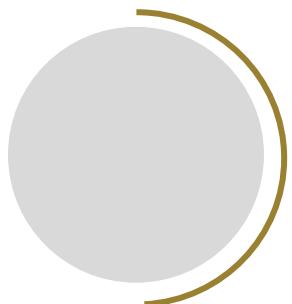
► JACCH-E

Electrification of Industrial Heat

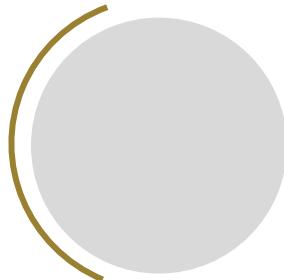
Autumn school "Open inventory data manipulation"
24-28 October 2022 - Grosshöchstetten, Switzerland



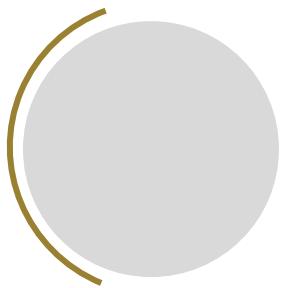
The Dream Team...



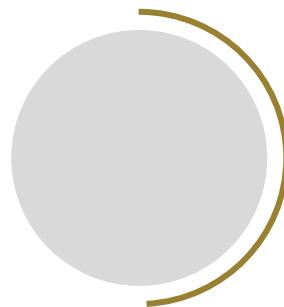
Joris Šimaitis
Orchestrator?..



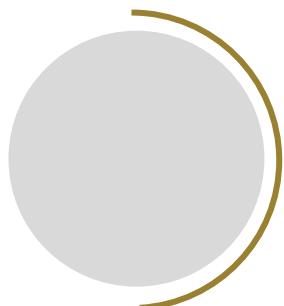
Christina Kockel
Electricity integration expert



Concetta Lodato
Energy market master



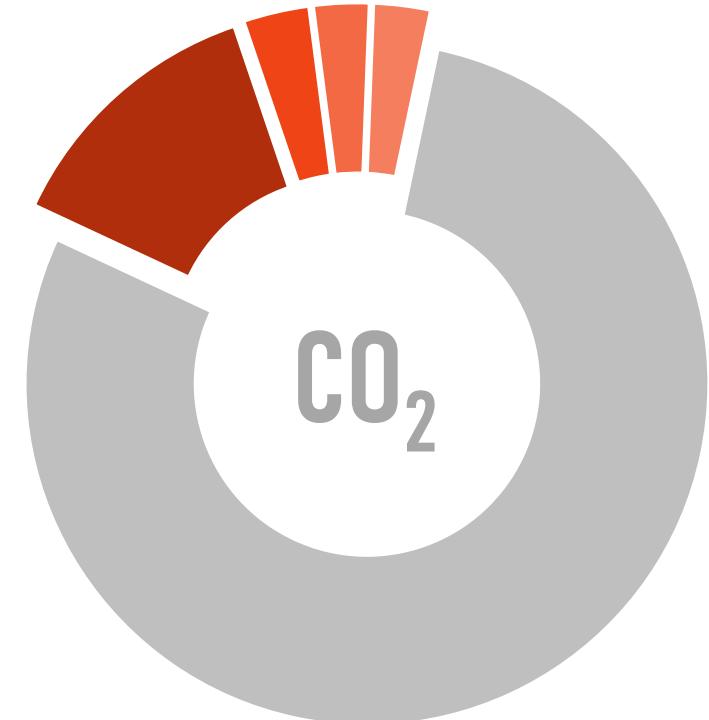
Hannes Schneider
Data packages guru



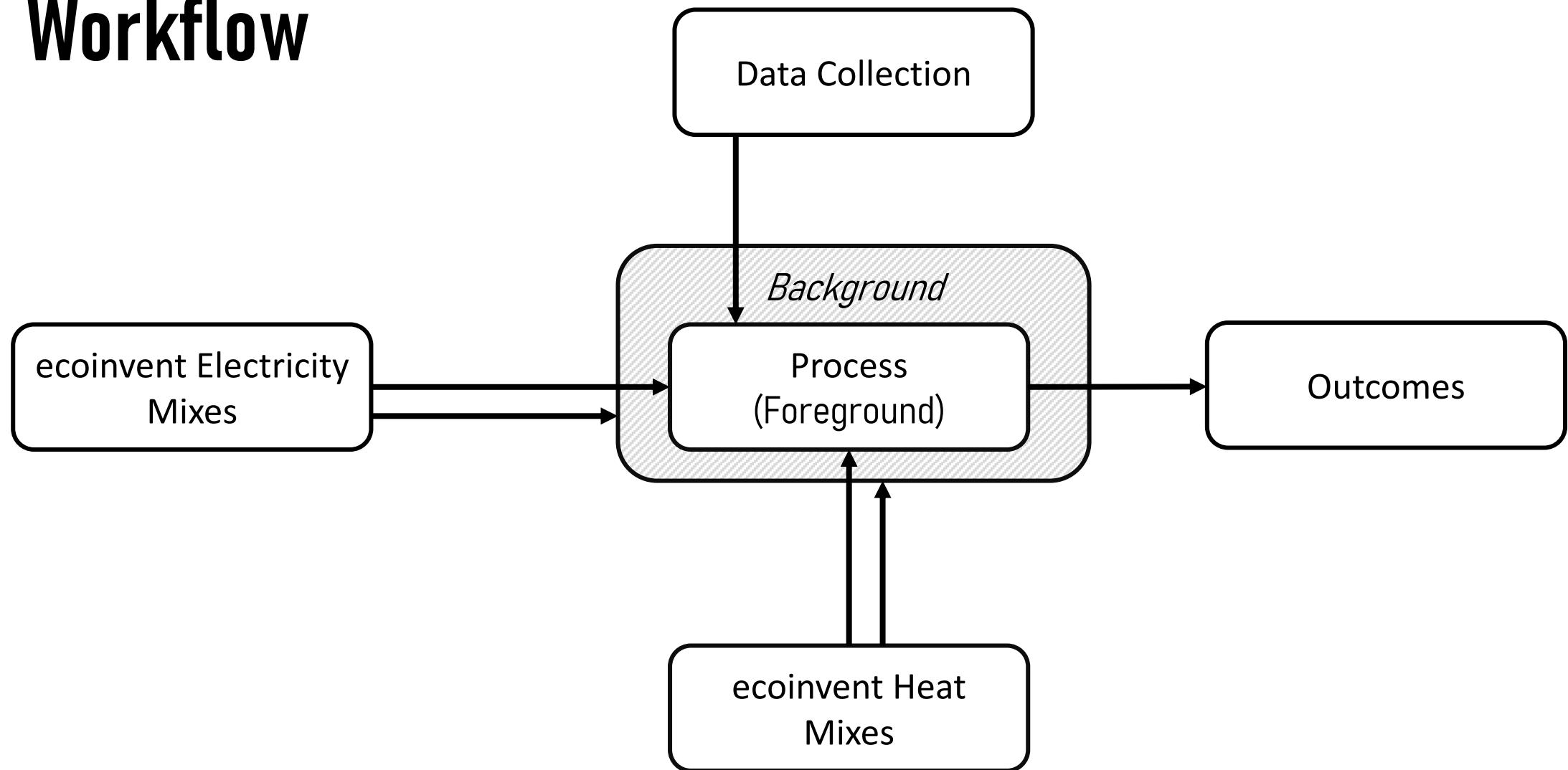
Alessandro Salvi
Process data engineer

Intro

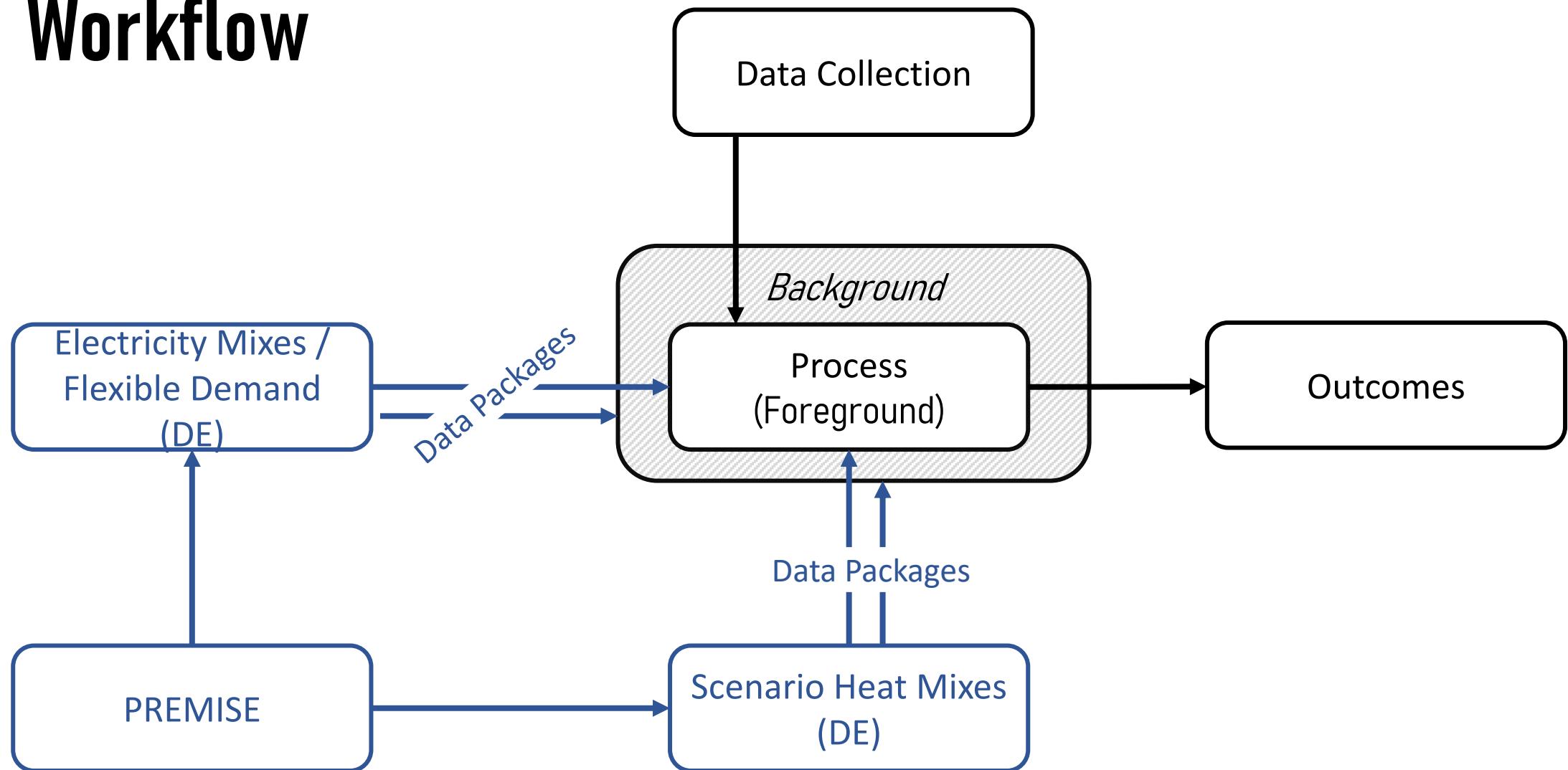
- Thermal energy key contributor to global CO₂ emissions – what if we electrify?
- Method to substitute heat activities with flexible, prospective electricity datasets
- Data packages – Regionalization - PREMISE



Workflow

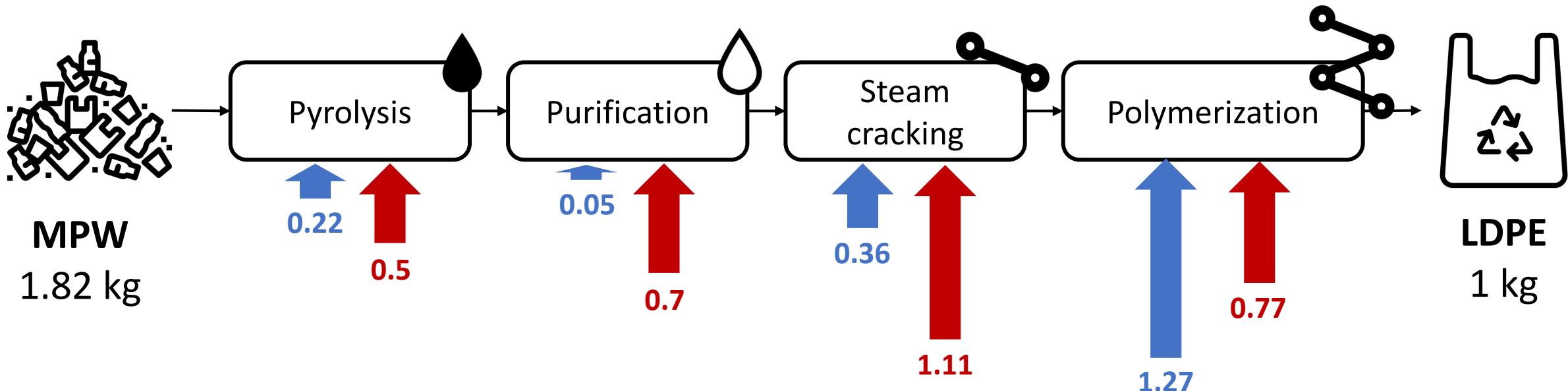


Workflow



Process

Production of LDPE by pyrolysis of Mixed Plastic Waste (MPW)



⚡ Electric energy (MJ)

🔥 Heat energy (MJ)

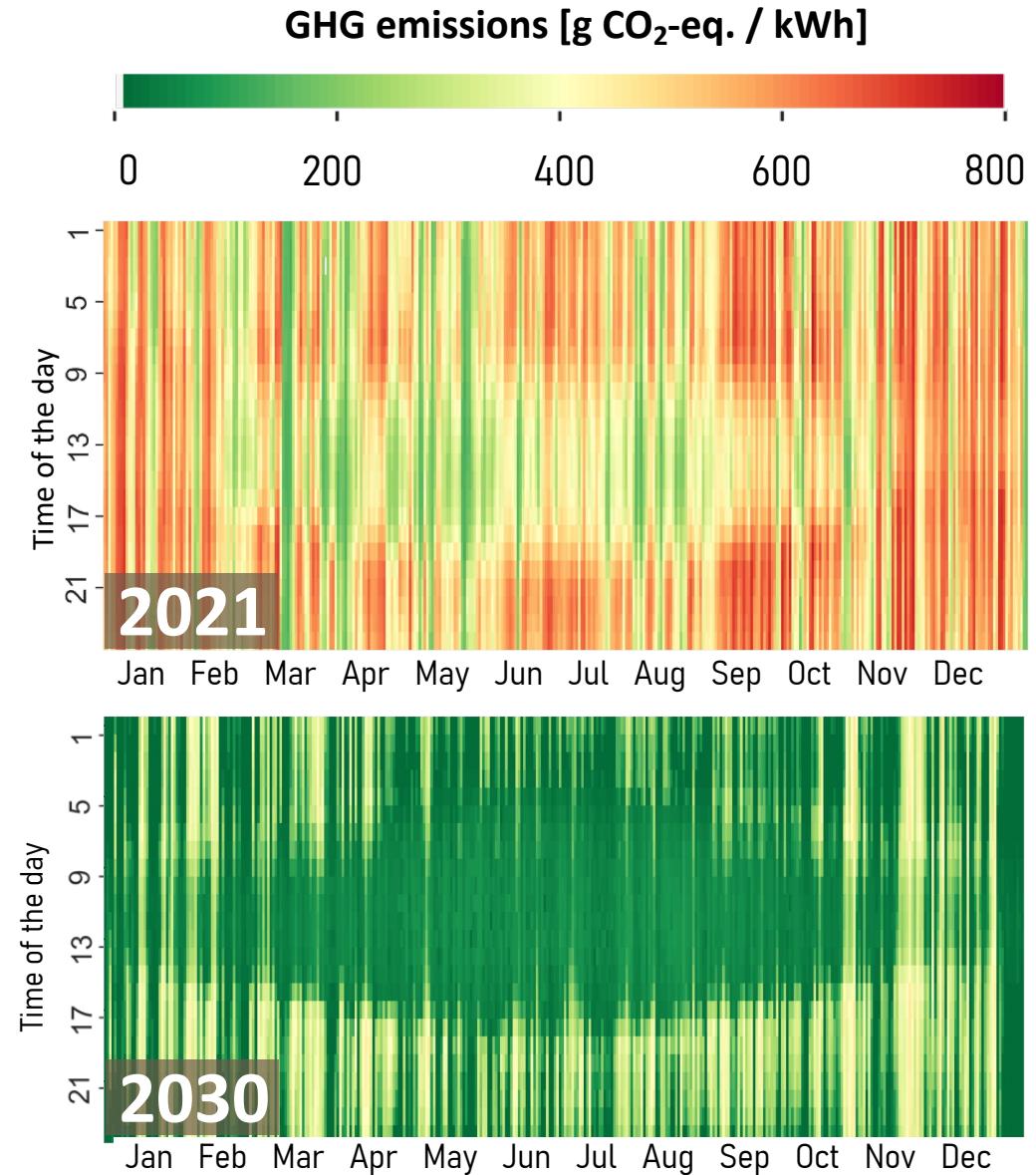
Energy Markets

- Electricity and heat market scenarios (2020, 2025, and 2030) created from PREMISE
- Production activities from ecoinvent matched with scenarios to create a database for Brightway2
- Challenges in identifying electricity within the heat processes; inputting H₂ into heating processes



Electricity

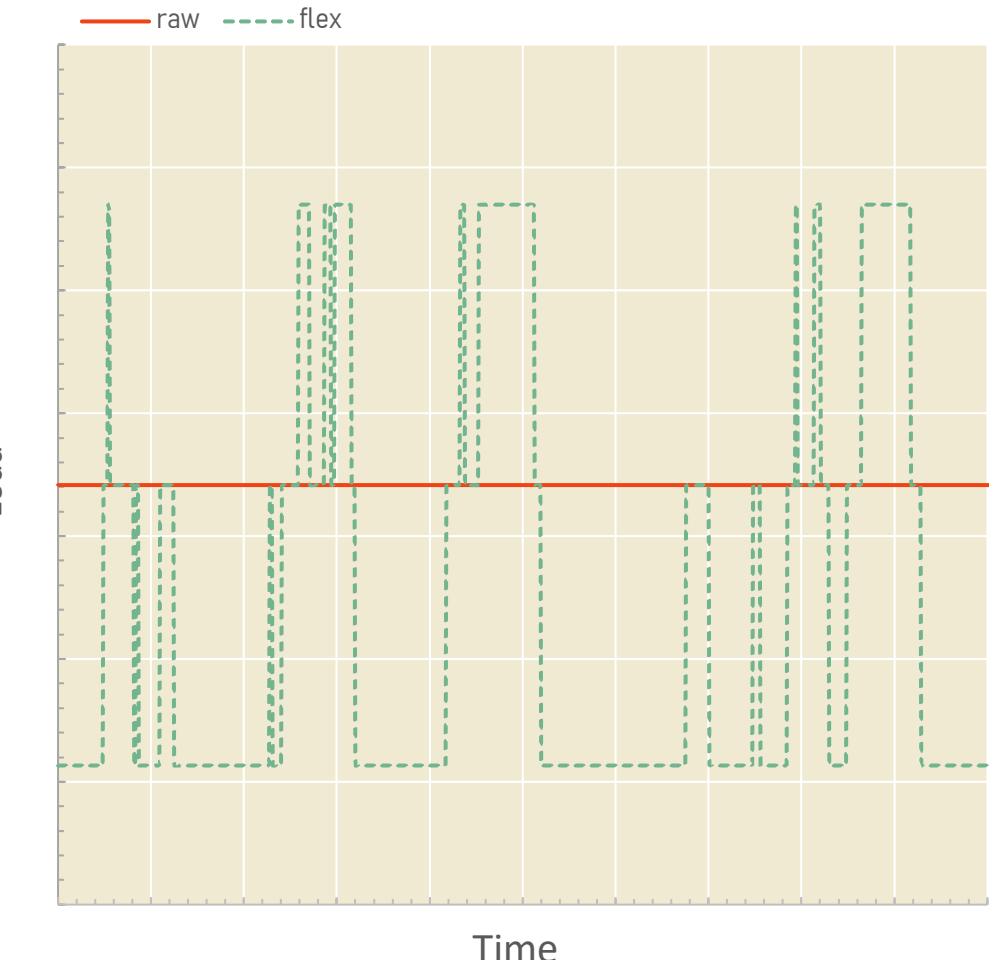
- German electricity mixes with hourly resolution time series.
- Scenarios for 2021, 2025, and 2030 based on energy system models.
- Load shifting from chemical industry based on GWP of the hourly electricity mix



Electricity

- German electricity mixes with hourly resolution time series.
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Example of load shifting



Integration

1 Recursive Processes

- Identify and get heat-electricity
- Foreground and background

```
def recurse_supply(act,max_depth, dic_heat_remove = defaultdict(float),
                  dic_el_remove= defaultdict(float)):
    global depth
    for exc in act.technosphere():
        if exc.input in heat_acts:
            #flow_list.append(np.array((exc.input.id, exc.output.id),
            #                          #bwp.INDICES_DTYPE))
            dic_heat_remove[exc.input] = exc['amount']
            #print(exc.input)
        elif exc.input in elek_acts:
            dic_el_remove[exc.input] = exc['amount']
        elif depth< max_depth:
            depth +=1
            dic_heat_remove, dic_el_remove= recurse_supply(exc.input,
                max_depth,dic_heat_remove, dic_el_remove)
    depth -= 1
    return dic_heat_remove, dic_el_remove
```

Integration

1 Recursive Processes

- Identify and get heat-electricity
- Foreground and background

2 Fossil Heat-Electricity Substitution

- Substitute and regionalize activities
- Y/N for electrifying heat/flexibility
- Create data packages

```
def replace_electricity_heat(process_name, process_loc, method, binary_var_electrification, max_depth):
    process = eiDB.search(process_name, filter={'location':process_loc})
    process = process[0]

    global depth
    depth=0

    dic_heat_remove, dic_el_remove=recurse_supply(process, max_depth)

    el_demand_process = sum([value for value in dic_el_remove.values()])
    heat_demand_process = sum([value for value in dic_heat_remove.values()])

    total_el_demanded = el_demand_process+ binary_var_electrification*heat_demand_process #
    total_heat_demanded = heat_demand_process * (1-binary_var_electrification)

    electrifying_heat = 10_000_000 ##create id dynamically - random number generator

    indices = np.array(
        [
            (electrifying_heat, electrifying_heat), # Production exchange for new motor
            (process.id, electrifying_heat),
        ] +
        [(node.id, electrifying_heat) for node in dic_el_remove] ##remove existing electricity
        ] +
        [(node.id, electrifying_heat) for node in dic_heat_remove] ##remove existing heat
        ] +
        [(node.id, electrifying_heat) for node in dic_powerplants_market] ## add Germany electricity mix
    ), dtype=bwp.INDICES_DTYPE
    )

    dp = bwp.create_datapackage()

    dp.add_persistent_vector(
        matrix="technosphere_matrix",
        data_array=data,
        indices_array=indices,
        flip_array=flip,
        name='electrifying_heat',
    )
```

Integration

1 Recursive Processes

- Identify and get heat-electricity
- Foreground and background

2 Fossil Heat-Electricity Substitution

- Substitute and regionalize activities
- Y/N for electrifying heat/flexibility
- Create data packages

3 LCA

- Compute LCA calculations

```
_ , data_objs, _ = bd.prepare_lca_inputs({process: 1}, method)

lca = bc.LCA({process.id: 1}, data_objs=data_objs + [dp])
lca.lci()
lca.lcia()
lca.score
print(lca.score)

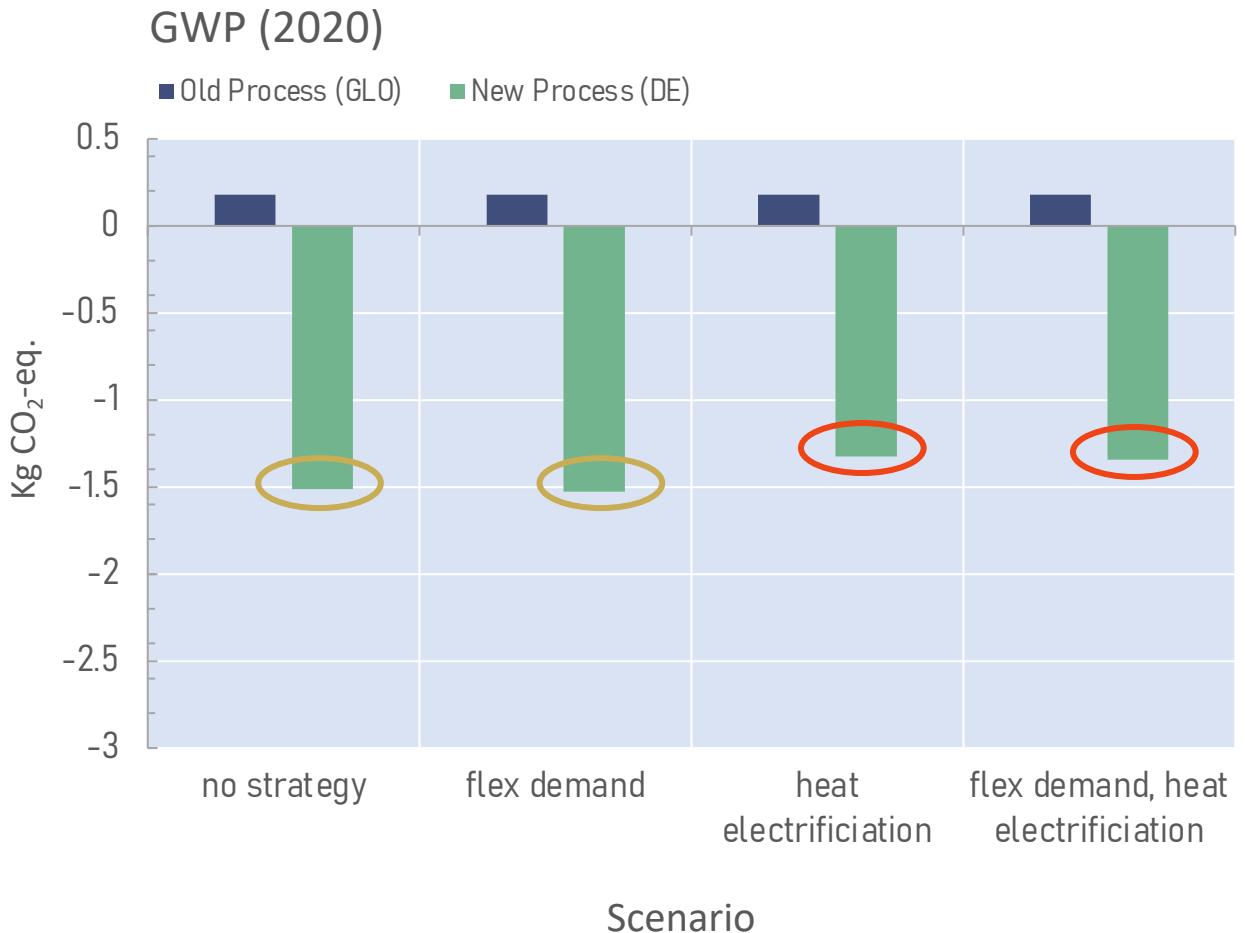
lca.lcia({electrifying_heat: 1})
lca.score
print(lca.score)

name_new_process = str('electrification'+process_name+'_'+process_loc)

return ([name_new_process,dp, indices, data, flip, dic_el_remove])
```

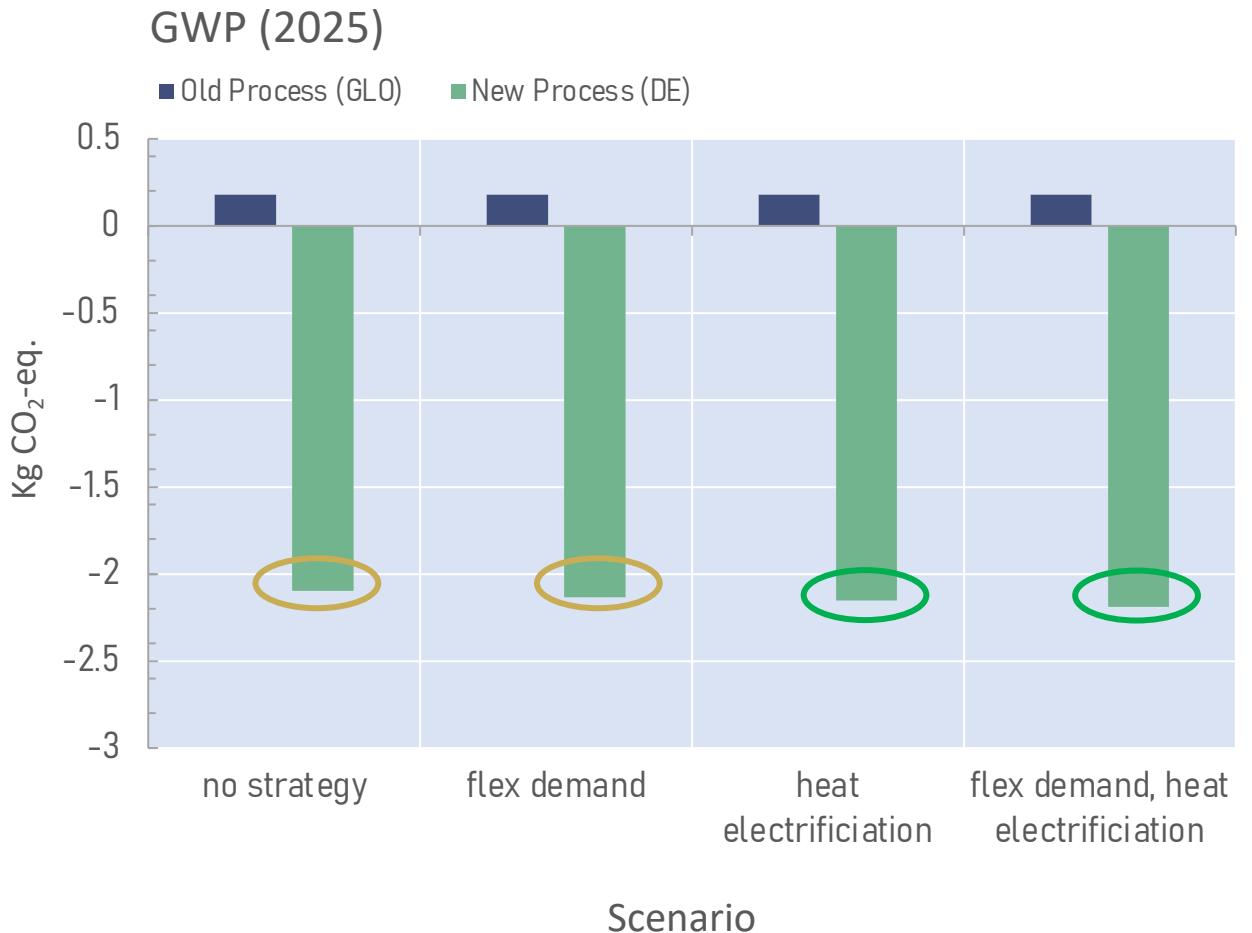
Outcomes

- Interesting results... We've solved climate change! ;-)
- Nonetheless... in current heat-electricity systems, electrifying heat has a higher GWP.



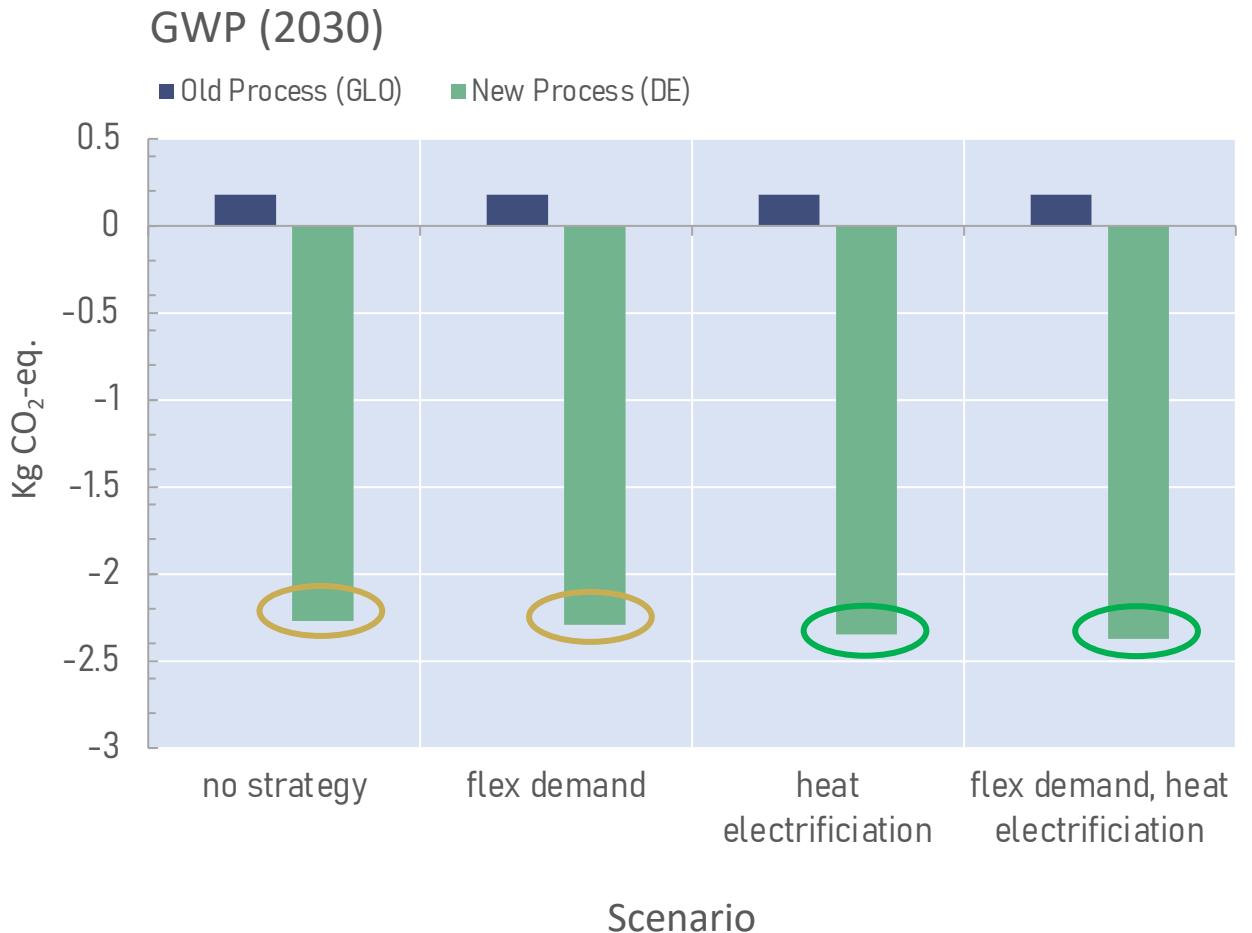
Outcomes

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- With future decarbonization, electrifying heat leads to a lower GWP



Outcomes

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- Nonetheless... in current heat-electricity systems, electrifying heat has a higher GWP.
- With future decarbonization, electrifying heat leads to a lower GWP



Challenges

Process Data	<ul style="list-style-type: none">Finding reliable and consistent data for a process (pyrolysis) that currently has a limited industrial implementation
Energy Markets (PREMISE)	<ul style="list-style-type: none">Matching scenarios and technologies between ecoinvent e.g. H₂ inventories
Electricity	<ul style="list-style-type: none">Incorporating flexibilization into the model (simplified approach)
Integration	<ul style="list-style-type: none">Importing BW2 project in BW25 environmentMerging electricity/ processes / heat mixes didn't fully workMore time was needed to integrate all aspects of the projectDebugging code... (Obviously!)

Repository: <https://github.com/Akxst/JACCH-E>

Reflections

	+ Understanding the full potential of Brightway - Advanced course difficult for beginners
	+ Working with multidisciplinary people from different interests - Intense to digest exercises and concepts
	+ Advanced and challenging nature of course - Intense to digest exercises and apply to project
	+ Challenging nature and realising potential Brightway - Limited time to digest and practice exercises
	+ Understanding the “behind-the-scenes” of Brightway - Intense to apply exercise to group work

J A C C H → E

THANK YOU!

Questions?