In [1]:
```python
#Calculation_Example
```

In [2]:
```python
#Loading Python Libraries
import pandas as pd
import os
import numpy as np
import matplotlib.pyplot as plt
```

In [3]:
```python
#Load the projections for income and housesize

os.chdir("C:/Users/PeterRobertWalke/Documents/QGASSP/Data sources/Calculation_Data/Updated")


House_proj = pd.read_csv("House_proj_exio.csv" , index_col = 0)

Income_proj = pd.read_csv("Income_proj_exio.csv" , index_col = 0)
```

In [4]:
```python
#Load the different Y vectors.

#The user selects which one
#to use based on the urban density of the region (or the
#average one for mixed regions or if they are unsure)

os.chdir("C:/Users/PeterRobertWalke/Documents/QGASSP/Data sources/Calculation_Data/Updated/Demand_Vectors")


Y_average = pd.read_csv("Average_2020_Exio_elec_trans_en_Euro.csv", index_col = 0)
Y_city = pd.read_csv("City_2020_Exio_elec_trans_en_Euro.csv", index_col = 0)
Y_rural = pd.read_csv("Rural_2020_Exio_elec_trans_en_Euro.csv", index_col = 0)
Y_town = pd.read_csv("Town_2020_Exio_elec_trans_en_Euro.csv", index_col = 0)
```

In [5]:
```python
#Load the Use phase and tail pipe emissions.

os.chdir("C:/Users/PeterRobertWalke/Documents/QGASSP/Data sources/Calculation_Data/Updated")


Use_phase =  pd.read_csv("Energy_use_phase_Euro.csv", index_col = 0)



Tail_pipe =  pd.read_csv("Tailpipe_emissions_bp.csv", index_col = 0)
```

In [6]:
```python
#Load default house sizes

House_size = pd.read_csv("Household_characteristics_2015.csv", index_col = 0)
```

In [7]:
```python
#Load the Emission intesnities

os.chdir("C:/Users/PeterRobertWalke/Documents/QGASSP/Data sources/Calculation_Data/Updated/Emission_Intensities


#M_countries is the standard Emissions factors
M_countries = pd.read_csv("Country_Emissions_intensities.csv", index_col = 0)

#M_countries_LCA is the same as M_countries, but with the electricity sector replaced with individual LCA value
#This is useful if there is local electricity production. The user can replace certain values with these values
#if needed

M_countries_LCA = pd.read_csv("Country_Emissions_intensities_LCA.csv", index_col = 0)

products = M_countries.columns

Exio_products = pd.read_csv("Exio_products.csv")
```

In [8]:
```python
#Load the IW sectors

#This is needed to put the emissions into different 'sectors', such as transport, food, building energy use, et
os.chdir("C:/Users/PeterRobertWalke/Documents/QGASSP/Data sources/Calculation_Data/Updated")


IW_sectors = pd.read_csv("IW_sectors_reduced.csv", index_col = 0)

IW_sectors_np = IW_sectors.to_numpy()
IW_sectors_np_tr = np.transpose(IW_sectors_np)
```

In [9]:
```python
#Load the adjustable amounts.

#This says how much electricity is spent on heating. There are some other things here but decided not to incluc


Adjustable_amounts = pd.read_csv("adjustable_energy_amounts.csv", index_col = 0)
```

In [10]:
```python
#Electricity prices database might need upstaing still

#Load the electricity prices. This is so we know in monetary terms how much is being spent on electricity. The
#at the moment has the electricity used by households in kWh. However, maybe this should now be changed?

Electricity_prices = pd.read_csv("electricity_prices_2019.csv", index_col = 0)
```

In [11]:
```python
#Load the fuel prices at basic price
#We need this because of electric vehicles. The electricity and fuels need to be in the same units.

Fuel_prices = pd.read_csv("Fuel_prices_bp_attempt.csv", index_col = 0)
```

In [12]:
```python
#Load the Income scaler. This describes how much each household spends depending on their income.

Income_scaling = pd.read_csv("mean_expenditure_by_quint.csv", index_col = 0)
```

In [13]:
```python
#The different Policies are written as functions to reduce the length of the calculation code
```

In [14]:
```python
def BioFuels(ab_Y,scaler):
    """        ##Explanation/Description
        This sort of policy acts only on the Expenditure (Intensities don't change)
        Similar polices could exist for houseing fuel types, ...
        Similar adjustments to this could also be needed to correct the baselines if the user knows the
        results to be different"""

    ## Step 1. Determine current expenditure on fuels and the proportions of each type

    Total_fuel = ab_Y['Biogasoline'] + ab_Y['Biodiesels'] + ab_Y['Motor Gasoline'] + ab_Y['Gas/Diesel Oil']

    Diesel = (ab_Y['Biodiesels'] + ab_Y['Gas/Diesel Oil'])

    Petrol = (ab_Y['Motor Gasoline'] + ab_Y['Biogasoline'])

        #Step 2. Increase the biofuel to the designated amount

    ab_Y['Biogasoline'] = bio_scaler * Total_fuel * (Petrol/ (Diesel + Petrol))
    ab_Y['Biodiesels'] =  bio_scaler * Total_fuel * (Diesel / (Diesel + Petrol))

                #Step 3. Decrease the others by the correct amount, taking into account their initial values

        #The formula to do this is :
        #New Value = Remaining_expenditure * Old_proportion (once the previous categories are removed)

    Sum_changed = ab_Y['Biogasoline'] + ab_Y['Biodiesels'] #This can't be more than the total!

    ab_Y['Motor Gasoline'] = (Total_fuel - Sum_changed) * (Petrol / (Diesel + Petrol))
    ab_Y['Gas/Diesel Oil'] = (Total_fuel - Sum_changed) * (Diesel / (Diesel + Petrol))
```

In [15]:
```python
def Electric_Vehicles(ab_Y, scaler):
    """
                ##Policy explanation
        xx% of vehicles are ev
        First we reduce the expenditure on all forms of transport fuels by 20 %
        Then, we need to add something onto the electricity

        For this we need to: calculate how much fuel is saved and convert it back into Litres (and then kwh)
        Take into account the difference in efficiency between the two types
        Add the Kwh evenly onto the electricity sectors

        Explanation/Description
        This sort of policy acts only on the Expenditure

    """



    #step 1 Assign a proportion of the fuels to be converted and reduce the fuels by the correct amount

    Diesel = (ab_Y['Biodiesels'] + ab_Y['Gas/Diesel Oil'])*scaler

    Petrol = (ab_Y['Motor Gasoline'] + ab_Y['Biogasoline'])*scaler

    Fuels = ['Biodiesels', 'Gas/Diesel Oil', 'Motor Gasoline', 'Biogasoline']

    for fuel in Fuels:

        ab_Y[fuel] = ab_Y[fuel]*(1-scaler)


    #step 2 Turn the amount missing into kwh

    Diesel /= Fuel_prices.loc['Diesel_2020', country]
    Petrol /= Fuel_prices.loc['petrol_2020', country]

    Diesel *= 38.6*0.278   #litres, then Kwh
    Petrol *= 34.2*0.278   #litres, then kwh

    #step 3. #Divide that amount by 4.54 (to account foe the efficiency gains)

    Diesel /= 4.54         #Efficiency saving
    Petrol /=4.54          #Efficiency saving

    #step 4. Assign this to increased electricity demand

    Elec_vehicles = Diesel + Petrol

    elec_total = ab_Y[electricity].sum()

    elec_scaler = (Elec_vehicles + elec_total) / elec_total

    ab_Y[electricity] *= elec_scaler


        #Proportions MUST always sum to 1!!!!!!!!!!!
```

In [16]:
```python
def Eff_improvements(ab_Y, scaler):
    """
    Policy Explanation
    Retrofitting reduces energy expenditure on heating by xx %

    This sort of policy acts only on the Expenditure (Intensities don't change)
    Take the expenditure on household fuels and reduce it by a scale factor defined by the user

    """


        #Step 1. This can be done as a single stage.
        #Just reduce the parts that can be reduced by the amount in the scaler

    for liquid in liquids:

        ab_Y[liquid] = (ab_Y[liquid]*(1-scaler))

    for solid in solids:
        ab_Y[solid] = (ab_Y[solid]*(1-scaler))

    for gas in gases:
        ab_Y[gas] = (ab_Y[gas]*(1-scaler))

    for elec in electricity:
        elec_hold = ab_Y[elec] * (1-(ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"]))  #Parts not related
        ab_Y[elec] = (ab_Y[elec]*(ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"])*(1-scaler))
        ab_Y[elec] +=elec_hold

    ab_Y[district] = ab_Y[district]*(1-scaler)

        #Proportions MUST always sum to 1!!!!!!!!!!!
```

In [17]:
```python
def Transport_Modal_Shift(ab_Y,scaler, scaler_2, scaler_3):
    """
    Policy explanation
    Modal share - decrease in private transport and increase in public transport


    This sort of policy acts only on the Expenditure (Intensities don't change)
    The expenditure on private transport is reduced by a certain amount (1 part for fuels and 1 for vehicles)

    The public transport is also increased by a different amount. This is to account for the effects of active

    """


    Fuels = ['Biodiesels', 'Gas/Diesel Oil', 'Motor Gasoline', 'Biogasoline']

    for fuel in Fuels:

        ab_Y[fuel] *= (1-scaler)
        #In this case, we also assume that there is a reduction on the amount spent on vehicles
        #Change in modal shift takes vehicles off the road?
    Vehicles = ['Motor vehicles, trailers and semi-trailers (34)',
                'Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycle

    for vehicle in Vehicles:

        ab_Y[vehicle] *=(1-scaler_3)



    for transport in public_transport:  #Public transport was defined above

        ab_Y[transport] *=(1+scaler_2)

        #Proportions MUST always sum to 1!!!!!!!!!!!
```

In [18]:
```python
def Local_generation(ab_M, ab_Y, scaler, type_electricity):

    """
    ##Policy explanation
        Local electricity is produced by (usually) rooftop solar and it utilised only in that area

        #Reduce current electricity by xx %
        #Introduce a new electricity emission intensity (based on PV in the LCA emission intensities)
        ##that accounts for the missing xx %


    """

    elec_total = ab_Y[electricity].sum()

    for elec in electricity:

        ab_Y[elec] = (ab_Y[elec] * (1 - scaler))

    #Assign the remaning amount to the spare category (electricity nec)

    ab_Y['Electricity nec'] = elec_total * scaler

    #Set the emission intensitiy of this based on LCA values

    ab_M.loc[direct_ab:indirect_ab,'Electricity nec'] = M_countries_LCA.loc[direct_ab:indirect_ab,type_electric
```

In [19]:
```python
def local_heating(ab_M, ab_Y, district_prop, elec_heat_prop, combustable_fuels_prop, liquids_prop, gas_prop, sc
    """

THIS JUST REPEATS BASELINE QUESTIONS 9 - 10.
ALLOWING THE USER TO CHANGE THE VALUES
"""

#DISTRICT HEATING
    ab_Y[district] = Total_Fuel * district_prop


#ELECTRICITY
    for elec in electricity:

        prop = ab_Y[elec] / elec_total #determine amount of each electricity source in total electricity mix.
        elec_hold = (1 - (ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"])) * ab_Y[elec] #electricity for a
        ab_Y[elec] = prop * electricity_heat_prop * Total_Fuel / elec_price #Scale based on electricity use in
        ab_Y[elec] += elec_hold #Add on the parts to do with appliances



    for liquid in liquids:

        if ab_Y[liquids].sum() != 0:

            prop = ab_Y[liquid] / ab_Y[liquids].sum()  #Amount of each liquid in total liquid expenditure
            ab_Y[liquid] = prop * liquids_prop * combustable_fuels_prop * Total_Fuel
        else:

            ab_Y['Kerosene'] = liquids_prop * combustable_fuels_prop * Total_Fuel



    for solid in solids:

        if ab_Y[solids].sum() != 0:
            prop = ab_Y[solid] / ab_Y[solids].sum()  #Amount of each solid in total solid expenditure
            ab_Y[solid] = prop * solids_prop * combustable_fuels_prop * Total_Fuel

        else:
            ab_Y['Wood and products of wood and cork (except furniture); articles of straw and plaiting materia


    for gas in gases:

        if ab_Y[gases].sum() != 0:
            prop = ab_Y[gas] / ab_Y[gases].sum()  #Amount of each gas in total gas expenditure
            ab_Y[gas] = prop * gases_prop * combustable_fuels_prop * Total_Fuel

        else:
            ab_Y['Distribution services of gaseous fuels through mains'] = gases_prop * combustable_fuels_prop


    #The 'direct_ab' value should be changed to the value the user wants.
    #The user needs to convert the value into kg CO2e / Euro
    ab_M.loc[direct_ab,district] = district_val ####1.0475#USER_INPUT
###############################################################
```

In [20]:
```python
#Baseline calculation here - policies is essentially the same calcualtion
##########Explanation#######################
#The calculations work by describing the economy as being composed of 200 products, given by 'products'.
#For each product there is an emission intensity and they are collected together in ab_M. There are seperate em
#intensties for the 'direct production' and the 'indirect production' (rest of the supply chain). So ab_M is a
#table
#Some products that describe household fuel use for heat and also transport fuel use for cars have another emis
#intesntiy as well. These are held in seperate tables 'use_phase' and 'tail_pipe' (all other products have 0 he

#To calculate the Emissions, each value in ab_M + the values in use_phase and tail_pipe are multiplied by the a
#the household spends on each of the 200 products. These are stored in another table caled ab_Y (demand vector)
#The emissions for each product from the direct production, indirect production, and use_phase/tail_pipe
#to get the total emissions for that product.

#Once we have the total emissions for each product for that year, they are grouped together into 'sectors' that
#There are 7 in total: Household Energy, Household Other, transport fuels, transport other, air transport, food
#tangible goods and  services

#The calculations are performed every year until 2050, with the values of ab_Y and ab_M changing slighting each
#This is based on 3 factors, efficiency improvements, changes in income and changes in household size. There is
#section where these projections can change as a result of different policies (for the baseline no policies are

################################################################################################################
################################################################################################################
#Determine Emissions for all years
##############Question 2#######################################
year = 2020

policy_year = 2025#USER_INPUT
########################################
Region = "Berlin" #User_input
Policy_label = "BL"  #This is just a label for the policy
########Question 3#######################################
country = "Germany"  #This is to choose the country - USER_INPUT
ab = "DE"            #This is to identify the country, should match above
#################################################################

######Question 4################################################
U_type = "city" #'average', 'town', 'city', 'rural'  #This is to select the demand vector - the user should cho
################################################################




#Forming data for the calculations

#These are needed for holding the results
DF = pd.DataFrame(np.zeros((30,8)),index = list(range(2020,2050))
                                                 , columns = IW_sectors.columns)  #Holds final data in sec

DF_tot = pd.DataFrame(np.zeros((30,200)),index = list(range(2020,2050))
                                                 ,columns = products) #holds final data in products (200)


direct_ab = "direct_"+ab
indirect_ab = "indirect_"+ab
M_countries.loc[direct_ab:indirect_ab,:].copy()

ab_M = locals() [ab + "_M"] = M_countries.loc[direct_ab:indirect_ab,:].copy()  #Here the emission intensities
                                                                                #are selected

    #Extract

ab_Y = Y_city[country].copy()  ##Here the demand vector is selected



#These are needed for the use phase emissions

Tail_pipe_ab = Tail_pipe[country].copy()

Use_phase_ab = Use_phase[country].copy()

#This is needed for calculating the amount of electricity coming from heating

ad = Adjustable_amounts[country].copy()

elec_price = Electricity_prices[country]["BP_2019_S2_Euro"]


#Baseline Modifications go here


############Question 5#########################################################
#House_size

House_size_ab = House_size.loc['Average_size_'+ U_type, country] #This is the default
#House_size_ab = 2.14#xx###USER_INPUT
#############################################################################

###########Question 6##########################################################
#Population_size

pop_size = 174167 #USER_INPUT
##################################################################################



##########Question 7##############################################################
#Income_scaler

Income_scaler = 1   #USER_INPUT#This is the default and should be used if the user doesn't know the income type
Elasticity = 1


#Otherwise,  the user selects the income level of the household (they choose by quntiles)

#Income_scaler = Income_scaling.loc['1st_household',country] / Income_scaling.loc['Total_household',country] #U
#Elasticity = 1 # Random number for now. It should be specific to country and product

ab_Y *= Income_scaler * Elasticity
#########################################################################################

##This is the end of the mandatory questions


##Optional questions
###########################################################################################
#Here the user can modify the default values for the the demand. IF THEY DON'T WANT TO THEN SKIP THIS PART.


########Question 8#########################################################################
    #Public Transport types

public_transport = ['Railway transportation services', 'Other land transportation services',
                    'Sea and coastal water transportation services', 'Inland water transportation services']


Public_transport_sum = ab_Y[public_transport].sum()    ###This describes the total use of public transport

rail_prop = ab_Y['Railway transportation services'] / Public_transport_sum
bus_prop = ab_Y['Other land transportation services'] / Public_transport_sum
ferry_prop = ab_Y['Sea and coastal water transportation services'] / Public_transport_sum
river_prop = ab_Y['Inland water transportation services'] / Public_transport_sum


#These 'prop' values can be adjustable by the user.
#For example, if the user thinks there should be no water based travel this can be set to 0
#but then the other values should be increased so that total proportions sum to equal to 1

#In such a case, the code to do this would be

river_prop = 0#USER_INPUT (often 0)
ferry_prop = 0#USER_INPUT (often 0)
bus_prop = bus_prop / (bus_prop + rail_prop) #USER_INPUT - code maintains the ratio between bus and rail
rail_prop = rail_prop / (bus_prop + rail_prop) #USER_INPUT - code maintains the ratio between bus and rail



#The values that should be adjusted are:

ab_Y['Railway transportation services'] = rail_prop * Public_transport_sum
ab_Y['Other land transportation services'] = bus_prop * Public_transport_sum
ab_Y['Sea and coastal water transportation services'] = river_prop * Public_transport_sum
ab_Y['Inland water transportation services'] = ferry_prop * Public_transport_sum

#########################################################################

#Otherwise, if there is no rail travel or river/sea travel then it should be:

#rail_prop = 0
#river_prop = 0
#ferry_prop = 0
#bus_prop = 1

###########################################################################################


########Question 9#########################################################################
    #Electricity _ mix
#IT SHOULD BE SUGGESTED TO LEAVE THE DEFAULT VALUES
#As above, the user can specify if the electricity mix is different to the country average for the BL

electricity = ['Electricity by coal', 'Electricity by gas','Electricity by nuclear',
                      'Electricity by hydro', 'Electricity by wind','Electricity by petroleum and other oil der
                      'Electricity by biomass and waste', 'Electricity by solar photovoltaic',
                      'Electricity by solar thermal', 'Electricity by tide, wave, ocean',
                      'Electricity by Geothermal', 'Electricity nec']

#No electricity goes in 'electricity nec'. This is used for local electricity production

elec_total = ab_Y[electricity].sum()

#The code works the same as above the the public transport.

#e.g.

#hydro_prop = 0.7
#solar_pvc_prop = 0.3
#coal_prop = 0
#gas_prop = 0
#nuclear_prop = 0
#wind_prop = 0
#petrol_prop = 0
#solar_thermal_prop = 0
#tide_prop = 0
#geo_prop = 0
#nec_prop = 0

#Then the total kWh is determined from these props
#ab_Y[electricity] = 0

#ab_Y['Electricity by solar photovoltaic'] = solar_pvc_prop * elec_total
#ab_Y['Electricity by hydro'] = hydro_prop * elec_total


#if the user specifies the mix, then the electricity values change to the LCA values:

#for elec in electricity:

    #ab_M.loc[direct_ab:indirect_ab,electricity] = M_countries_LCA.loc[direct_ab:indirect_ab,electricity]

#IT SHOULD BE SUGGESTED THAT THE USER DOES NOT ALTER THE ELECTRICITY MIX
##################################################################################################################

######Question 10##########################################################################


    #Supply of household heating

liquids = ['Natural Gas Liquids', 'Kerosene', 'Heavy Fuel Oil', 'Other Liquid Biofuels']
solids = ['Wood and products of wood and cork (except furniture); articles of straw and plaiting materials (20)
                'Coke Oven Coke']
gases = ['Distribution services of gaseous fuels through mains', 'Biogas']

district = 'Steam and hot water supply services'

electricity_heat = (ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"]) * elec_total * elec_price

Total_Fuel = ab_Y[solids].sum() + ab_Y[liquids].sum() + ab_Y[gases].sum() + ab_Y[district].sum() + electricity_

#We assume all 'fuels' are the same efficiency (obviously wrong, but no time to fix)

########################
#PART 1 - The user selects the heating proportions from district heating, electricity and household combustion
########################


#Default values are given by:
district_prop = ab_Y[district] / Total_Fuel

electricity_heat_prop = electricity_heat / Total_Fuel

combustable_fuels_prop = (ab_Y[solids].sum() + ab_Y[liquids].sum() + ab_Y[gases].sum()) / Total_Fuel

###THE USER CAN ALTER THESE BY::

#THESE NUMBERS NEED TO SUM TO 1
#district_prop = 0.0#district_prop#1##USER_INPUT
#electricity_heat_prop = 1.0#electricity_heat_prop##USER_INPUT
#combustable_fuels_prop = 0.0#combustable_fuels_prop##USER_INPUT

####################################
##Part 2 - Determine final values
####################################

#Then, the final values are given by:

#DISTRICT HEATING
ab_Y[district] = Total_Fuel * district_prop


#ELECTRICITY
for elec in electricity:

    prop = ab_Y[elec] / elec_total #determine amount of each electricity source in total electricity mix.
    elec_hold = (1 - (ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"])) * ab_Y[elec] #electricity for appli
    ab_Y[elec] = prop * electricity_heat_prop * Total_Fuel / elec_price #Scale based on electricity use in heat
    ab_Y[elec] += elec_hold #Add on the parts to do with appliances


#COMBUSTABLE FUELS

#Here, the user can also alter the mix of the combustable fuels.

liquids_prop = ab_Y[liquids].sum()/ (ab_Y[liquids].sum() + ab_Y[solids].sum() + ab_Y[gases].sum())
solids_prop = ab_Y[solids].sum()/ (ab_Y[liquids].sum() + ab_Y[solids].sum() + ab_Y[gases].sum())
gases_prop = ab_Y[gases].sum()/ (ab_Y[liquids].sum() + ab_Y[solids].sum() + ab_Y[gases].sum())

#THE USER CAN CHANGE THESE VALUES BUT THE SUM MUST BE EQUAL TO 1!

###########Question 10.1####################
#liquids_prop = 0 # #USER INPUT
#solids_prop = 0 ##USER_INPUT
#gases_prop = 1 # #USER_INPUT


#Then

for liquid in liquids:

    if ab_Y[liquids].sum() != 0:

        prop = ab_Y[liquid] / ab_Y[liquids].sum()  #Amount of each liquid in total liquid expenditure
        ab_Y[liquid] = prop * liquids_prop * combustable_fuels_prop * Total_Fuel
    else:

        ab_Y['Kerosene'] = liquids_prop * combustable_fuels_prop * Total_Fuel



for solid in solids:

    if ab_Y[solids].sum() != 0:
        prop = ab_Y[solid] / ab_Y[solids].sum()  #Amount of each solid in total solid expenditure
        ab_Y[solid] = prop * solids_prop * combustable_fuels_prop * Total_Fuel

    else:
        ab_Y['Wood and products of wood and cork (except furniture); articles of straw and plaiting materials


for gas in gases:

    if ab_Y[gases].sum() != 0:
        prop = ab_Y[gas] / ab_Y[gases].sum()  #Amount of each gas in total gas expenditure
        ab_Y[gas] = prop * gases_prop * combustable_fuels_prop * Total_Fuel

    else:
        ab_Y['Distribution services of gaseous fuels through mains'] = gases_prop * combustable_fuels_prop * To

#####QUESTION 11#########################################
    #The 'direct_ab' value should be changed to the value the user wants.
    #The user needs to convert the value into kg CO2e / Euro
#ab_M.loc[direct_ab,district] = 1.0475#USER_INPUT
################################################################


######## Question 12#####################################
#This is the expected global reduction in product emissions
eff_scaling = 0.97 #USER_INPUT
##############################################################


################################################################
############The actual calculation starts here###############
#################################################################


income_scaling = Income_proj.loc[country]    #Scale factor applied to income - unique value for each decade
house_scaling = House_proj.loc[country]      #Scale factor applied to household size - unique value for each de

while year <= 2050:

    #check the policy part

    if year == 2020:

        income_mult = 1 #This is just for the year 2020
        house_mult = 1  #This is just for the year 2020
        eff_factor = 1  #This is just for the year 2020


##########Policies are from here##############################################################
    if year == policy_year:

        #Questions should be asked in this order! Some depend on the results of others
#############Household Efficiency##############################################
        EFF_gain = "FALSE" #USER_INPUT
        EFF_scaler = 0.5 #USER_INPUT

        if EFF_gain == "TRUE":

            Eff_improvements(ab_Y, EFF_scaler)

################################################################################################################

#############Local_Electricity##################################################################################

        Local_electricity = "FALSE" #USER_INPUT
        EL_Type = 'Electricity by solar photovoltaic'#USER_INPUT #'Electricity by solar photovoltaic','Electric
        EL_scaler = 0.5

        if Local_electricity == "TRUE":

            Local_generation(ab_M,ab_Y, EL_scaler, EL_Type)

################################################################################################################

#############Sustainable_Heating################################################################################

        S_heating = "FALSE" #USER_INPUT
        district_prop = 0.3 #USER_INPUT
        Electricity_prop = 0.2 #USER_INPUT
        combustable_fuels_prop = 0.5 #USER_INPUT
        solids_prop = 0.0 #USER_INPUT
        gases_prop = 0.0 #USER_INPUT
        liquids_prop = 0.0 #USER_INPUT
        District_value = ab_M.loc[direct_ab,district].sum()# ab_M   0.0 # USER_INPUT

        if S_heating == "TRUE":

            local_heating(ab_M, ab_Y, district_prop, Electricity_prop,
                          combustable_fuels_prop, liquids_prop, gases_prop, solids_prop, District_value)

            #This is just a repeat of the baseline part

################################################################################################################

##########Biofuel_in_transport##################################################################################
        Biofuel_takeup = "FALSE" #USER_INPUT
        bio_scaler = 0.5 #USER_INPUT

        if Biofuel_takeup == "TRUE":

            BioFuels(ab_Y, bio_scaler)

################################################################################################################

#######Electric_Vehicles########################################################################################
        EV_takeup = "FALSE" #USER_INPUT
        EV_scaler = 0.5

        if EV_takeup == "TRUE":

            Electric_Vehicles(ab_Y, EV_scaler)

################################################################################################################

########Modal_Shift#############################################################################################
        Modal_Shift = "FALSE" #USER_INPUT
        MS_fuel_scaler = 0.5 #USER_INPUT
        MS_veh_scaler = 0.5 #USER_INPUT
        MS_pt_scaler = 0.2  #USER_INPUT

        if Modal_Shift == "TRUE":

            Transport_Modal_Shift(ab_Y, MS_fuel_scaler, MS_pt_scaler, MS_veh_scaler)

################################################################################################################

    if year > 2020 and year <= 2030:

        income_mult = income_scaling['2020-2030']   #Select the income multiplier for this decade
        house_mult = house_scaling['2020-2030']     #Select the house multiplier for this decade
        eff_factor = eff_scaling

    if  year > 2030 and year <= 2040:

        income_mult = income_scaling['2030-2040']   #Seclectthe income multiplier for this decade
        house_mult = house_scaling['2030-2040']     #select the house multiplier for this decade
        eff_factor = eff_scaling

    if year > 2040 and year <=2050:

        income_mult = income_scaling['2040-2050']   #Seclectthe income multiplier for this decade
        house_mult = house_scaling['2040-2050']     #select the house multiplier for this decade
        eff_factor = eff_scaling


    ab_Y *= income_mult

    ab_M *=eff_factor

    Use_phase_ab *=eff_factor

    Tail_pipe_ab *=eff_factor


    #Then we have to recalculate


    GWP_ab = pd.DataFrame(ab_M.to_numpy().dot(np.diag(ab_Y.to_numpy()))) # This is the basic calculation

    GWP_ab.index = ['direct' , 'indirect']

    GWP_ab.columns = products

    Use_phase_ab_GWP = ab_Y * Use_phase_ab # This adds in the household heating fuel use

    Tail_pipe_ab_GWP = ab_Y * Tail_pipe_ab # This adds in the burning of fuel for cars

    Total_use_ab = Tail_pipe_ab_GWP.fillna(0) + Use_phase_ab_GWP.fillna(0) #This puts together in the same tabl
                                                                           #all of the other 200 products are z
    #Put together the IO and use phase

    GWP_ab.loc['Use phase',:] = Total_use_ab


    #GWP_EE_pc = GWP_EE/House_size_EE

    #print(year)



    #GWP_EE = GWP_EE * (eff_factor) * (income_mult)

    GWP_ab_pc = GWP_ab / (House_size_ab * house_mult)

#Put the results into sectors

    DF.loc[year] =IW_sectors_np_tr.dot(GWP_ab_pc.sum().to_numpy())
    DF_tot.loc[year] = GWP_ab_pc.sum()

    year +=1

DF['Total_Emissions'] = DF.sum(axis = 1)


#Building and Infrastructure Emissions form here (if included)

Building_Emissions = 0

DF.loc[policy_year, 'Total_Emissions'] += Building_Emissions


#F_tot.columns = Exio_products
locals()[Region + "_Emissions_" + Policy_label] = DF
locals()[Region+ "_Emissions_tot_" + Policy_label] = DF_tot
```

In [21]:
```python
#For a new area. Start the calculation from the year of buildign completion. ALlow the policies to be open fror
#Practically, this means setting to year of the policies to the start of the calculation
```

In [22]:

```python
#Baseline calculation here
##########Explanation####################
#The calculations work by describing the economy as being composed of 200 products, given by 'products'.
#For each product there is an emission intensity and they are collected together in ab_M. There are seperate en
#intensties for the 'direct production' and the 'indirect production' (rest of the supply chain). So ab_M is a
#table
#Some products that describe household fuel use for heat and also transport fuel use for cars have another emis
#intesntiy as well. These are held in seperate tables 'use_phase' and 'tail_pipe' (all other products have 0 he

#To calculate the Emissions, each value in ab_M + the values in use_phase and tail_pipe are multiplied by the a
#the household spends on each of the 200 products. These are stored in another table caled ab_Y (demand vector)
#The emissions for each product from the direct production, indirect production, and use_phase/tail_pipe
#to get the total emissions for that product.

#Once we have the total emissions for each product for that year, they are grouped together into 'sectors' that
#There are 7 in total: Household Energy, Household Other, transport fuels, transport other, air transport, food
#tangible goods and  services

#The calculations are performed every year until 2050, with the values of ab_Y and ab_M changing slighting each
#This is based on 3 factors, efficiency improvements, changes in income and changes in household size. There is
#section where these projections can change as a result of different policies (for the baseline no policies are

####################################################################################################
####################################################################################################
#Determine Emissions for all years
###############Question 2#########################################
year = 2025

policy_year = 2025#USER_INPUT
#########################################
Region = "Berlin" #User_input
Policy_label = "NA"  #This is just a label for the policy
########Question 3#######################################
country = "Germany"  #This is to choose the country - USER_INPUT
ab = "DE"            #This is to identify the country, should match above
##################################################################

######Question 4###############################################
U_type = "city" #'average', 'town', 'city', 'rural'  #This is to select the demand vector - the user should cho
#################################################################




#Forming data for the calculations

#These are needed for holding the results
DF = pd.DataFrame(np.zeros((30,8)),index = list(range(2020,2050))
                                                  , columns = IW_sectors.columns)  #Holds final data in sec

DF_tot = pd.DataFrame(np.zeros((30,200)),index = list(range(2020,2050))
                                                  ,columns = products) #holds final data in products (200)


direct_ab = "direct_"+ab
indirect_ab = "indirect_"+ab
M_countries.loc[direct_ab:indirect_ab,:].copy()

ab_M = locals() [ab + "_M"] = M_countries.loc[direct_ab:indirect_ab,:].copy()  #Here the emission intensities
                                                                               #are selected

    #Extract

ab_Y = Y_city[country].copy()  ##Here the demand vector is selected



#These are needed for the use phase emissions

Tail_pipe_ab = Tail_pipe[country].copy()

Use_phase_ab = Use_phase[country].copy()

#This is needed for calculating the amount of electricity coming from heating

ad = Adjustable_amounts[country].copy()

elec_price = Electricity_prices[country]["BP_2019_S2_Euro"]


#Baseline Modifications go here


############Question 5##########################################################
#House_size

House_size_ab = House_size.loc['Average_size_'+ U_type, country] #This is the default
#House_size_ab = 2.14#xx###USER_INPUT
############################################################################

###########Question 6############################################################
#Population_size

pop_size = 174167 #USER_INPUT
##############################################################################



##########Question 7############################################################
#Income_scaler

Income_scaler = 1   #USER_INPUT#This is the default and should be used if the user doesn't know the income type
Elasticity = 1


#Otherwise,  the user selects the income level of the household (they choose by quntiles)

#Income_scaler = Income_scaling.loc['1st_household',country] / Income_scaling.loc['Total_household',country] #U
#Elasticity = 1 # Random number for now. It should be specific to country and product

ab_Y *= Income_scaler * Elasticity
##################################################################################

##This is the end of the mandatory questions


##Optional questions
#####################################################################################
#Here the user can modify the default values for the the demand. IF THEY DON'T WANT TO THEN SKIP THIS PART.


########Question 8###########################################################################
    #Public Transport types

public_transport = ['Railway transportation services', 'Other land transportation services',
                    'Sea and coastal water transportation services', 'Inland water transportation services']


Public_transport_sum = ab_Y[public_transport].sum()    ###This describes the total use of public transport

rail_prop = ab_Y['Railway transportation services'] / Public_transport_sum
bus_prop = ab_Y['Other land transportation services'] / Public_transport_sum
ferry_prop = ab_Y['Sea and coastal water transportation services'] / Public_transport_sum
river_prop = ab_Y['Inland water transportation services'] / Public_transport_sum


#These 'prop' values can be adjustable by the user.
#For example, if the user thinks there should be no water based travel this can be set to 0
#but then the other values should be increased so that total proportions sum to equal to 1

#In such a case, the code to do this would be

river_prop = 0#USER_INPUT (often 0)
ferry_prop = 0#USER_INPUT (often 0)
bus_prop = bus_prop / (bus_prop + rail_prop) #USER_INPUT - code maintains the ratio between bus and rail
rail_prop = rail_prop / (bus_prop + rail_prop) #USER_INPUT - code maintains the ratio between bus and rail



#The values that should be adjusted are:

ab_Y['Railway transportation services'] = rail_prop * Public_transport_sum
ab_Y['Other land transportation services'] = bus_prop * Public_transport_sum
ab_Y['Sea and coastal water transportation services'] = river_prop * Public_transport_sum
ab_Y['Inland water transportation services'] = ferry_prop * Public_transport_sum

############################################################################

#Otherwise, if there is no rail travel or river/sea travel then it should be:

#rail_prop = 0
#river_prop = 0
#ferry_prop = 0
#bus_prop = 1

#########################################################################################


########Question 9##########################################################################
    #Electricity _ mix
#IT SHOULD BE SUGGESTED TO LEAVE THE DEFAULT VALUES
#As above, the user can specify if the electricity mix is different to the country average for the BL

electricity = ['Electricity by coal', 'Electricity by gas','Electricity by nuclear',
                      'Electricity by hydro', 'Electricity by wind','Electricity by petroleum and other oil der
                      'Electricity by biomass and waste', 'Electricity by solar photovoltaic',
                      'Electricity by solar thermal', 'Electricity by tide, wave, ocean',
                      'Electricity by Geothermal', 'Electricity nec']

#No electricity goes in 'electricity nec'. This is used for local electricity production

elec_total = ab_Y[electricity].sum()

#The code works the same as above the the public transport.

#e.g.

#hydro_prop = 0.7
#solar_pvc_prop = 0.3
#coal_prop = 0
#gas_prop = 0
#nuclear_prop = 0
#wind_prop = 0
#petrol_prop = 0
#solar_thermal_prop = 0
#tide_prop = 0
#geo_prop = 0
#nec_prop = 0

#Then the total kWh is determined from these props
#ab_Y[electricity] = 0

#ab_Y['Electricity by solar photovoltaic'] = solar_pvc_prop * elec_total
#ab_Y['Electricity by hydro'] = hydro_prop * elec_total


#if the user specifies the mix, then the electricity values change to the LCA values:

#for elec in electricity:

    #ab_M.loc[direct_ab:indirect_ab,electricity] = M_countries_LCA.loc[direct_ab:indirect_ab,electricity]

#IT SHOULD BE SUGGESTED THAT THE USER DOES NOT ALTER THE ELECTRICITY MIX
####################################################################################################

######Question 10################################################################################


    #Supply of household heating

liquids = ['Natural Gas Liquids', 'Kerosene', 'Heavy Fuel Oil', 'Other Liquid Biofuels']
solids = ['Wood and products of wood and cork (except furniture); articles of straw and plaiting materials (20)
                    'Coke Oven Coke']
gases = ['Distribution services of gaseous fuels through mains', 'Biogas']

district = 'Steam and hot water supply services'

electricity_heat = (ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"]) * elec_total * elec_price

Total_Fuel = ab_Y[solids].sum() + ab_Y[liquids].sum() + ab_Y[gases].sum() + ab_Y[district].sum() + electricity_

#We assume all 'fuels' are the same efficiency (obviously wrong, but no time to fix)

########################
#PART 1 - The user selects the heating proportions from district heating, electricity and household combustion
########################


#Default values are given by:
district_prop = ab_Y[district] / Total_Fuel

electricity_heat_prop = electricity_heat / Total_Fuel

combustable_fuels_prop = (ab_Y[solids].sum() + ab_Y[liquids].sum() + ab_Y[gases].sum()) / Total_Fuel

###THE USER CAN ALTER THESE BY::

#THESE NUMBERS NEED TO SUM TO 1
#district_prop = 0.0#district_prop#1##USER_INPUT
#electricity_heat_prop = 1.0#electricity_heat_prop##USER_INPUT
#combustable_fuels_prop = 0.0#combustable_fuels_prop##USER_INPUT

####################################
##Part 2 - Determine final values
####################################

#Then, the final values are given by:

#DISTRICT HEATING
ab_Y[district] = Total_Fuel * district_prop


#ELECTRICITY
for elec in electricity:

    prop = ab_Y[elec] / elec_total #determine amount of each electricity source in total electricity mix.
    elec_hold = (1 - (ad["elec_water"] +ad["elec_heat"] + ad["elec_cool"])) * ab_Y[elec] #electricity for appli
    ab_Y[elec] = prop * electricity_heat_prop * Total_Fuel / elec_price #Scale based on electricity use in heat
    ab_Y[elec] += elec_hold #Add on the parts to do with appliances


#COMBUSTABLE FUELS

#Here, the user can also alter the mix of the combustable fuels.

liquids_prop = ab_Y[liquids].sum()/ (ab_Y[liquids].sum() + ab_Y[solids].sum() + ab_Y[gases].sum())
solids_prop = ab_Y[solids].sum()/ (ab_Y[liquids].sum() + ab_Y[solids].sum() + ab_Y[gases].sum())
gases_prop = ab_Y[gases].sum()/ (ab_Y[liquids].sum() + ab_Y[solids].sum() + ab_Y[gases].sum())

#THE USER CAN CHANGE THESE VALUES BUT THE SUM MUST BE EQUAL TO 1!

###########Question 10.1####################
#liquids_prop = 0 # #USER INPUT
#solids_prop = 0 ##USER_INPUT
#gases_prop = 1 # #USER_INPUT


#Then

for liquid in liquids:

    if ab_Y[liquids].sum() != 0:

        prop = ab_Y[liquid] / ab_Y[liquids].sum()  #Amount of each liquid in total liquid expenditure
        ab_Y[liquid] = prop * liquids_prop * combustable_fuels_prop * Total_Fuel
    else:

        ab_Y['Kerosene'] = liquids_prop * combustable_fuels_prop * Total_Fuel



for solid in solids:

    if ab_Y[solids].sum() != 0:
        prop = ab_Y[solid] / ab_Y[solids].sum()  #Amount of each solid in total solid expenditure
        ab_Y[solid] = prop * solids_prop * combustable_fuels_prop * Total_Fuel

    else:
        ab_Y['Wood and products of wood and cork (except furniture); articles of straw and plaiting materials


for gas in gases:

    if ab_Y[gases].sum() != 0:
        prop = ab_Y[gas] / ab_Y[gases].sum()  #Amount of each gas in total gas expenditure
        ab_Y[gas] = prop * gases_prop * combustable_fuels_prop * Total_Fuel

    else:
        ab_Y['Distribution services of gaseous fuels through mains'] = gases_prop * combustable_fuels_prop * To

#####QUESTION 11######################################
    #The 'direct_ab' value should be changed to the value the user wants.
    #The user needs to convert the value into kg CO2e / Euro
ab_M.loc[direct_ab,district] = 1.0475#USER_INPUT
##############################################################


######## Question 12####################################
#This is the expected global reduction in product emissions
eff_scaling = 0.97 #USER_INPUT
#############################################################


#############################################################
############The actual calculation starts here##############
##############################################################


income_scaling = Income_proj.loc[country]    #Scale factor applied to income - unique value for each decade
house_scaling = House_proj.loc[country]      #Scale factor applied to household size - unique value for each de

while year <= 2050:

    #check the policy part

    if year == 2020:

        income_mult = 1 #This is just for the year 2020
        house_mult = 1  #This is just for the year 2020
        eff_factor = 1  #This is just for the year 2020


##########Policies are from here############################################################
    if year == policy_year:

        #Questions should be asked in this order! Some depend on the results of others
#############Household Efficiency################################################
        EFF_gain = "TRUE" #USER_INPUT
        EFF_scaler = 0.5 #USER_INPUT

        if EFF_gain == "TRUE":

            Eff_improvements(ab_Y, EFF_scaler)
####################################################################################################

#############Local_Electricity######################################################################
        Local_electricity = "TRUE" #USER_INPUT
        EL_Type = 'Electricity by solar photovoltaic'#USER_INPUT #'Electricity by solar photovoltaic','Electric
        EL_scaler = 0.75

        if Local_electricity == "TRUE":

            Local_generation(ab_M,ab_Y, EL_scaler, EL_Type)

####################################################################################################

#############Sustainable_Heating####################################################################

        S_heating = "TRUE" #USER_INPUT
        district_prop = 0.5 #USER_INPUT
        Electricity_prop = 0.5 #USER_INPUT
        combustable_fuels_prop = 0.0 #USER_INPUT
        solids_prop = 0.0 #USER_INPUT
        gases_prop = 1.0 #USER_INPUT
        liquids_prop = 0.0 #USER_INPUT
        District_value = ab_M.loc[direct_ab,district].sum()# ab_M   0.0 # USER_INPUT

        if S_heating == "TRUE":

            local_heating(ab_M, ab_Y, district_prop, Electricity_prop,
                          combustable_fuels_prop, liquids_prop, gases_prop, solids_prop, District_value)

            #This is just a repeat of the baseline part

####################################################################################################

##########Biofuel_in_transport######################################################################
        Biofuel_takeup = "FALSE" #USER_INPUT
        bio_scaler = 0.5 #USER_INPUT

        if Biofuel_takeup == "TRUE":

            BioFuels(ab_Y, bio_scaler)

####################################################################################################

#######Electric_Vehicles############################################################################
        EV_takeup = "FALSE" #USER_INPUT
        EV_scaler = 0.5

        if EV_takeup == "TRUE":

            Electric_Vehicles(ab_Y, EV_scaler)

####################################################################################################

########Modal_Shift#################################################################################
        Modal_Shift = "FALSE" #USER_INPUT
        MS_fuel_scaler = 0.5 #USER_INPUT
        MS_veh_scaler = 0.5 #USER_INPUT
        MS_pt_scaler = 0.2  #USER_INPUT

        if Modal_Shift == "TRUE":

            Transport_Modal_Shift(ab_Y, MS_fuel_scaler, MS_pt_scaler, MS_veh_scaler)

####################################################################################################

    if year > 2020 and year <= 2030:

        income_mult = income_scaling['2020-2030']   #Select the income multiplier for this decade
        house_mult = house_scaling['2020-2030']     #Select the house multiplier for this decade
        eff_factor = eff_scaling

    if  year > 2030 and year <= 2040:

        income_mult = income_scaling['2030-2040']   #Seclectthe income multiplier for this decade
        house_mult = house_scaling['2030-2040']     #select the house multiplier for this decade
        eff_factor = eff_scaling

    if year > 2040 and year <=2050:

        income_mult = income_scaling['2040-2050']   #Seclectthe income multiplier for this decade
        house_mult = house_scaling['2040-2050']     #select the house multiplier for this decade
        eff_factor = eff_scaling


    ab_Y *= income_mult

    ab_M *=eff_factor

    Use_phase_ab *=eff_factor

    Tail_pipe_ab *=eff_factor


    #Then we have to recalculate


    GWP_ab = pd.DataFrame(ab_M.to_numpy().dot(np.diag(ab_Y.to_numpy()))) # This is the basic calculation

    GWP_ab.index = ['direct' , 'indirect']

    GWP_ab.columns = products

    Use_phase_ab_GWP = ab_Y * Use_phase_ab # This adds in the household heating fuel use

    Tail_pipe_ab_GWP = ab_Y * Tail_pipe_ab # This adds in the burning of fuel for cars

    Total_use_ab = Tail_pipe_ab_GWP.fillna(0) + Use_phase_ab_GWP.fillna(0) #This puts together in the same tab
                                                                              #all of the other 200 products are z
    #Put together the IO and use phase

    GWP_ab.loc['Use phase',:] = Total_use_ab


    #GWP_EE_pc = GWP_EE/House_size_EE

    #print(year)



    #GWP_EE = GWP_EE * (eff_factor) * (income_mult)

    GWP_ab_pc = GWP_ab / (House_size_ab * house_mult)

#Put the results into sectors

    DF.loc[year] =IW_sectors_np_tr.dot(GWP_ab_pc.sum().to_numpy())
    DF_tot.loc[year] = GWP_ab_pc.sum()

    year +=1

DF['Total_Emissions'] = DF.sum(axis = 1)


#Building and Infrastructure Emissions form here (if included)

Building_Emissions = 100000

DF.loc[policy_year, 'Total_Emissions'] += Building_Emissions


#F_tot.columns = Exio_products
locals()[Region + "_Emissions_" + Policy_label] = DF
locals()[Region+ "_Emissions_tot_" + Policy_label] = DF_tot
```

In [23]:

```python
Berlin_Emissions_NA
```

Out[23]:

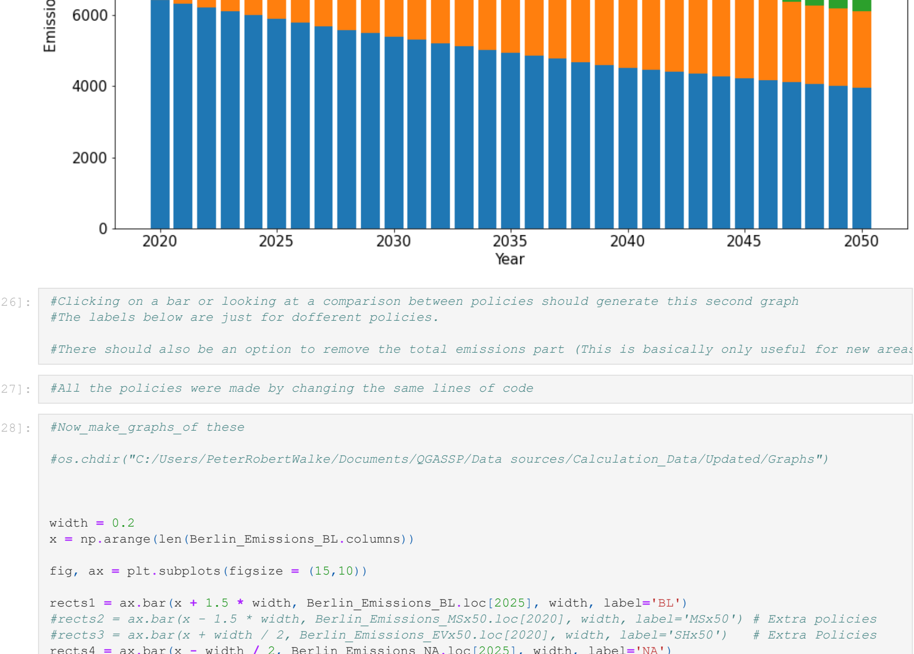
	Housing_Energy	Housing_Other	Transport_Fuels	Transport_Other	Air_travel	Food	Tangible_goods	Services	Total_Emissions
2020	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2021	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2022	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2023	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2024	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2025	542.289687	3461.528081	1639.406546	178.283292	110.470079	795.568264	642.885424	387.008600	107757.439974
2026	532.859269	3401.332108	1610.897267	175.182946	108.549005	781.733332	631.705647	380.278521	7622.538093
2027	523.592846	3342.182943	1582.883763	172.136514	106.661337	768.138989	620.720285	373.665477	7489.982155
2028	514.487567	3284.062381	1555.357415	169.143060	104.806497	754.781052	609.925960	367.167434	7359.731366
2029	505.540628	3226.952536	1528.309749	166.201662	102.983912	741.655410	599.319347	360.782393	7231.745637
2030	496.749277	3170.835832	1501.732443	163.311415	101.193022	728.758022	588.897184	354.508387	7105.985581
2031	488.110807	3115.694997	1475.617315	160.471430	99.433275	716.084920	578.656262	348.343486	6982.412491
2032	479.622560	3061.513061	1449.956330	157.680832	97.704130	703.632203	568.593429	342.285793	6860.988338
2033	471.281923	3008.273349	1424.741590	154.938762	96.005055	691.396039	558.705590	336.333443	6741.675751
2034	463.086331	2955.959475	1399.965333	152.244377	94.335528	679.372662	548.989699	330.484604	6624.438010
2035	455.033259	2904.555340	1375.619936	149.596847	92.695033	667.558372	539.442769	324.737477	6509.239033
2036	447.120231	2854.045122	1351.697906	146.995358	91.083066	655.949532	530.061859	319.090292	6396.043366
2037	439.344810	2804.413278	1328.191879	144.439109	89.499132	644.542569	520.844083	313.541312	6284.816172
2038	431.704604	2755.644531	1305.094622	141.927313	87.942742	633.333974	511.786605	308.088829	6175.523219
2039	424.197261	2707.723872	1282.399027	139.459197	86.413417	622.320296	502.886635	302.731164	6068.130870
2040	416.820471	2660.636554	1260.098108	137.034001	84.910688	611.498146	494.141437	297.466669	5962.606074
2041	411.189226	2624.691354	1243.074182	135.182672	83.763545	603.236806	487.465586	293.447894	5882.051266
2042	405.634060	2589.231774	1226.280250	133.356354	82.631899	595.087077	480.879926	289.483413	5802.584753
2043	400.153943	2554.251253	1209.713204	131.554710	81.515542	587.047451	474.383238	285.572492	5724.191833
2044	394.747864	2519.743318	1193.369978	129.777406	80.414267	579.116439	467.974321	281.714408	5646.858002
2045	389.414820	2485.701586	1177.247550	128.024113	79.327871	571.292576	461.651988	277.908446	5570.568950
2046	384.153826	2452.119758	1161.342936	126.294507	78.256151	563.574414	455.415069	274.153903	5495.310563
2047	378.963908	2418.991620	1145.653193	124.588268	77.198910	555.960523	449.262412	270.450084	5421.068918
2048	373.844105	2386.311043	1130.175418	122.905081	76.155953	548.449497	443.192876	266.796303	5347.830277
2049	368.793471	2354.071981	1114.906748	121.244633	75.127086	541.039944	437.205341	263.191885	5275.581090
2050	363.811072	2322.268468	1099.844358	119.606618	74.112119	533.730494	431.298697	259.636163	5204.307989

In [24]:

```python
#Graphs are from here
```

In [25]:

```python
#First Graph is a breakdown of the Emissions as a stacked bar graph. Maybe best to just show this one by itsel

#Describe Emissions over time

fig, ax = plt.subplots(1,figsize = (15,10))
#Name of country Emissions
country = "Berlin"
Policy_label = "BL"

DF = locals()[country + "_Emissions_" + Policy_label].copy()

###
#x = np.arange(list(range(2020,2050)))
#plot bars

Labels = ['HE','HO','TF','TO','AT','F','TG','S']
sectors = list(IW_sectors.columns)

bottom = len(DF) * [0]
for idx, name in enumerate(sectors):
    plt.bar(DF.index, DF[name], bottom = bottom)
    bottom = bottom + DF[name]


ax.set_title("Annual Household Emissions for %s" % country, fontsize = 20)
ax.set_ylabel('Emissions / kG CO2 eq', fontsize = 15)
ax.tick_params(axis="y", labelsize=15)
ax.set_xlabel('Year', fontsize = 15)
ax.tick_params(axis="x", labelsize=15)

ax.legend(Labels, bbox_to_anchor=([1, 1, 0, 0]), ncol=8, prop={'size': 15})

plt.show()
```



In [26]:

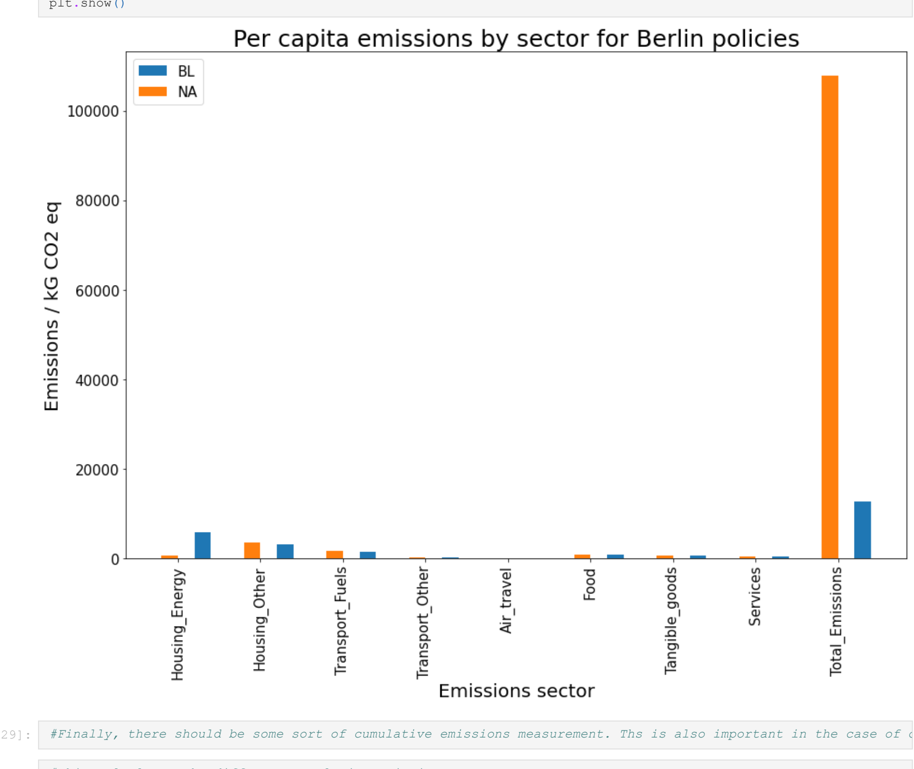
```python
#Clicking on a bar or looking at a comparison between policies should generate this second graph
#The labels below are just for dofferent policies.

#There should also be an option to remove the total emissions part (This is basically only useful for new area
```

In [27]:

```python
#All the policies were made by changing the same lines of code
```

In [28]:

```python
#Now_make_graphs_of these

#os.chdir("C:/Users/PeterRobertWalke/Documents/QGASSP/Data sources/Calculation_Data/Updated/Graphs")



width = 0.2
x = np.arange(len(Berlin_Emissions_BL.columns))

fig, ax = plt.subplots(figsize = (15,10))

rects1 = ax.bar(x + 1.5 * width, Berlin_Emissions_BL.loc[2025], width, label='BL')
#rects2 = ax.bar(x - 1.5 * width, Berlin_Emissions_MSx50.loc[2020], width, label='MSx50') # Extra policies
#rects3 = ax.bar(x + width / 2, Berlin_Emissions_EVx50.loc[2020], width, label='SHx50')   # Extra Policies
rects4 = ax.bar(x - width / 2, Berlin_Emissions_NA.loc[2025], width, label='NA')


#plt.bar(x_sectors, E_countries_GWP_sectors_pp['EE'], width = 0.5,  color='green')
#plt.bar(x_sectors, E_countries_GWP_sectors_pp['FI'], width = 0.5, color='blue', alpha = 0.5)
ax.legend_size = 20
ax.set_ylabel('Emissions / kG CO2 eq', fontsize = 20)
ax.set_xlabel('Emissions sector', fontsize = 20)
ax.set_title('Per capita emissions by sector for Berlin policies', fontsize = 25)
ax.set_xticks(x)
ax.set_xticklabels(Berlin_Emissions_BL.columns, fontsize = 15)
#ax.set_yticklabels( fontsize = 15)
ax.tick_params(axis="y", labelsize=15)
ax.legend(prop={'size': 15})



#x.label(rects1, padding=3)
#x.label(rects2, padding=3)

#lt.xlabel("Sectors")
#lt.ylabel("CO2 eq /  kG?")
#lt.title("Global Emissions by Sector")

plt.xticks(x, Berlin_Emissions_BL.columns, rotation = 90)

#plt.savefig("Sectoral_Graphs_breakdown.jpg",bbox_inches='tight', dpi=300)


plt.show()
```



In [29]:

```python
#Finally, there should be some sort of cumulative emissions measurement. Ths is also important in the case of
```

In [30]:

```python
#This calculates the different cumulative emissions
#Policy_labels = ["BL", "MSx50", "SHx50", "EVx50", "NA", "ALLx50_2035", "ALLx50_2025"]   #THIS is just all the
Policy_labels = ["BL", "NA"]                                                             #for the graphs
region = "Berlin"
for policy in Policy_labels:

    locals()[region + "_summed_" + policy] = pd.DataFrame(np.zeros((30,1)),index = list(range(2020,2050)), colu

    locals()[region + "_summed_" + policy].loc[2020, "Summed_Emissions"] = locals()[region + "_Emissions_" + po
    years = list(range(2020,2050))
    for year in years:
        locals()[region + "_summed_" + policy].loc[year+1,"Summed_Emissions"] = locals()[region + "_summed_" +

    print("The Emissions in 2025 for %s is" % policy, locals()[region + "_Emissions_" + policy].loc[2025,'Total
```

```
The Emissions in 2025 for BL is 12618.343997580578
The Emissions in 2025 for NA is 107757.43997398426
```

In [31]:

```python
#Make the graph

#Describe Emissions over time


fig, ax = plt.subplots(1,figsize = (15,10))
#Name of country Emissions
country = "Berlin"
#Policy_labels = ["BL","EVx50", "MSx50", "SHx50", "NA"]
Policy_labels = ["BL", "NA"]


counter = 0
for policy in Policy_labels:



    DF = locals()[country + "_summed_" + policy].copy()

###
#x = np.arange(list(range(2020,2050)))
#plot bars

#Labels = ['HE','HO','TF','TO','AT','F','TG','S']
    sectors = list(IW_sectors.columns)

#bottom = len(DF) * [0]
#for idx, name in enumerate(sectors):
 #   plt.bar(DF.index, DF[name], bottom = bottom)
  #  bottom = bottom + DF[name]

    plt.plot(DF.index, DF.Summed_Emissions, )

    plt.fill_between(DF.index, DF.Summed_Emissions,alpha = 0.4)#+counter)

    counter+=0.1

#x = np.arange(len(Ireland_Emissions.index))
#width = 0.8

#rects1 = ax.bar(x, Ireland_Emissions['Housing_Energy'], width, label=ab)

ax.set_title("Aggregated Household Emissions for %s 2020-2050" % country, fontsize = 20)
ax.set_ylabel('Emissions / kG CO2 eq', fontsize = 15)
ax.tick_params(axis="y", labelsize=15)
ax.set_xlabel('Year', fontsize = 15)
ax.tick_params(axis="x", labelsize=15)

ax.legend(Policy_labels, loc='upper left' , ncol=2, prop={'size': 15})

#plt.savefig("Cumulatove_example_high_buildphase.jpg",bbox_inches='tight', dpi=300)


plt.show()
```

In [32]:

```
"""
#Second_Example_eith_different_years

#Make the graph

#Describe Emissions over time


fig, ax = plt.subplots(1,figsize = (15,10))
#Name of country Emissions
country = "Berlin"
Policy_labels = ["BL","ALLx50_2035", "ALLx50_2025"]
#Policy_labels = ["BL", "NA"]


counter = 0
for policy in Policy_labels:



    DF = locals()[country + "_summed_" + policy].copy()

###
#x = np.arange(list(range(2020,2050)))
#plot bars

#Labels = ['HE','HO','TF','TO','AT','F','TG','S']
    sectors = list(IW_sectors.columns)

#bottom = len(DF) * [0]
#for idx, name in enumerate(sectors):
 #   plt.bar(DF.index, DF[name], bottom = bottom)
  #  bottom = bottom + DF[name]

    plt.plot(DF.index, DF.Summed_Emissions, )

    plt.fill_between(DF.index, DF.Summed_Emissions,alpha = 0.4)#+counter)

    counter+=0.1

#x = np.arange(len(Ireland_Emissions.index))
#width = 0.8

#rects1 = ax.bar(x, Ireland_Emissions['Housing_Energy'], width, label=ab)

ax.set_title("Aggregated Household Emissions for %s 2020-2050" % country, fontsize = 20)
ax.set_ylabel('Emissions / kG CO2 eq', fontsize = 15)
ax.tick_params(axis="y", labelsize=15)
ax.set_xlabel('Year', fontsize = 15)
ax.tick_params(axis="x", labelsize=15)

ax.legend(Policy_labels, loc='upper left' , ncol=2, prop={'size': 15})

#plt.savefig("Cumulative_example_diff_years.jpg",bbox_inches='tight', dpi=300)


plt.show()"""
```

Out[32]:

```
'\n#Second_Example_eith_different_years\n\n#Make the graph \n\n#Describe Emissions over time\n\n\nfig, ax = pl
t.subplots(1,figsize = (15,10))\n#Name of country Emissions\ncountry = "Berlin"\nPolicy_labels = ["BL","ALLx50_
2035", "ALLx50_2025"]\n#Policy_labels = ["BL", "NA"]\n\n\ncounter = 0\nfor policy in Policy_labels:\n    \n
\n\n    DF = locals()[country + "_summed_" + policy].copy()\n\n###\n#x = np.arange(list(range(2020,2050)))\n#pl
ot bars\n\n#Labels = [\'HE\',\'HO\',\'TF\',\'TO\',\'AT\',\'F\',\'TG\',\'S\']\n    sectors = list(IW_sectors.col
umns)\n\n#bottom = len(DF) * [0]\n#for idx, name in enumerate(sectors):\n #   plt.bar(DF.index, DF[name], botto
m = bottom)\n  #  bottom = bottom + DF[name]\n\n    plt.plot(DF.index, DF.Summed_Emissions, )\n    \n    plt.fi
ll_between(DF.index, DF.Summed_Emissions,alpha = 0.4)#+counter)\n    \n    counter+=0.1\n\n#x = np.arange(len(I
reland_Emissions.index))\n#width = 0.8\n\n#rects1 = ax.bar(x, Ireland_Emissions[\'Housing_Energy\'], width, lab
el=ab)\n\nax.set_title("Aggregated Household Emissions for %s 2020-2050" % country, fontsize = 20)\nax.set_ylab
el(\'Emissions / kG CO2 eq\', fontsize = 15)\nax.tick_params(axis="y", labelsize=15)\nax.set_xlabel(\'Year\', f
ontsize = 15)\nax.tick_params(axis="x", labelsize=15)\n\nax.legend(Policy_labels, loc=\'upper left\' , ncol=2,
prop={\'size\': 15})\n\n#plt.savefig("Cumulative_example_diff_years.jpg",bbox_inches=\'tight\', dpi=300)\n\n\np
lt.show()'
```

In [ ]: