Hands-on exercise 4: Adding a service demand

In this section, we detail how to add a service demand to MUSE. In the residential sector, a service demand could be cooking. Houses require energy to cook food and a technology to service this demand, such as an electric stove. This process consists of setting a demand, either through inputs derived from the user or correlations of GDP and population which reflect the socioeconomic development of a region or country. In addition, a technology must be added to service this new demand.

This tutorial will build off the default model that comes with MUSE. To copy the files for this model, run:

```
python -m muse --model default --copy PATH/TO/COPY/THE/MODEL/TO
```

Adding demand for `cook`

First, we must edit the `GlobalCommodities.csv` file to add a new commodity called `cook`

commodity	commodity_type	unit
electricity	Energy	PJ
gas	Energy	PJ
heat	Energy	PJ
wind	Energy	PJ
CO2f	Environmental	kt
cook	**Energy**	**PJ**

Next, we will add a cooking preset demand. To achieve this, we will first edit the `Residential2020Consumption.csv` and `Residential2050Consumption.csv` files, found within the `residential_presets` directory. These files allow us to specify end-use demands in 2020 and 2050, with datapoints between these years being interpolated. For simplicity, we will copy over the values from the `heat` column in both files, e.g. for `Residential2020Consumption.csv` :

region	timeslice	heat	cook
R1	1	1.0	**1.0**
R1	2	1.5	**1.5**
R1	3	1.0	**1.0**
R1	4	1.5	**1.5**
R1	5	3.0	**3.0**
R1	6	2.0	**2.0**

Adding `electric_stove` and `gas_stove` technologies

Next, we must add a technology to service this new demand. This is similar to how we added the `solarPV` technology in a previous tutorial. For this example, we will add two competing technologies to service the cooking demand (`electric_stove` and `gas_stove`) to the `residential/Technodata.csv` file. For simplicity, we will copy parameters from existing technologies: `electric_stove` will copy the parameters from `heatpump` , and `gas_stove` will copy the parameters from `gasboiler` :

technology	region	year	cap_par	…	Agent1
...	...	...	...	...	...
electric_stove	**R1**	**2020**	**8.8667**	**…**	**1**
gas_stove	**R1**	**2020**	**3.8**	**…**	**1**

Note the extreme difference in `cap_par` costs. For the full file please see here (https://github.com/EnergySystemsModellingLab/MUSE_OS/blob/v1.5.1/docs/tutorial-code/add-service-demand/1-exogenous-demand/residential/Technodata.csv).

We must also add the data for these new technologies to the following files:

- `CommIn.csv`
- `CommOut.csv`
- `ExistingCapacity.csv`

This is largely a similar process to the previous tutorial. We must add the input to each of the technologies (gas and electricity for `gas_stove` and `electric_stove` respectively), outputs of `cook` for both and the existing capacity for each technology in each region. To prevent repetition of the previous tutorial, we will leave the full files here (https://github.com/EnergySystemsModellingLab/MUSE_OS/tree/main/docs/tutorial-code/add-service-demand/1-exogenous-demand).

Again, we run the simulation with our modified input files using the following command, in the relevant directory:

```
python -m muse settings.toml
```

Once this has run we are ready to visualise our results.

In [1]:

```
import matplotlib.pyplot as plt
import pandas as pd
```

In [2]:

```
mca_capacity = pd.read_csv(
    "../tutorial-code/add-service-demand/1-exogenous-demand/Results/MCACapacity.csv"
)
mca_capacity.head()
```

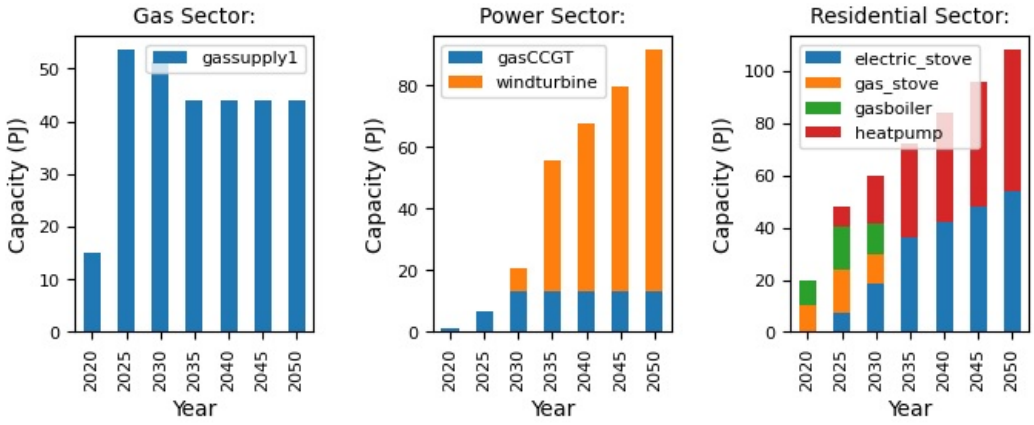
Out[2]:

	agent	capacity	dst_region	installed	region	sector	technology	type	year
0	A1	10.0000	r1	2020	r1	residential	gas_stove	newcapa	2020
1	A1	10.0000	r1	2020	r1	residential	gasboiler	newcapa	2020
2	A1	1.0000	r1	2020	r1	power	gasCCGT	newcapa	2020
3	A1	15.0000	r1	2020	r1	gas	gassupply1	newcapa	2020
4	A1	7.5938	r1	2025	r1	residential	electric_stove	newcapa	2025

In [3]:

```
fig, axes = plt.subplots(1, 3)
all_years = mca_capacity["year"].unique()
for ax, (sector_name, sector_data) in zip(axes, mca_capacity.groupby("sector")):
    sector_capacity = sector_data.groupby(["year", "technology"]).sum().reset_index()
    sector_capacity.pivot(
        index="year", columns="technology", values="capacity"
    ).reindex(all_years).plot(kind="bar", stacked=True, ax=ax)
    ax.set_ylabel("Capacity (PJ)")
    ax.set_xlabel("Year")
    ax.set_title(f"{sector_name.capitalize()} Sector:", fontsize=10)
    ax.legend(title=None, prop={"size": 8})
    ax.tick_params(axis="both", labelsize=8)

fig.set_size_inches(8, 2.5)
fig.subplots_adjust(wspace=0.5)
```



We can see that `electric_stove` is heavily used in the residential sector, and `gas_stove` is barely used at all. Therefore, compared to the default model, there is a larger increase in capacity in the `power` sector to accommodate this increase in demand for electricity, which is largely driven by `windturbine`.

Summary

In this tutorial we have shown how to add a service demand to MUSE, and how to add technologies to meet this demand. Try changing the demand profile for `cook` to see how this influences investment decisions.