Comprehensive Analytical Dashboard of European Countries Carbon Emission

Presentation of Final Project

Machine Learning 1: Classification

Faculty of Economic Sciences, University of Warsaw
Warsaw, Poland 2025

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Objective & Functionalities

Objective

- Europe houses some of the world’s largest and most influential economies.
- Analyze Europe’s carbon emissions, given the region’s economic prominence.
- Explore the environmental, economic, and policy implications of those emissions.

Data obtained from eurostat “Carbon dioxide emission footprints (FIGARO application)”

Required columns: year, countries, sector total emission

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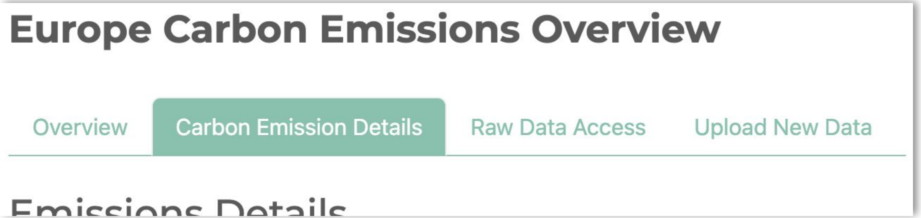
Functionalities

- Emission data visualizations to explore trends and carry out comparative analysis (e.g. line plots, bar graphs, pir chat, maps)
- Flexible and reproducible exploration tool:
    - Available for new emission data upload for future analysis
    - Able to filter and export data source used
    - Allowed to save plots / charts if available



Europe Carbon Emissions Overview

Emissions Details

Utilisation of Coding Methods

Implementation of Interactive Web Applications using Shiny

Frontend (UI):

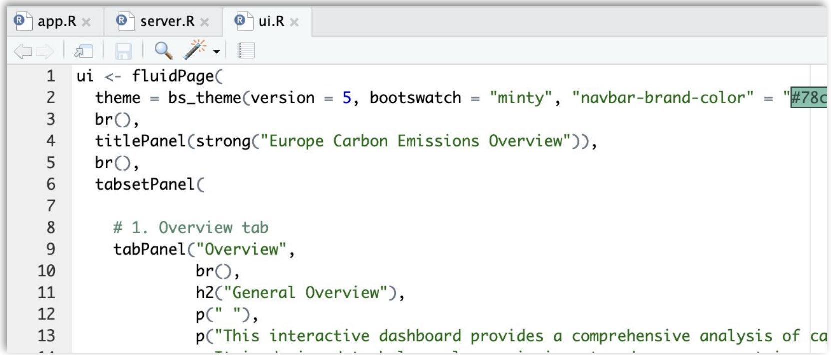
- “tabsetPanel” and reactive inputs (sliders, dropdowns)

Backend (Server):

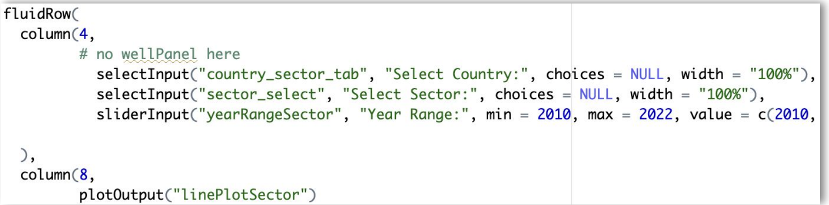
- Reactive programming e.g. “observe”, and integrated with table / plots output like DT
- Data validation workflow for new uploads

Setup (App):

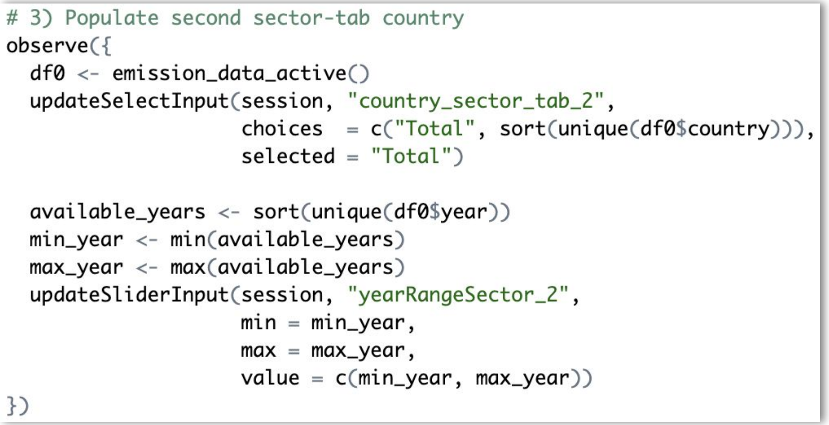
- For preloading necessary components



```
ui <- fluidPage(
  theme = bs_theme(version = 5, bootswatch = "minty", "navbar-brand-color" = "#78c
  br(),
  titlePanel(strong("Europe Carbon Emissions Overview")),
  br(),
  tabsetPanel(

    # 1. Overview tab
    tabPanel("Overview",
             br(),
             h2("General Overview"),
             p(" "),
             p("This interactive dashboard provides a comprehensive analysis of ca
```



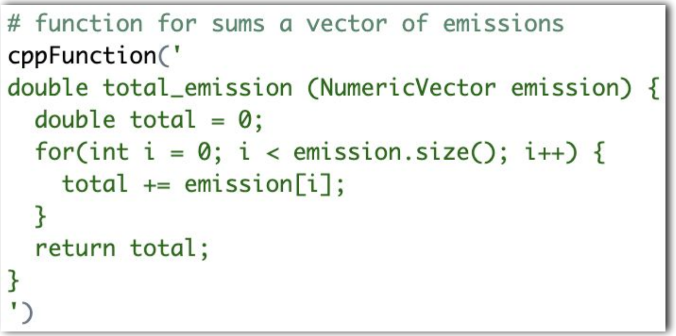
```
fluidRow(
  column(4,
         # no wellPanel here
           selectInput("country_sector_tab", "Select Country:", choices = NULL, width = "100%"),
           selectInput("sector_select", "Select Sector:", choices = NULL, width = "100%"),
           sliderInput("yearRangeSector", "Year Range:", min = 2010, max = 2022, value = c(2010,

  ),
  column(8,
         plotOutput("linePlotSector")
```



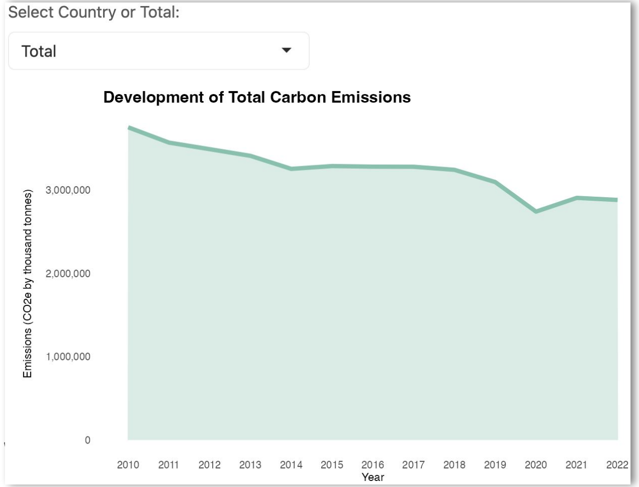
```
# 3) Populate second sector-tab country
observe({
  df0 <- emission_data_active()
  updateSelectInput(session, "country_sector_tab_2",
                    choices  = c("Total", sort(unique(df0$country))),
                    selected = "Total")

  available_years <- sort(unique(df0$year))
  min_year <- min(available_years)
  max_year <- max(available_years)
  updateSliderInput(session, "yearRangeSector_2",
                    min = min_year,
                    max = max_year,
                    value = c(min_year, max_year))
})
```

Utilisation of Coding Methods

Usage of C++ in Newly-Built Functions

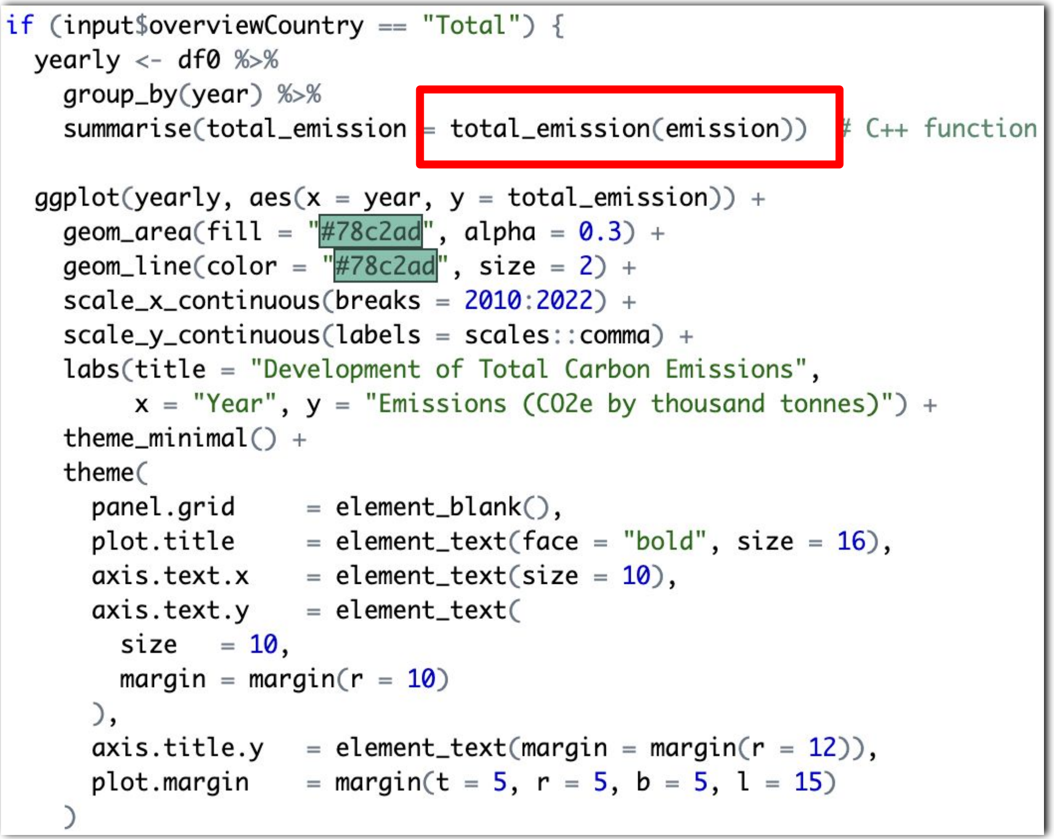


```
# function for sums a vector of emissions
cppFunction('
double total_emission (NumericVector emission) {
  double total = 0;
  for(int i = 0; i < emission.size(); i++) {
    total += emission[i];
  }
  return total;
}
')
```



Select Country or Total:

Total

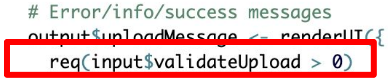


```
if (input$overviewCountry == "Total") {
  yearly <- df0 %>%
    group_by(year) %>%
    summarise(total_emission = total_emission(emission))  # C++ function

  ggplot(yearly, aes(x = year, y = total_emission)) +
    geom_area(fill = "#78c2ad", alpha = 0.3) +
    geom_line(color = "#78c2ad", size = 2) +
    scale_x_continuous(breaks = 2010:2022) +
    scale_y_continuous(labels = scales::comma) +
    labs(title = "Development of Total Carbon Emissions",
         x = "Year", y = "Emissions (CO2e by thousand tonnes)") +
    theme_minimal() +
    theme(
      panel.grid     = element_blank(),
      plot.title     = element_text(face = "bold", size = 16),
      axis.text.x    = element_text(size = 10),
      axis.text.y    = element_text(
        size   = 10,
        margin = margin(r = 10)
      ),
      axis.title.y   = element_text(margin = margin(r = 12)),
      plot.margin    = margin(t = 5, r = 5, b = 5, l = 15)
    )
```

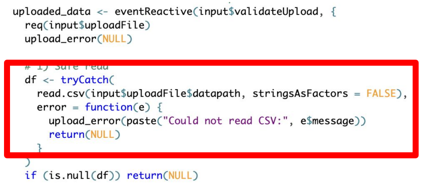
Utilisation of Coding Methods

Defensive programming methods

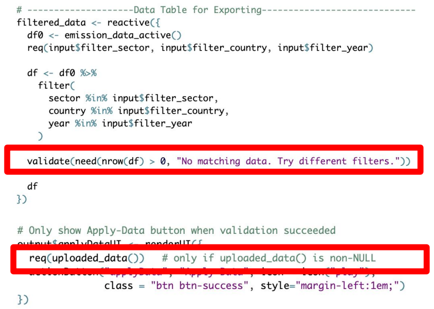
- Input validation in each frequent use of req() and validate() functions -> stop render plot if the required inputs are wrong or unavailable
- TryCatch() for error handling when importing file to check for corrupted file or different format, then returns different messages.



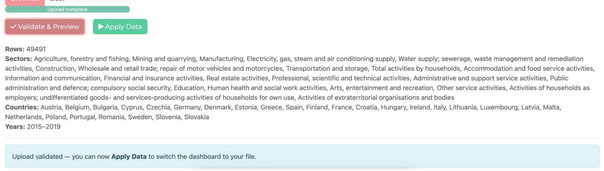
```
# Error/info/success messages
output$uploadMessage <- renderUI({
  req(input$validateUpload > 0)
```



```
uploaded_data <- eventReactive(input$validateUpload, {
  req(input$uploadFile)
  upload_error(NULL)

  # 1) Safe read
  df <- tryCatch(
    read.csv(input$uploadFile$datapath, stringsAsFactors = FALSE),
    error = function(e) {
      upload_error(paste("Could not read CSV:", e$message))
      return(NULL)
    }
  )
  if (is.null(df)) return(NULL)
```

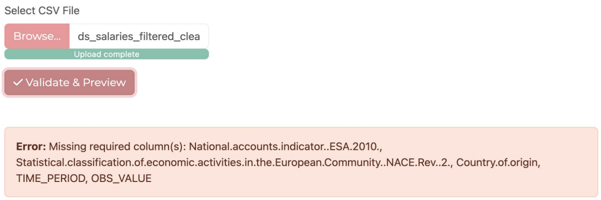


```
# -------------------Data Table for Exporting---------------------------
filtered_data <- reactive({
  df0 <- emission_data_active()
  req(input$filter_sector, input$filter_country, input$filter_year)

  df <- df0 %>%
    filter(
      sector %in% input$filter_sector,
      country %in% input$filter_country,
      year %in% input$filter_year
    )

  validate(need(nrow(df) > 0, "No matching data. Try different filters."))

  df
})

# Only show Apply-Data button when validation succeeded
output$applyDataUI <- renderUI({
  req(uploaded_data())   # only if uploaded_data() is non-NULL
  actionButton("applyData", "Apply Data", icon = icon("play"),
               class = "btn btn-success", style="margin-left:1em;")
})
```



Rows: 49491
Sectors: Agriculture, forestry and fishing, Mining and quarrying, Manufacturing, Electricity, gas, steam and air conditioning supply, Water supply; sewerage, waste management and remediation activities, Construction, Wholesale and retail trade; repair of motor vehicles and motorcycles, Transportation and storage, Total activities by households, Accommodation and food service activities, Information and communication, Financial and insurance activities, Real estate activities, Professional, scientific and technical activities, Administrative and support service activities, Public administration and defence; compulsory social security, Education, Human health and social work activities, Arts, entertainment and recreation, Other service activities, Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use, Activities of extraterritorial organisations and bodies
Countries: Austria, Belgium, Bulgaria, Cyprus, Czechia, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia
Years: 2015–2019

Upload validated — you can now **Apply Data** to switch the dashboard to your file.



Error: Missing required column(s): National.accounts.indicator..ESA.2010., Statistical.classification.of.economic.activities.in.the.European.Community..NACE.Rev..2., Country.of.origin, TIME_PERIOD, OBS_VALUE

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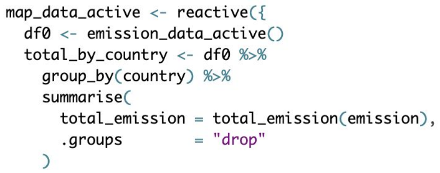
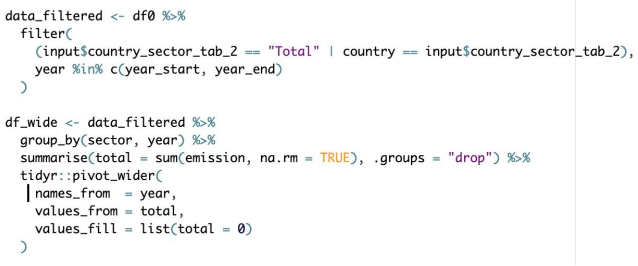
Utilisation of Coding Methods

Code vectorisation

- Most of the code are vectorised as tibble using dplyr to filter each columns according to certain conditions
- Minimal for-loop function for (except in C++) function



```r
map_data_active <- reactive({
  df0 <- emission_data_active()
  total_by_country <- df0 %>%
    group_by(country) %>%
    summarise(
      total_emission = total_emission(emission),
      .groups        = "drop"
    )
```



```r
data_filtered <- df0 %>%
  filter(
    (input$country_sector_tab_2 == "Total" | country == input$country_sector_tab_2),
    year %in% c(year_start, year_end)
  )

df_wide <- data_filtered %>%
  group_by(sector, year) %>%
  summarise(total = sum(emission, na.rm = TRUE), .groups = "drop") %>%
  tidyr::pivot_wider(
    names_from  = year,
    values_from = total,
    values_fill = list(total = 0)
  )
```

Short Demo

Comprehensive Dashboard of European Countries Carbon Emission

Advanced Programming in R [2400-DS1APR]

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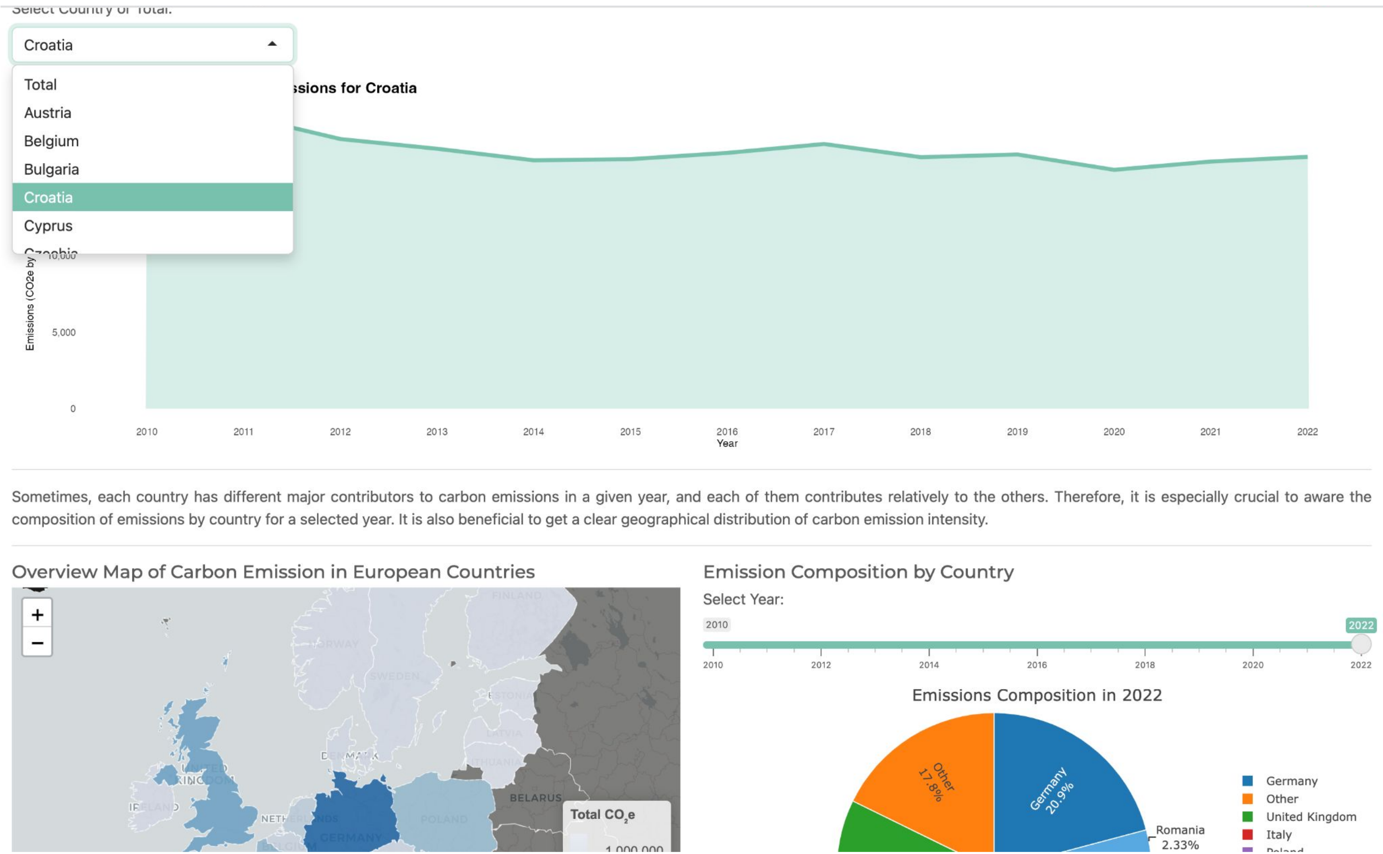

Sometimes, each country has different major contributors to carbon emissions in a given year, and each of them contributes relatively to the others. Therefore, it is especially crucial to aware the composition of emissions by country for a selected year. It is also beneficial to get a clear geographical distribution of carbon emission intensity.

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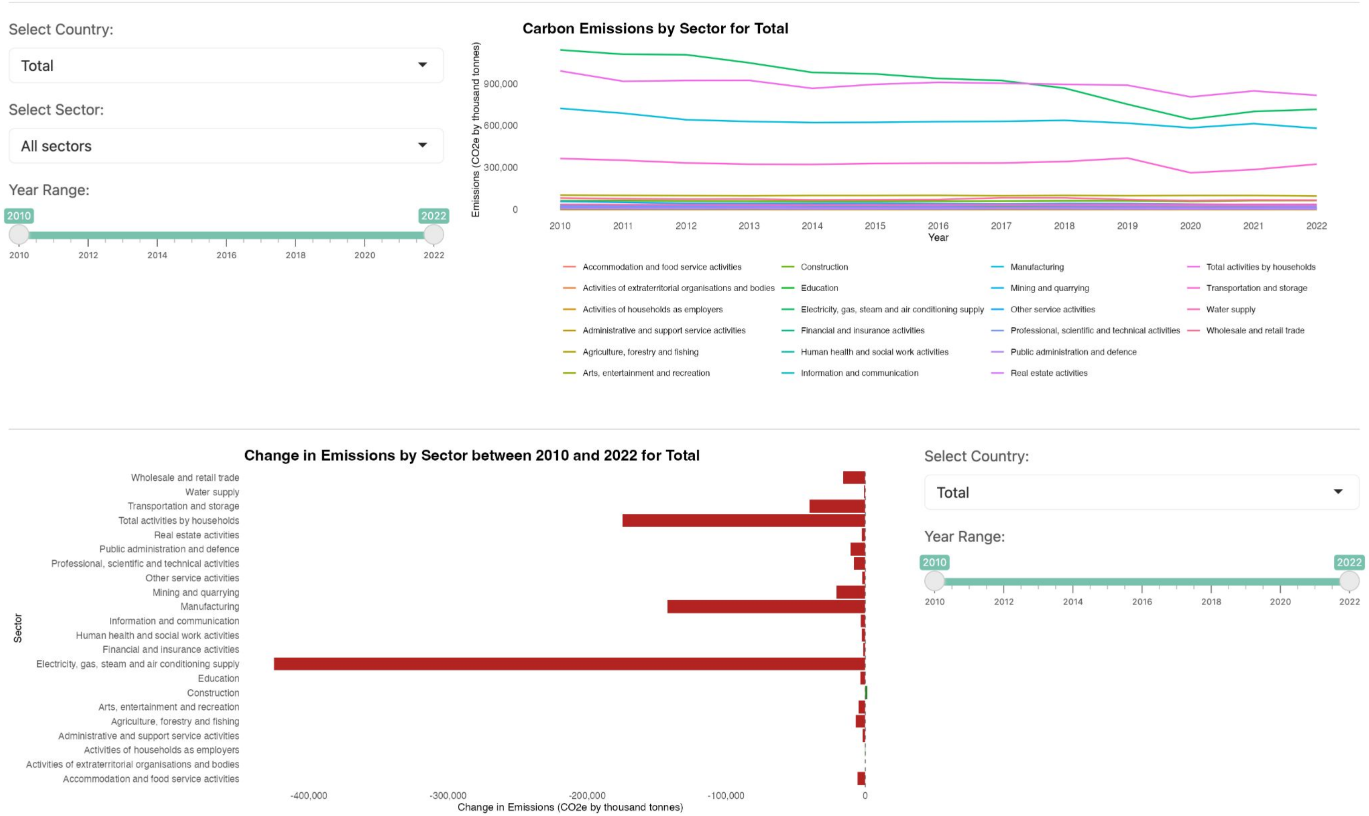
difficult to spot which sectors have made progress in reducing emissions and which have seen increases.



Select Country: Total

Select Sector: All sectors

Year Range: 2010 – 2022

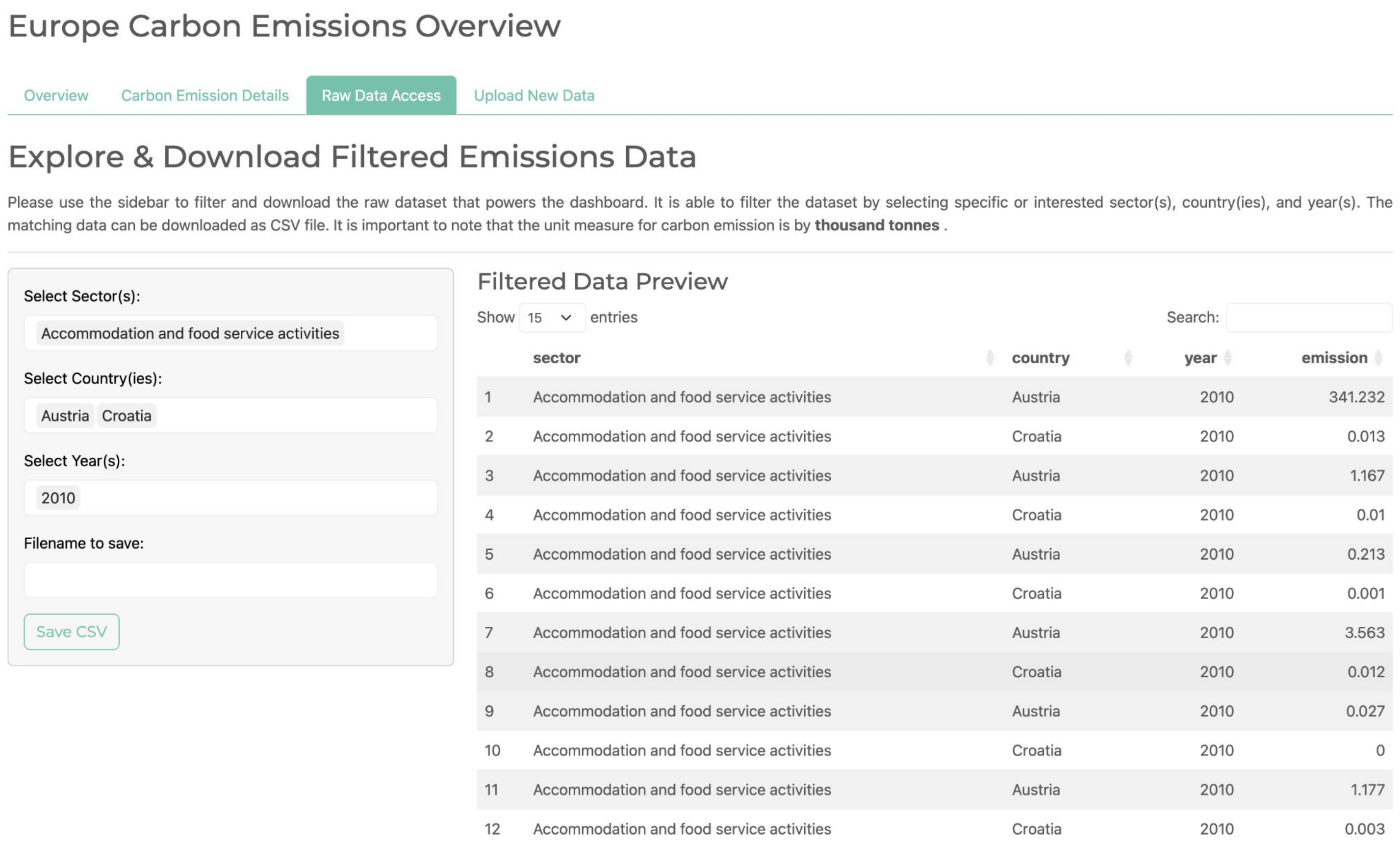
2010
2012
2014
2016
2018
2020
2022
Carbon Emissions by Sector for Total
Emissions (CO2e by thousand tonnes)
900,000
600,000
300,000
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Year
Accommodation and food service activities
Activities of extraterritorial organisations and bodies
Activities of households as employers
Administrative and support service activities
Agriculture, forestry and fishing
Arts, entertainment and recreation
Construction
Education
Electricity, gas, steam and air conditioning supply
Financial and insurance activities
Human health and social work activities
Information and communication
Manufacturing
Mining and quarrying
Other service activities
Professional, scientific and technical activities
Public administration and defence
Real estate activities
Total activities by households
Transportation and storage
Water supply
Wholesale and retail trade

Change in Emissions by Sector between 2010 and 2022 for Total
Sector
Wholesale and retail trade
Water supply
Transportation and storage
Total activities by households
Real estate activities
Public administration and defence
Professional, scientific and technical activities
Other service activities
Mining and quarrying
Manufacturing
Information and communication
Human health and social work activities
Financial and insurance activities
Electricity, gas, steam and air conditioning supply
Education
Construction
Arts, entertainment and recreation
Agriculture, forestry and fishing
Administrative and support service activities
Activities of households as employers
Activities of extraterritorial organisations and bodies
Accommodation and food service activities
-400,000
-300,000
-200,000
-100,000
0
Change in Emissions (CO2e by thousand tonnes)

Select Country: Total

Year Range: 2010 – 2022

2010
2012
2014
2016
2018
2020
2022



Europe Carbon Emissions Overview

Explore & Download Filtered Emissions Data

Please use the sidebar to filter and download the raw dataset that powers the dashboard. It is able to filter the dataset by selecting specific or interested sector(s), country(ies), and year(s). The matching data can be downloaded as CSV file. It is important to note that the unit measure for carbon emission is by **thousand tonnes** .

Select Sector(s): Accommodation and food service activities

Select Country(ies): Austria Croatia

Select Year(s): 2010

Filename to save:

Filtered Data Preview

Show 15 entries

Search:

	sector	country	year	emission
1	Accommodation and food service activities	Austria	2010	341.232
2	Accommodation and food service activities	Croatia	2010	0.013
3	Accommodation and food service activities	Austria	2010	1.167
4	Accommodation and food service activities	Croatia	2010	0.01
5	Accommodation and food service activities	Austria	2010	0.213
6	Accommodation and food service activities	Croatia	2010	0.001
7	Accommodation and food service activities	Austria	2010	3.563
8	Accommodation and food service activities	Croatia	2010	0.012
9	Accommodation and food service activities	Austria	2010	0.027
10	Accommodation and food service activities	Croatia	2010	0
11	Accommodation and food service activities	Austria	2010	1.177
12	Accommodation and food service activities	Croatia	2010	0.003

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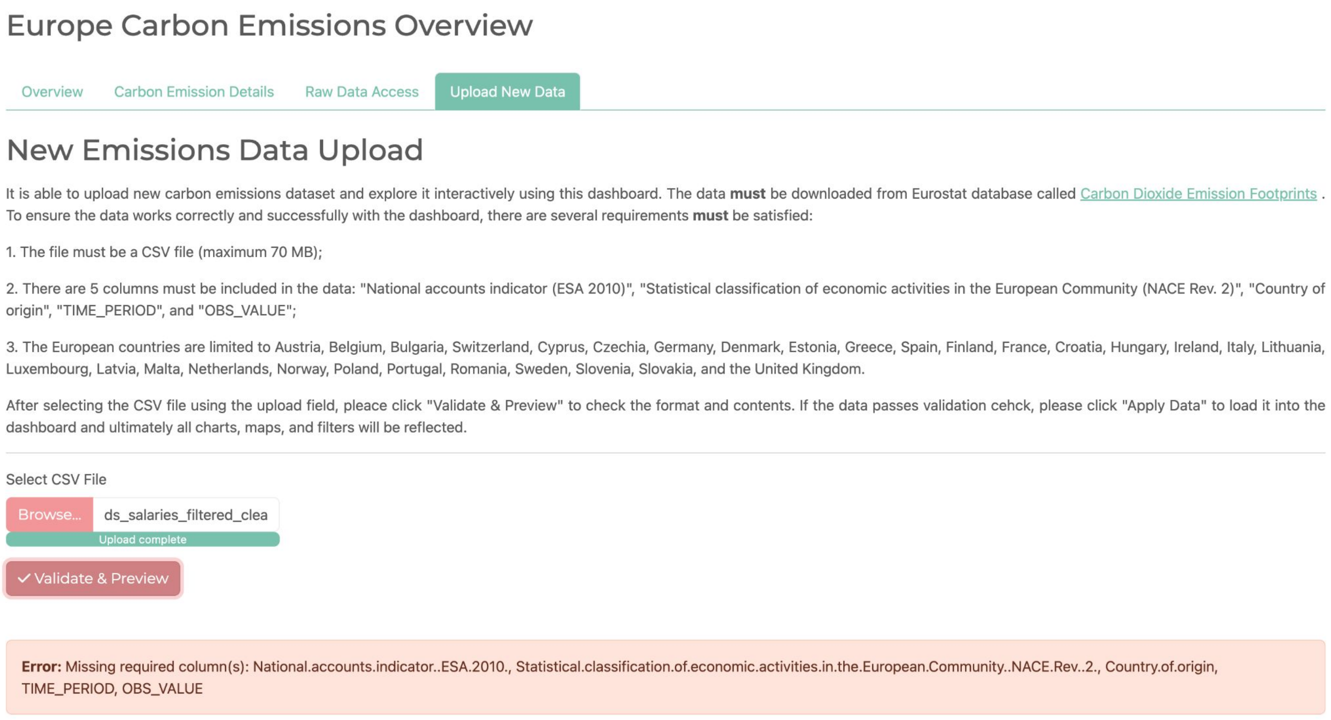

Europe Carbon Emissions Overview

New Emissions Data Upload

It is able to upload new carbon emissions dataset and explore it interactively using this dashboard. The data **must** be downloaded from Eurostat database called Carbon Dioxide Emission Footprints . To ensure the data works correctly and successfully with the dashboard, there are several requirements **must** be satisfied:

1. The file must be a CSV file (maximum 70 MB);

2. There are 5 columns must be included in the data: "National accounts indicator (ESA 2010)", "Statistical classification of economic activities in the European Community (NACE Rev. 2)", "Country of origin", "TIME_PERIOD", and "OBS_VALUE";

3. The European countries are limited to Austria, Belgium, Bulgaria, Switzerland, Cyprus, Czechia, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Croatia, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, and the United Kingdom.

After selecting the CSV file using the upload field, pleace click "Validate & Preview" to check the format and contents. If the data passes validation cehck, please click "Apply Data" to load it into the dashboard and ultimately all charts, maps, and filters will be reflected.

Select CSV File

ds_salaries_filtered_clea

Error: Missing required column(s): National.accounts.indicator..ESA.2010., Statistical.classification.of.economic.activities.in.the.European.Community..NACE.Rev..2., Country.of.origin, TIME_PERIOD, OBS_VALUE

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Thank you!

Questions?

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