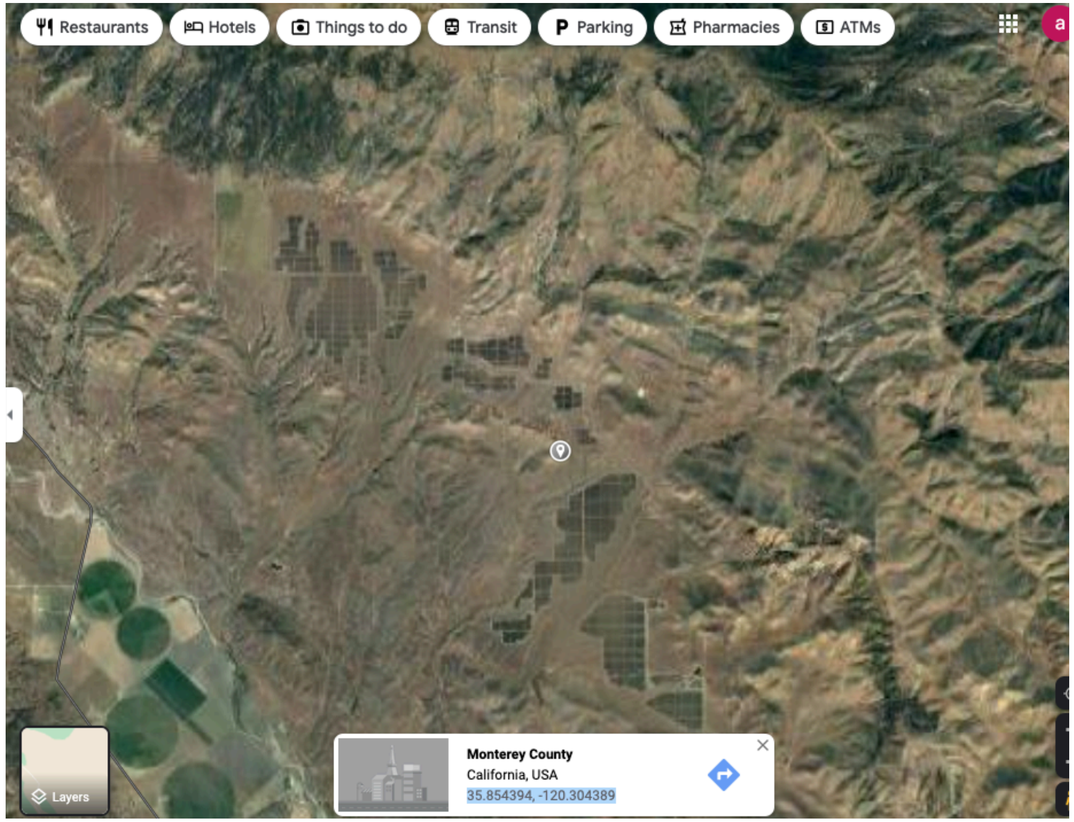
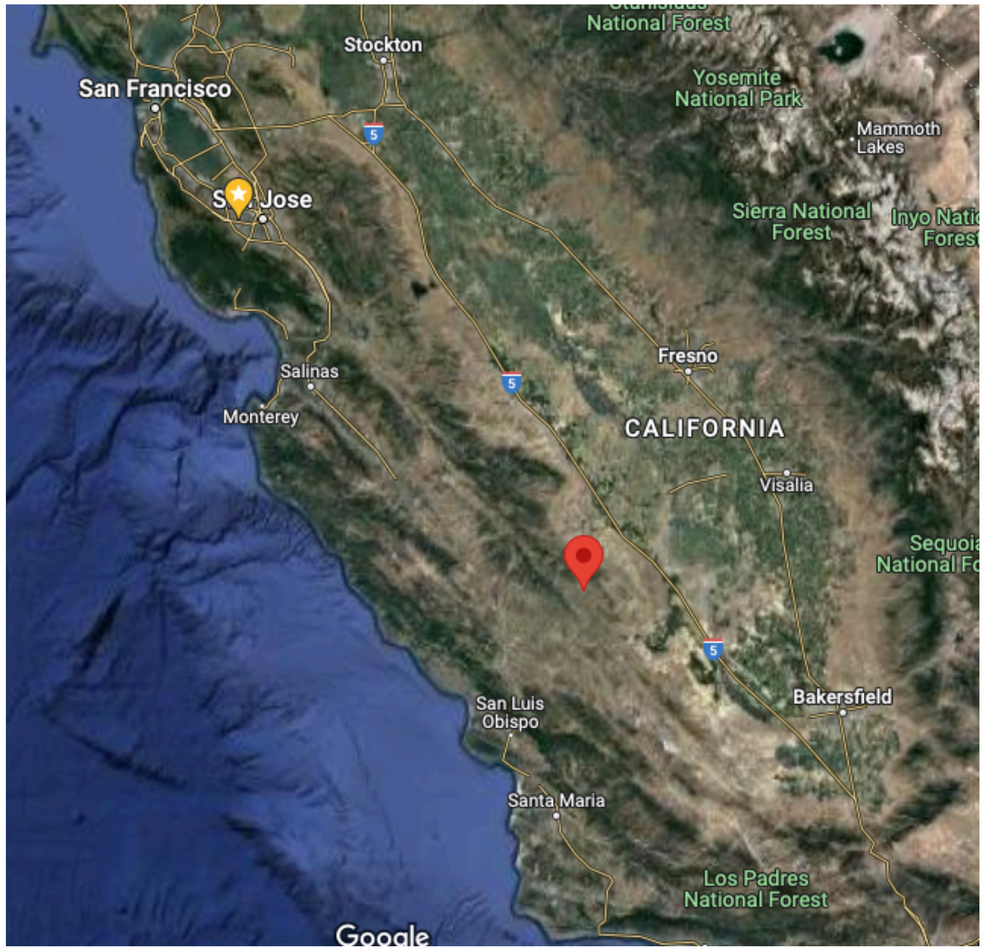
APPLAUSE project meeting

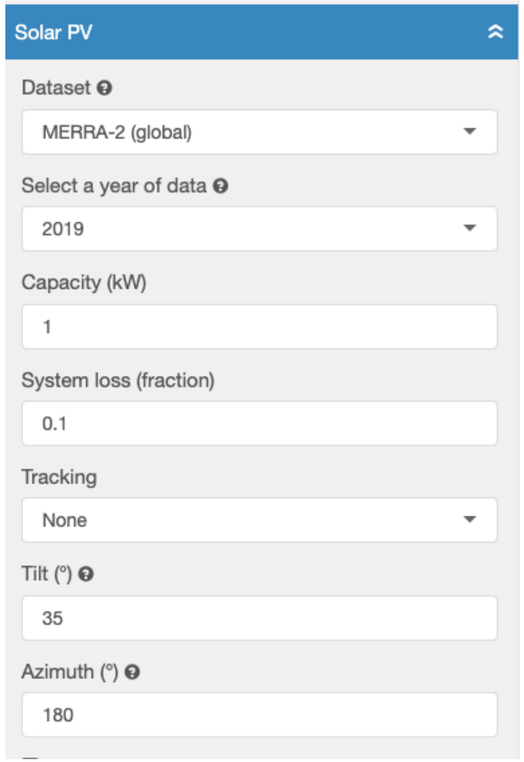
25 October

California flats

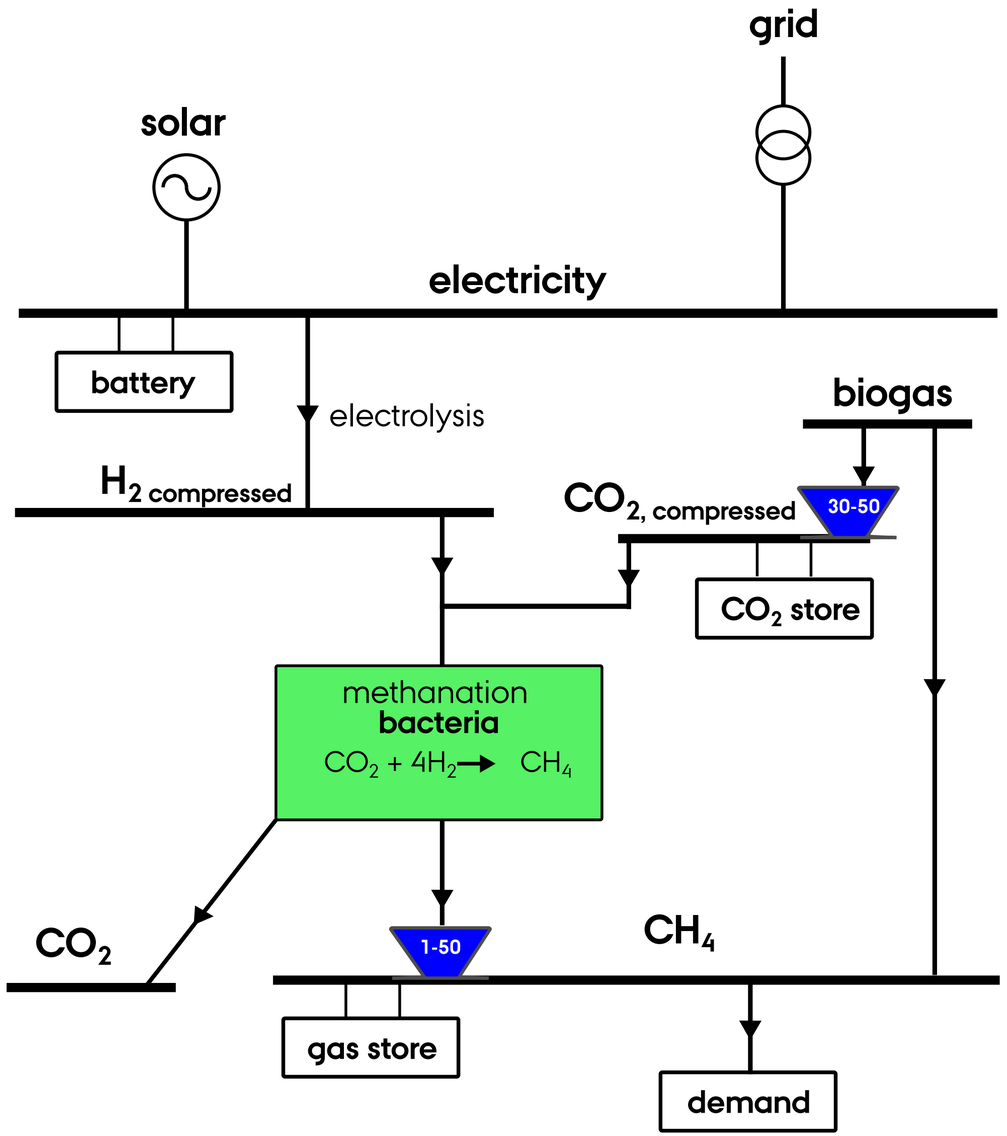




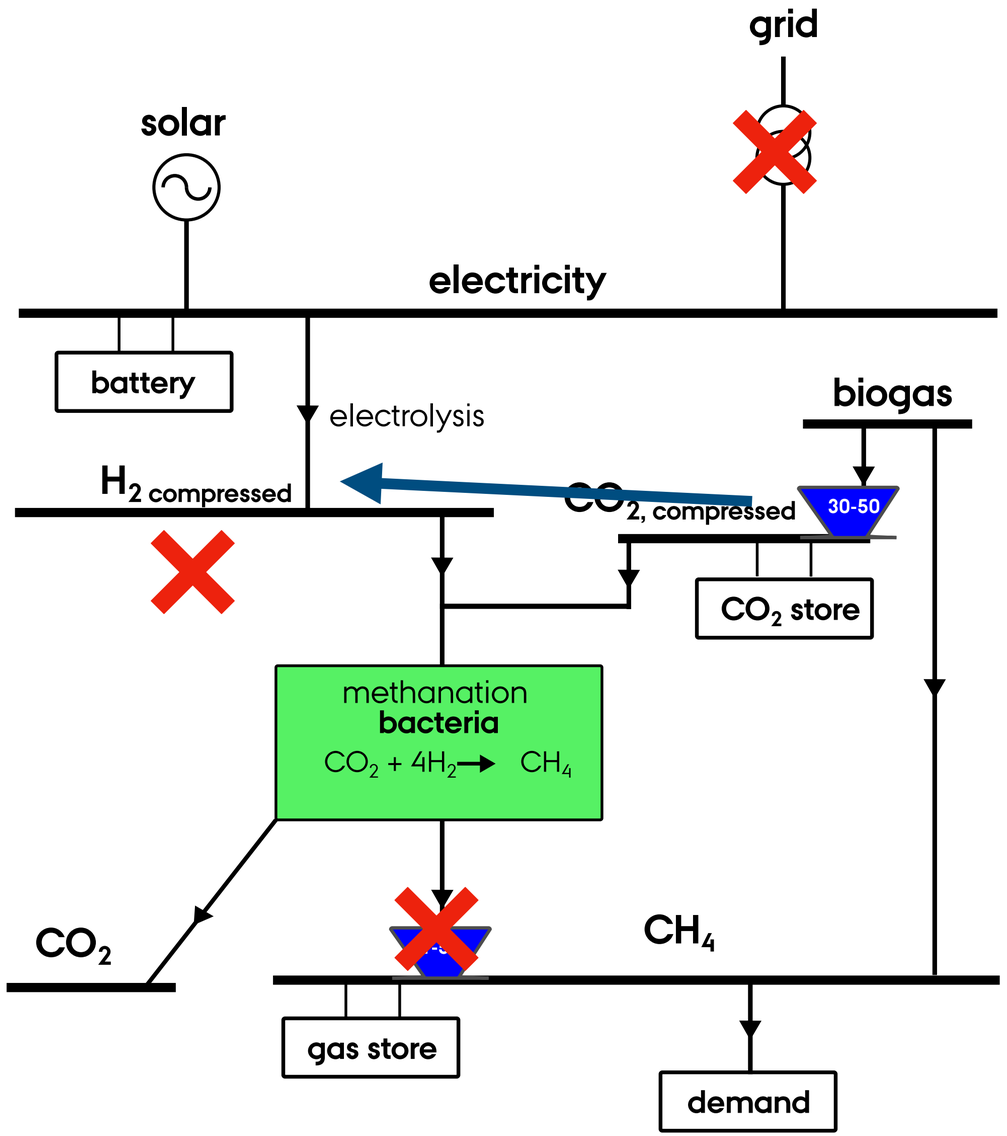
- Using the default assumptions about the solar installation
-



Model


grid
solar
electricity
battery
electrolysis
biogas
H_2 compressed
CO_2, compressed
30-50
CO_2 store
methanation
bacteria
$CO_2 + 4H_2 \rightarrow CH_4$
CO_2
1-50
CH_4
gas store
demand

Model


grid
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CO_2 store
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CO_2
CH_4
gas store
demand

Limitations

- No electricity grid
- No hydrogen storage
- Free biogas, unlimited biogas

Cost assumptions

S1. Cost assumptions

Table S1: Efficiency, lifetime and FOM cost per technology (values shown corresponds to 2020).

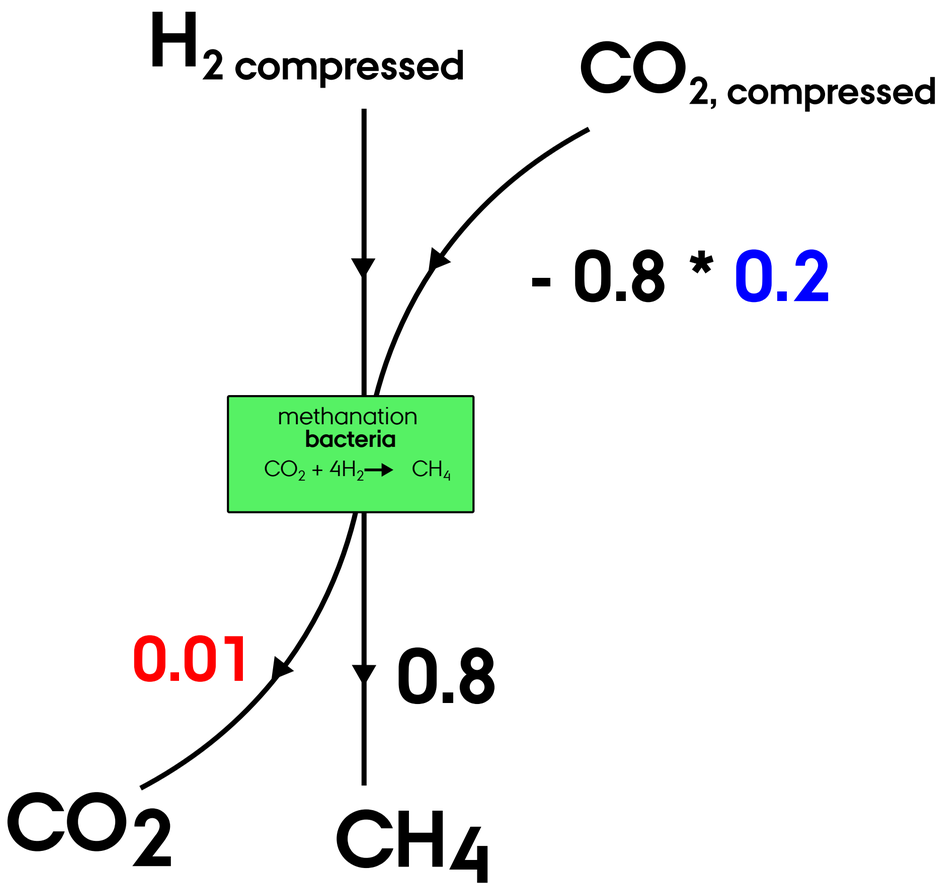
Technology	Unit	2025 Cost	FOM[a]	Lifetime	Efficiency	Source
	[%/a]	[a]				
Solar PV (utility-scale)	€/kW	452	1.6	35		[1]
Battery storage	€/kWh	187		20		[1]
Battery inverter	€/kW	215	0.2	10	0.95	[1]
Electrolysis	€/kW$_{el}$	550	2.0	25	0.66	[1]
Methanation	€/kW$_{CH4}$	278	4.0	30	0.8	[2]
methanogens	€/kW$_{CH4}$	834	4.0	30	0.8	
biogas generator	€/kW$_{CH4}$	0			0.9	
CO2 storage	€/kWh	0				
gas storage	€/kWh	0				

Difference

- Sabatier vs methanogen
  - Assuming that methanogenesis is 3x cost of sabatier
  - Sabatier uses electricity

Methanogens

Efficiencies



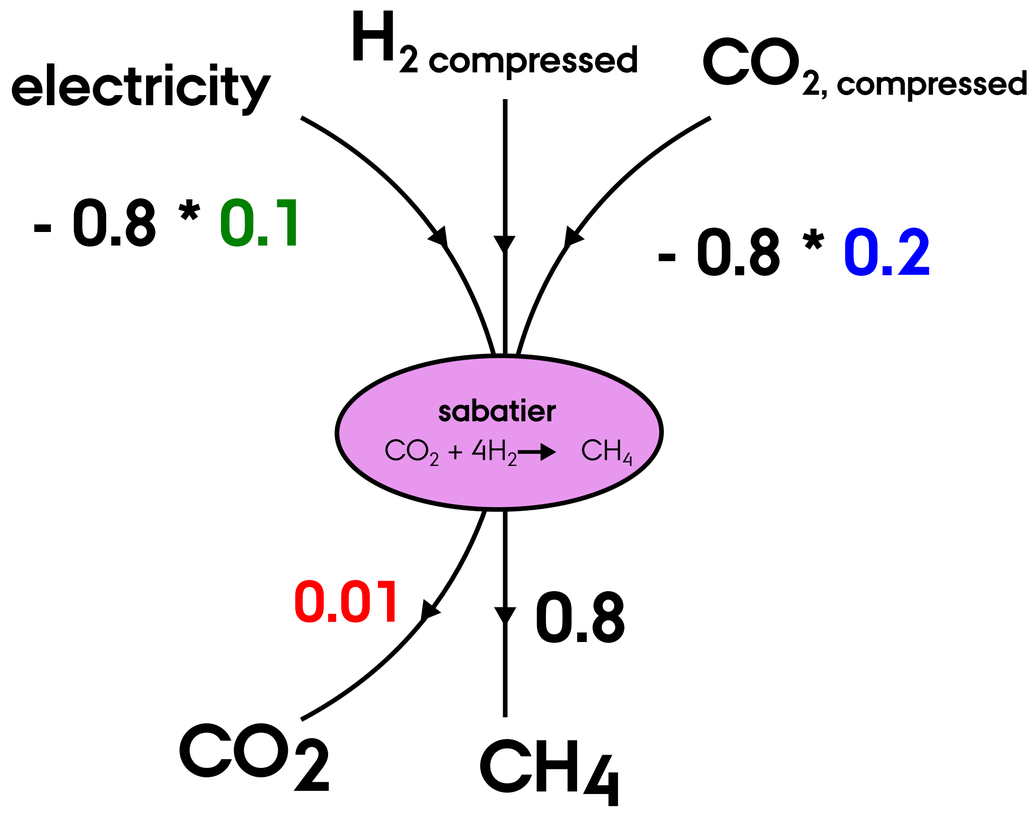
Sabatier eff

CO2 intensity/MW CH4

CO2 emissions/MW CH4

Sabatier

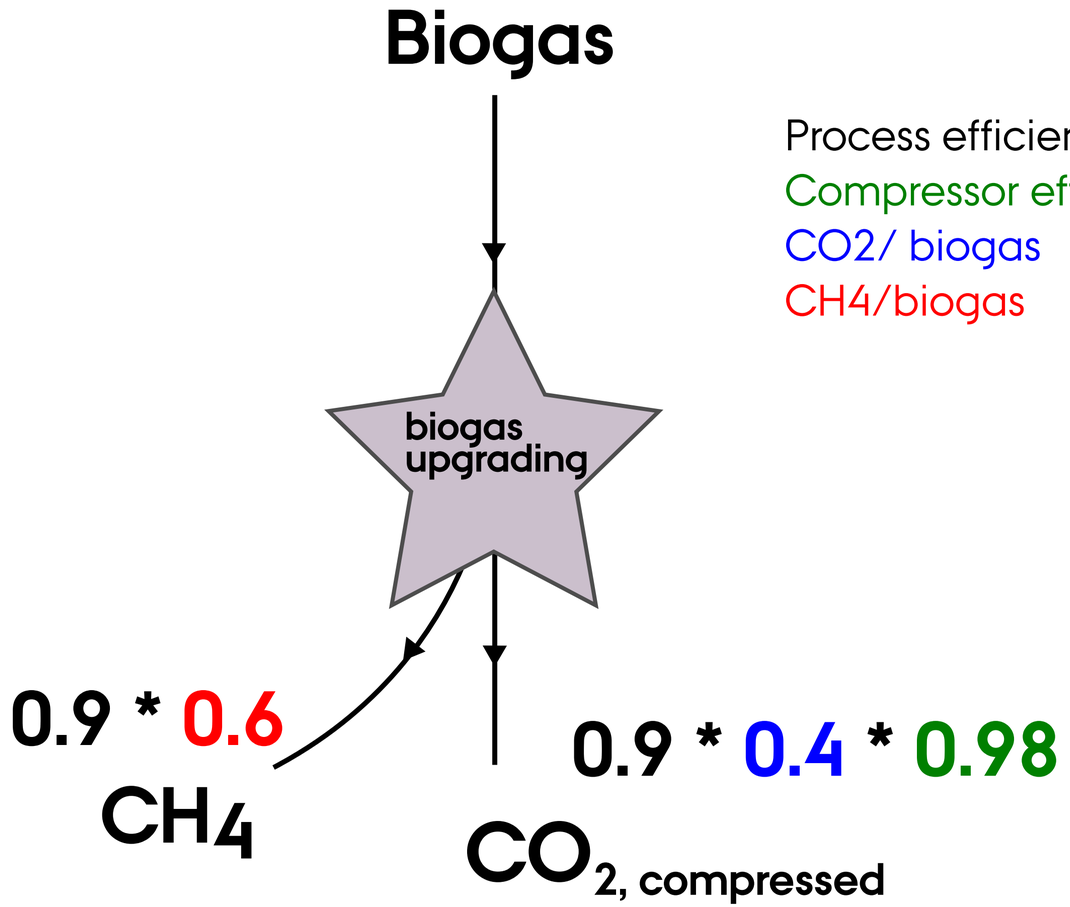
Efficiencies



Sabatier eff
MW Electricity/MW CH4
MW CO2/MW CH4
CO2 emissions/MW CH4

Biogas upgrading

Efficiencies



Process efficiency
Compressor efficiency
CO2/ biogas
CH4/biogas

Results

Objective

methanogen

```
n.objective
6126.647634826454
```

sabatier

```
n.objective
5535.379865817146
```

Results

Generators

methanogen

```
Generator
Solar PV    21.139298
Biogas       1.953359
Name: p_nom_opt, dtype: float64
```

sabatier

```
Generator
Solar PV    21.963748
Biogas       1.989954
Name: p_nom_opt, dtype: float64
```

CO2 store = 0 because CO2 is used instantly?
CO2 env = 0 because of typo

Results

Links

methanogen

Link	p_nom_opt
To CO2 store	0.000000
From CO2 store	0.000000
battery charger	10.252560
battery discharger	15.749899
To gas store	3.600432
From gas store	26276.399568
To CO2 environment	0.000000
From CO2 environment	0.000000
H2 Electrolysis	5.179128
Biogas upgrading	1.562687
methanogens	3.445726

sabatier

Link	
To CO2 store	0.000000
From CO2 store	0.000000
battery charger	10.674232
battery discharger	12.288173
To gas store	3.667883
From gas store	26276.332117
To CO2 environment	0.000000
From CO2 environment	0.000000
H2 Electrolysis	5.276155
Biogas upgrading	1.591963
sabatier	3.510279

Results

Stores

methanogen

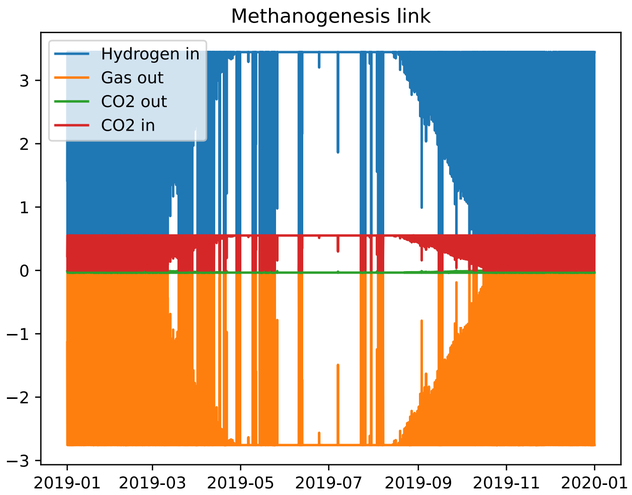
```
Store
CO2 compressed store        0.000000
battery                    68.350246
gas store                26276.399568
CO2 environment             0.000000
Name: e_nom_opt, dtype: float64
```

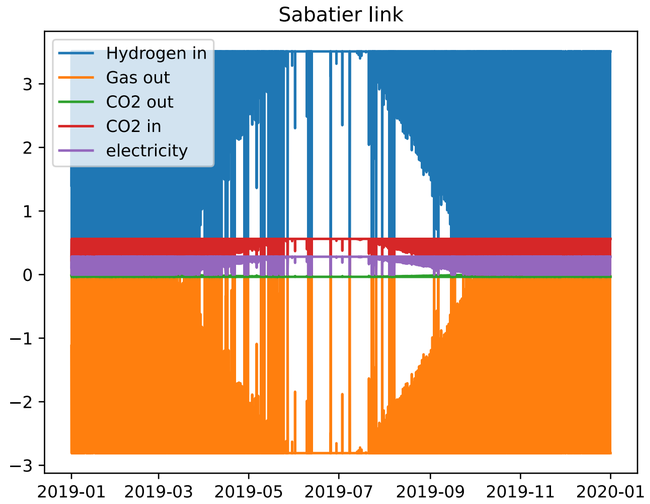
sabatier

```
Store
CO2 compressed store        0.000000
battery                    71.466430
gas store                26276.332117
CO2 environment             0.000000
Name: e_nom_opt, dtype: float64
```

Results

Methanation link



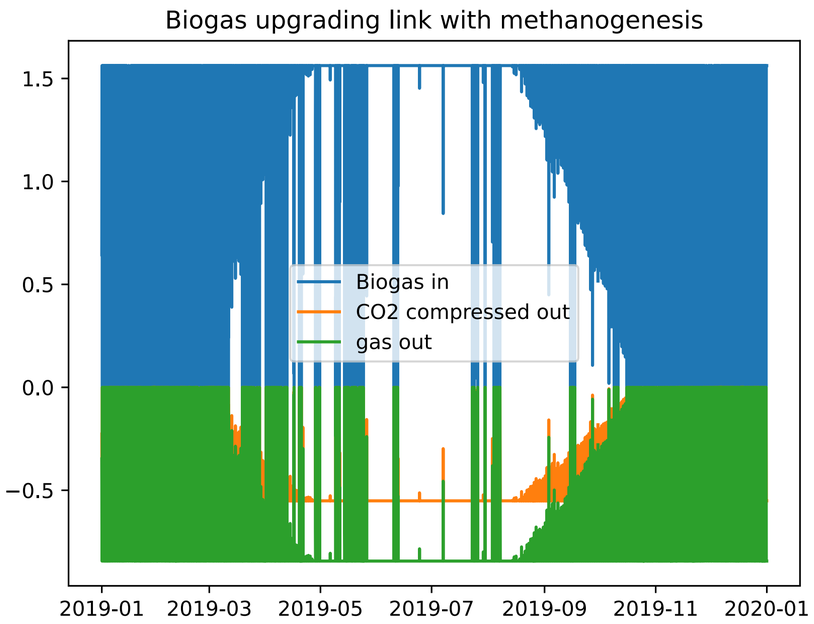


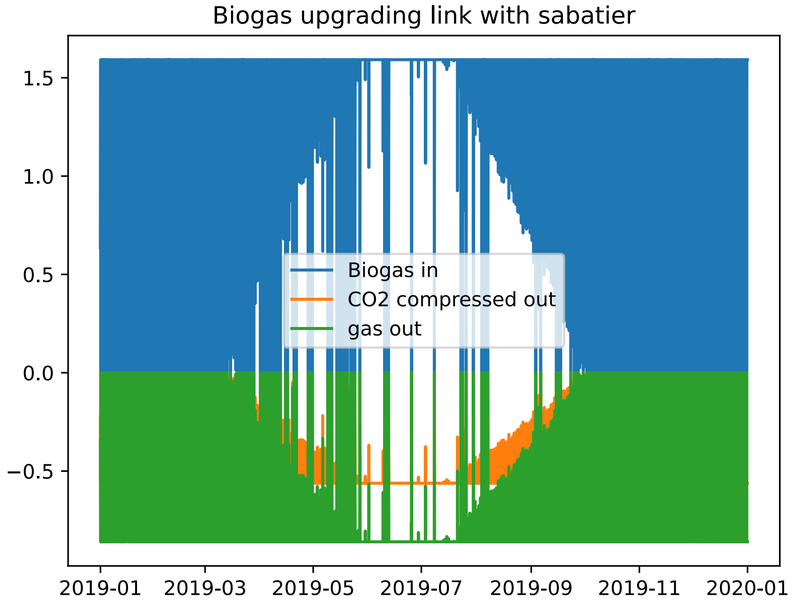
methanogen

sabatier

Results

Biogas upgrading link



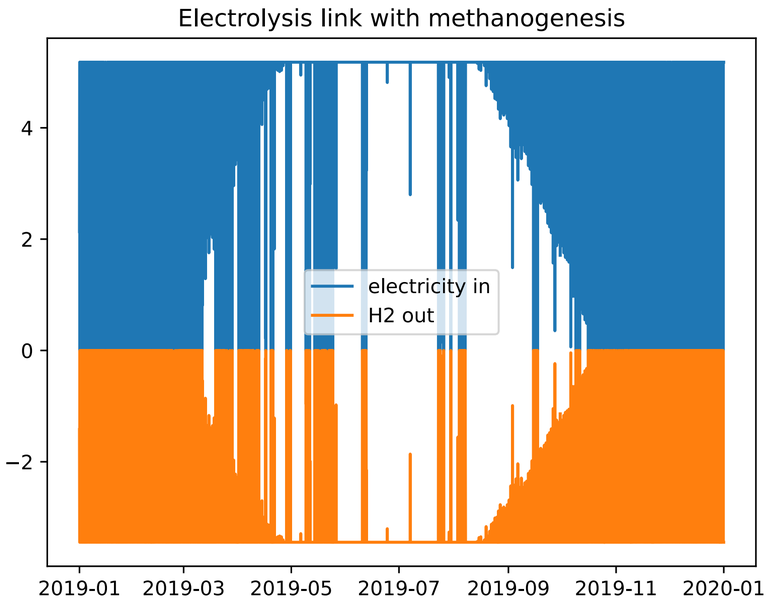


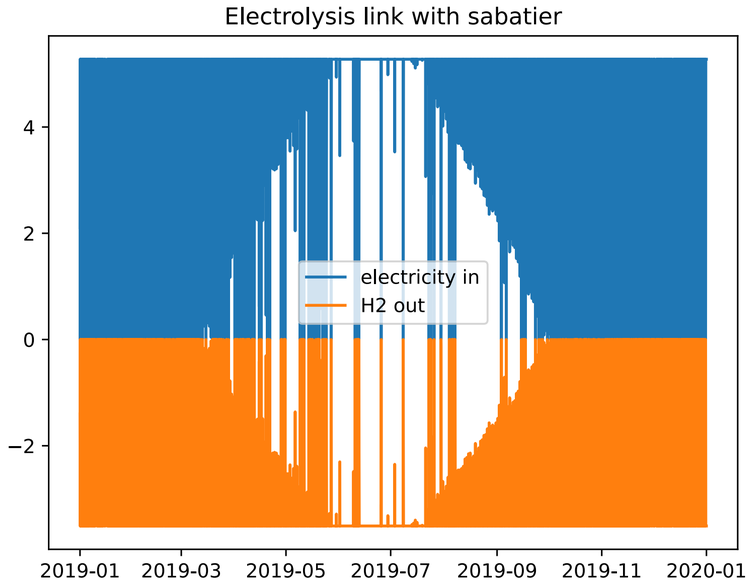
methanogen

sabatier

Results

Electrolysis



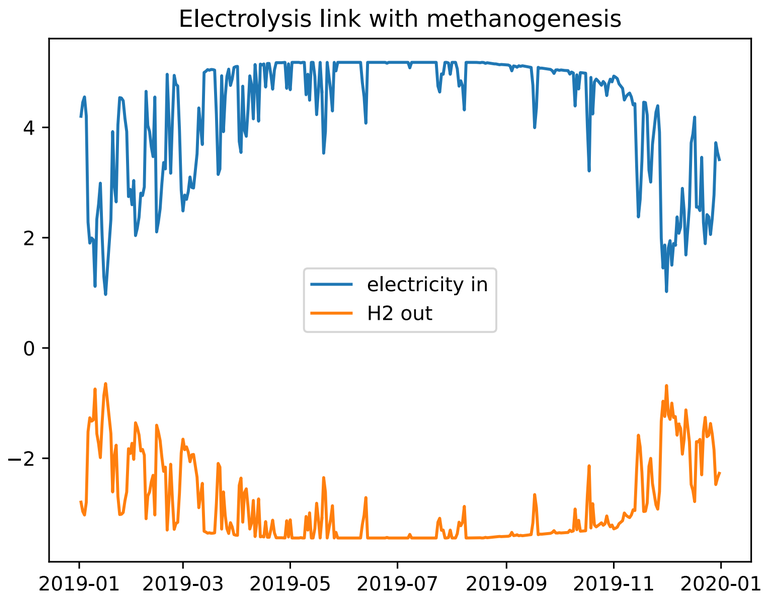


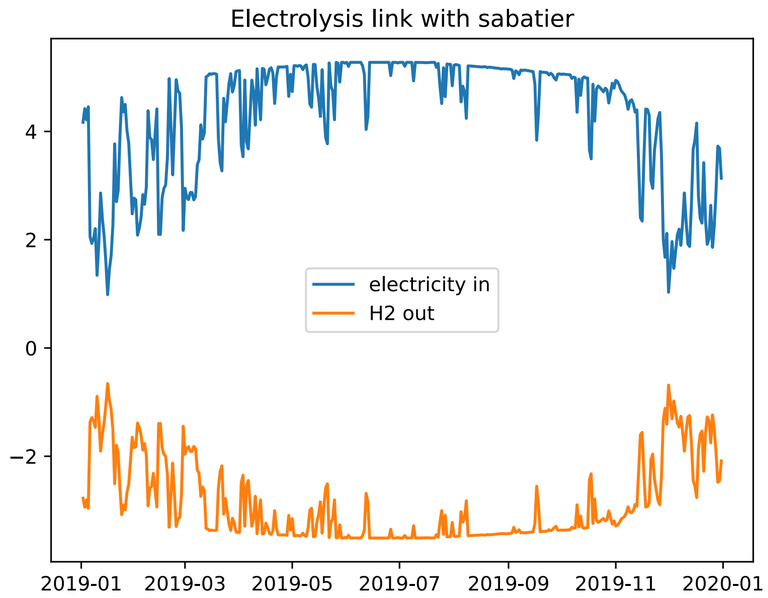
methanogen

sabatier

Results

Electrolysis



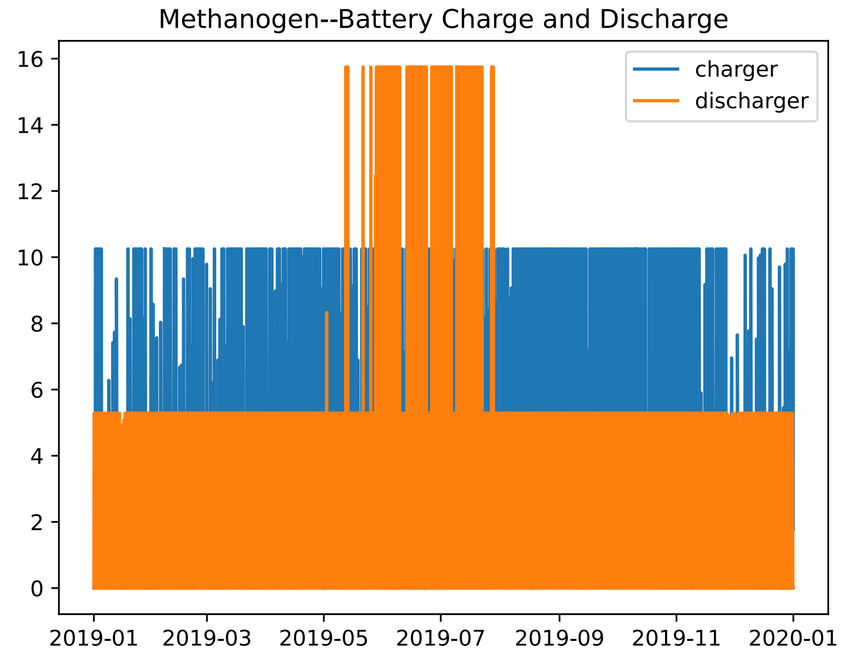


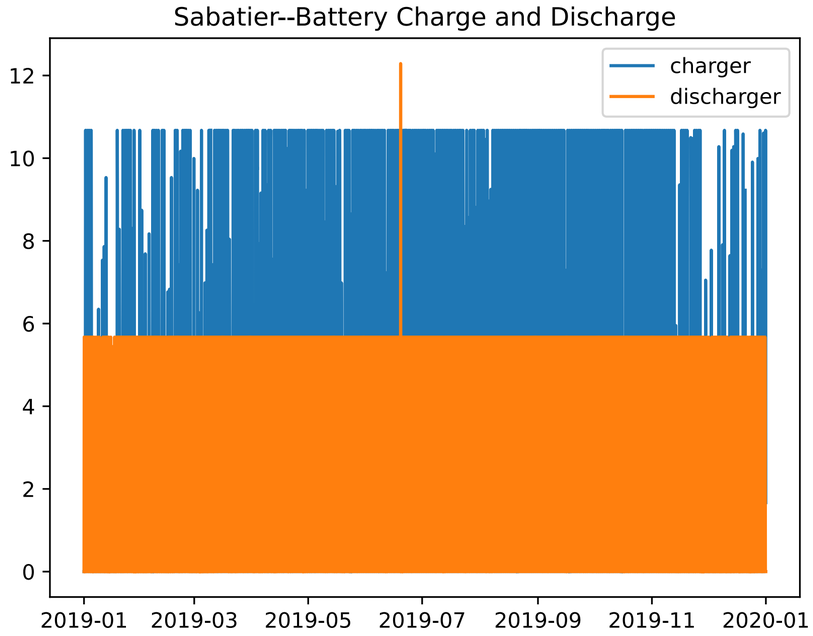
methanogen

sabatier

Results

Electricity battery



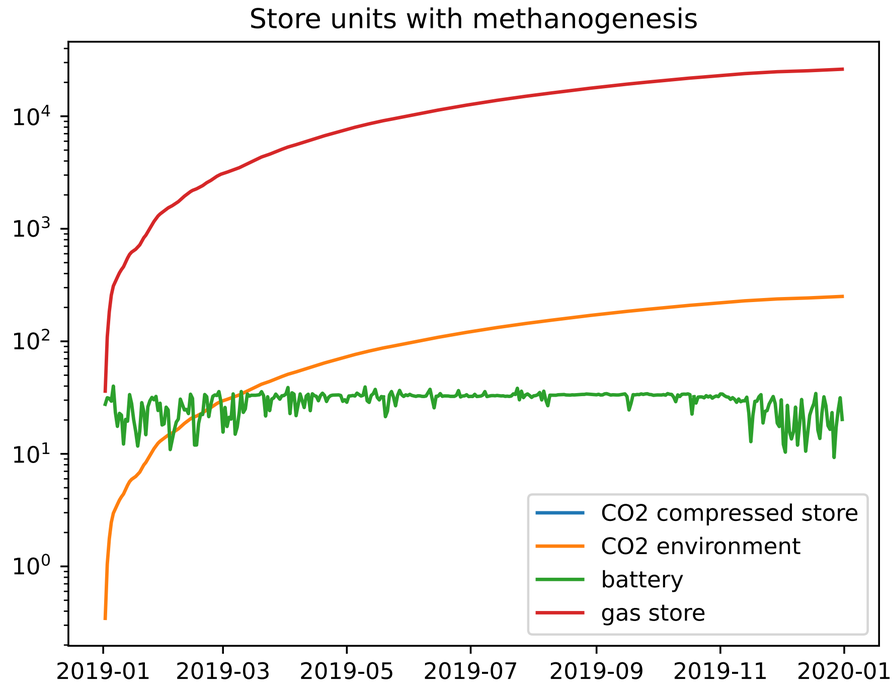


methanogen

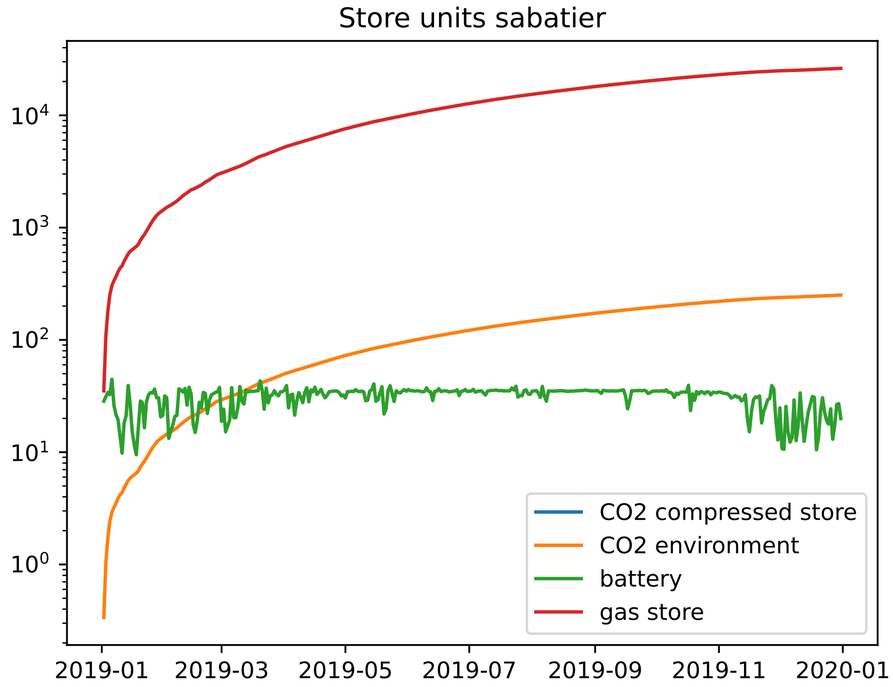
sabatier

Results

Storage



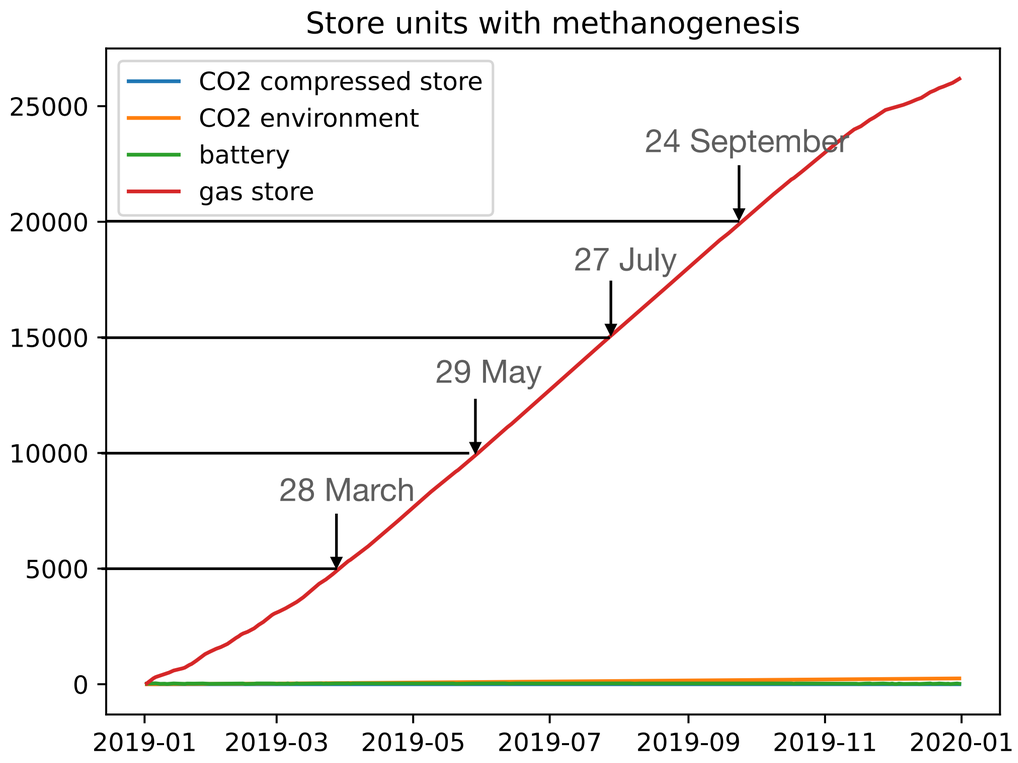
methanogen



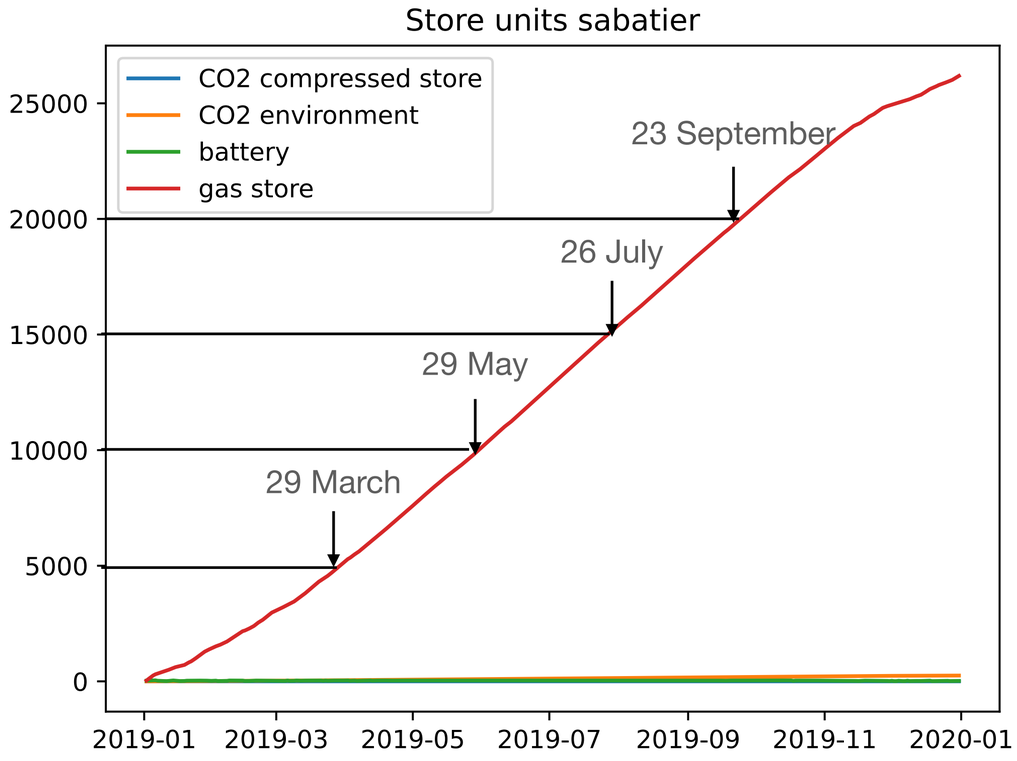
sabatier

Results

Storage



methanogen



sabatier

Research Question

- What percentage of methane is from the biogas source vs the methane source?

- Answer: 6150 kWh/26280 kWh = 23.4%

Research Question

- What is the proportion of the relative costs?
- A: mostly electrolysis/methanogen process

Research Question

```
In [183]: n.generators['capital_cost']
Out[183]:
Generator
Solar PV    95.329548
Biogas       0.000000
Name: capital_cost, dtype: float64

In [184]: n.links['capital_cost']
Out[184]:
Link
To CO2 store             0.000000
From CO2 store           0.000000
battery charger         38.263954
battery discharger       0.000000
To gas store             0.000000
From gas store           0.000000
To CO2 environment       0.000000
H2 Electrolysis        273.559662
Biogas upgrading         0.000000
methanogens            336.045303
Name: capital_cost, dtype: float64

In [185]: n.stores['capital_cost']
Out[185]:
Store
CO2 compressed store     0.000000
battery                 16.743523
gas store                0.000000
CO2 environment          0.000000
Name: capital_cost, dtype: float64
```

methanogen

```
In [188]: nsab.generators['capital_cost']
Out[188]:
Generator
Solar PV    95.329548
Biogas       0.000000
Name: capital_cost, dtype: float64

In [189]: nsab.links['capital_cost']
Out[189]:
Link
To CO2 store             0.000000
From CO2 store           0.000000
battery charger         38.263954
battery discharger       0.000000
To gas store             0.000000
From gas store           0.000000
To CO2 environment       0.000000
H2 Electrolysis        273.559662
Biogas upgrading         0.000000
sabatier               112.015101
Name: capital_cost, dtype: float64

In [190]: nsab.stores['capital_cost']
Out[190]:
Store
CO2 compressed store     0.000000
battery                 16.743523
gas store                0.000000
CO2 environment          0.000000
Name: capital_cost, dtype: float64
```

sabatier

Next steps

- Change costs?
- Add right compressors?
- New project meeting with Michael?
- ???