SmogSense

Understand the unseen

PROCESS BOOK

LORENZO DRUDI
BEATRICE GRASSANO
EMANUELE RIMOLDI

BACKGROUND

Air quality goes beyond fresh air, underpinning human health, productivity and ecosystem resilience. Exposure to pollutants drives respiratory and cardiovascular diseases and cognitive decline, making clean air a critical public health issue in Europe and worldwide. Once viewed as a local problem, air pollution is now a transboundary threat thanks to advances in monitoring and modeling.

Existing web based tools map air quality interactively but often lack context and education, leaving users to interpret raw data alone. SmogSense – Understand the Unseen bridges that gap with a streamlined, narrative driven, single page application that not only visualizes pollutant levels but also delivers the insights and explanations users need to act.

GOAL

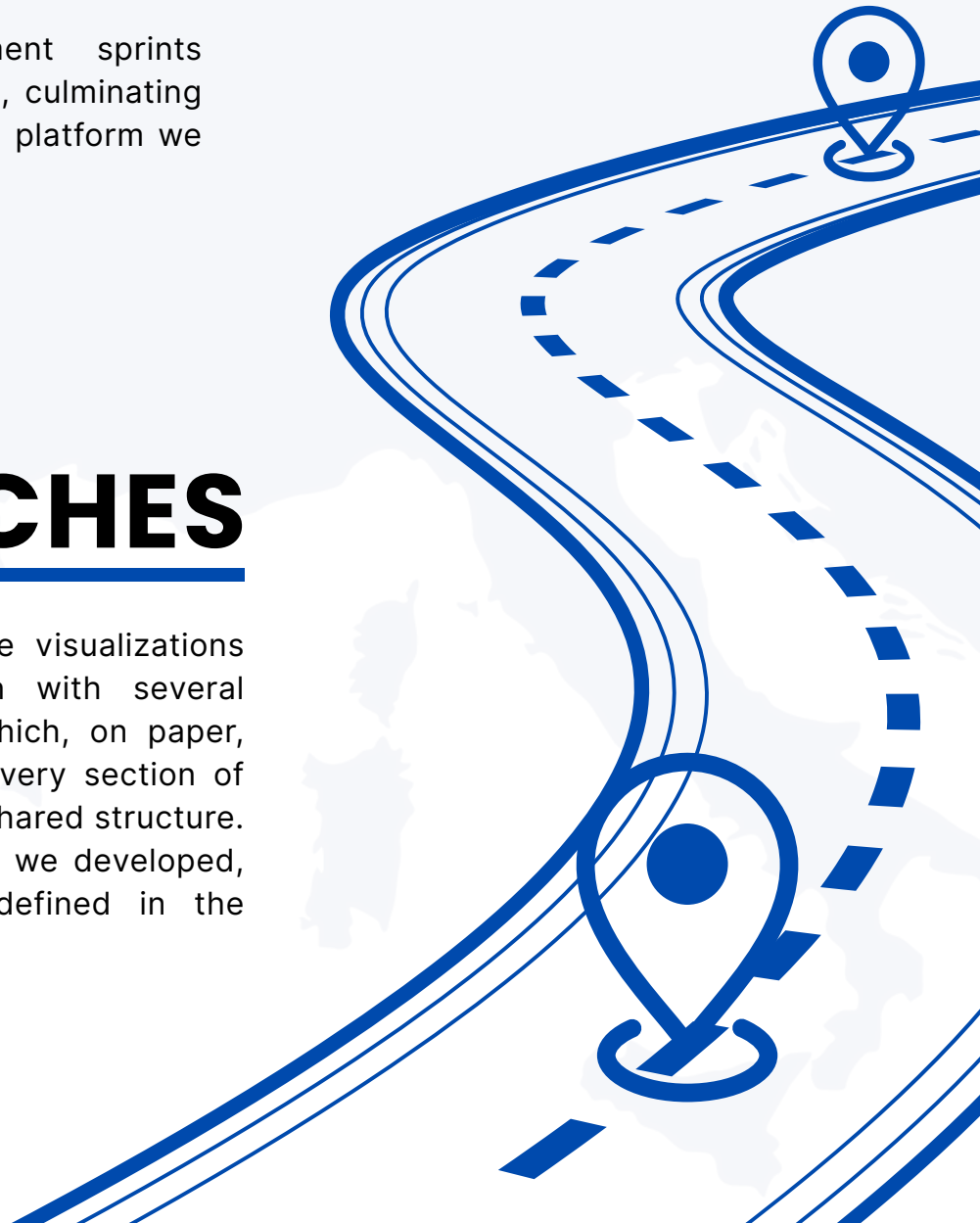
Our narrative-driven interface guides you through Europe's air quality, from a continental AQI map that highlights clean and caution zones to country and city charts revealing fresh breezes or breathing challenges at a glance. Switch to pollutant mode to track O_3, NO_2 and more over time and explore Curiosities for insights, such as how EV adoption often coincides with pollution dips, so you leave with actionable ideas. Embracing "less is more," our minimal design keeps interactions intuitive and focused, grounded in three core values: Clarity: straightforward data; Accessibility: intuitive for every user; Empowerment: insights for informed decisions.

FROM IDEAS

What a journey it's been. We began by exploring existing air-quality visualizations and environmental reports to spark our own ideas. From there, we sketched several rough layouts, experimenting with map styles, color palettes, and simple animations that communicate pollution levels without distraction.

Our brainstorming sessions helped us refine each interaction, from country-click navigation to tooltip phrasing, ensuring every detail remained clear and approachable. In parallel, we tackled performance challenges by optimizing data handling so our visualizations load smoothly.

Finally, focused development sprints brought these designs to life, culminating in the interactive SmogSense platform we present today.

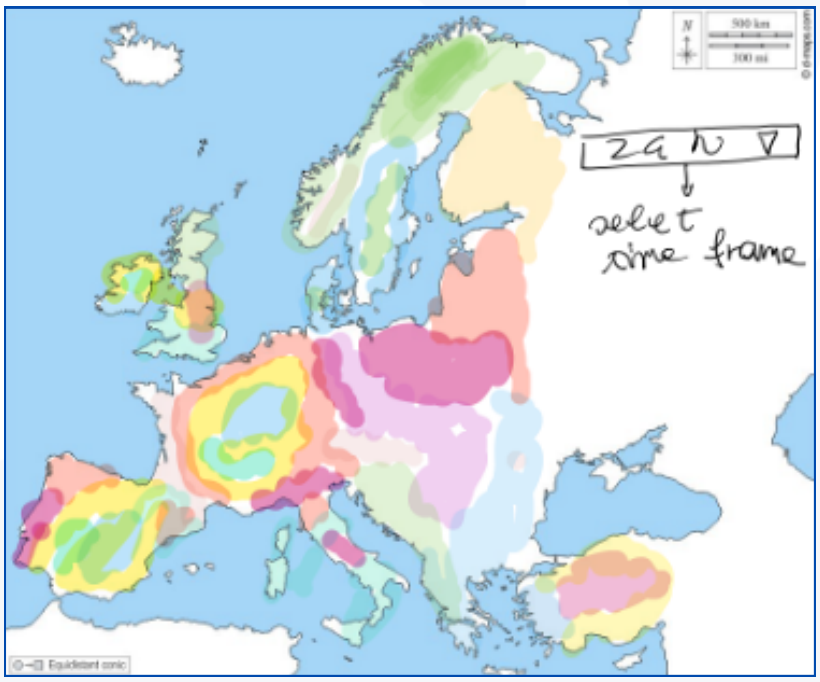


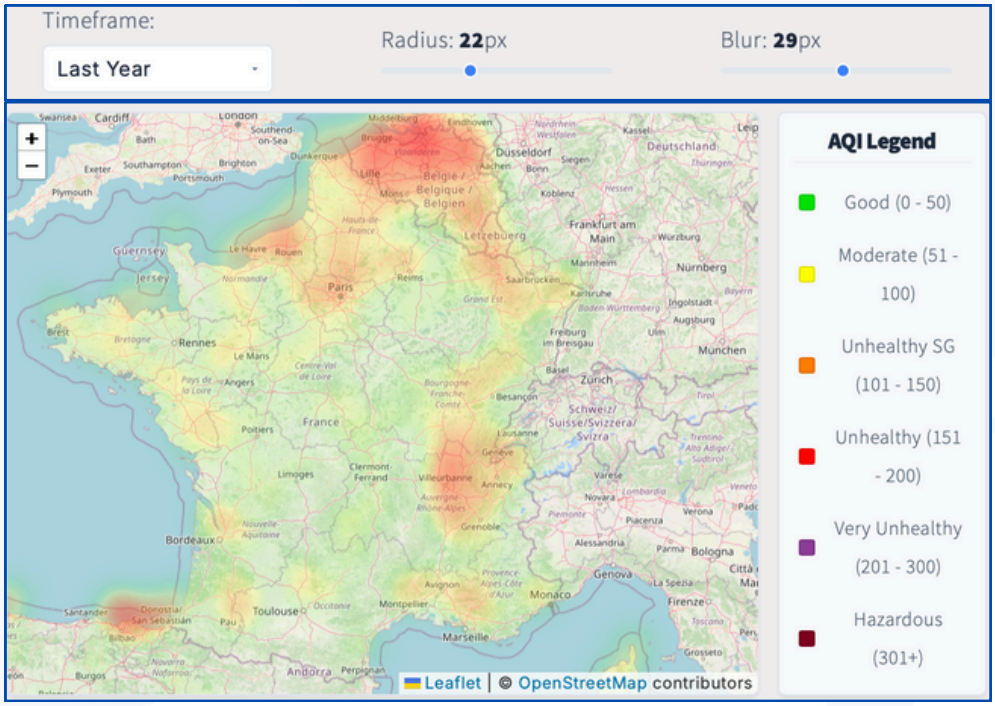
TO SKETCHES

To define the most effective visualizations for SmogSense, we began with several brainstorming sessions in which, on paper, we sketched out drafts of every section of the site until we arrived at a shared structure. Below are the main sketches we developed, aligned with the content defined in the project's Milestone 2.

MAP

In our initial phase, we drafted multiple layouts to identify the clearest way to display Europe's air quality. We chose a full continent heat map of the Air Quality Index paired with a drop down menu for selecting timeframes, offering live data from the last 24 hours, the past month, the previous year or any custom range. By fine tuning color gradients, from deep violet reds for severe pollution through yellows to greens for the cleanest air, and experimenting with different map styles, we ensured users can immediately understand pollution patterns across the continent.

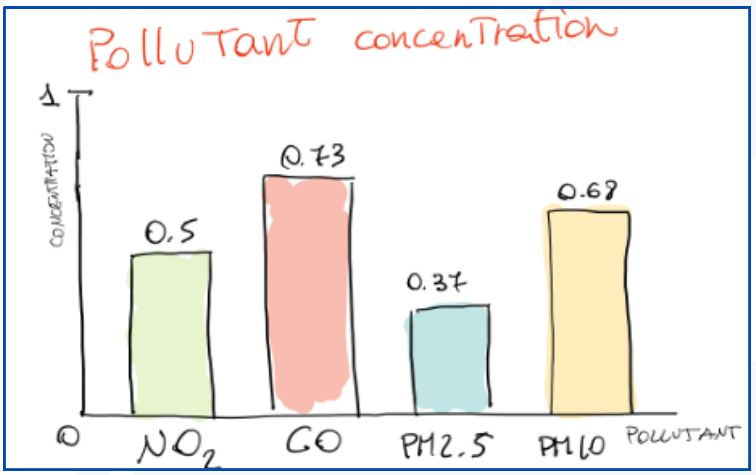


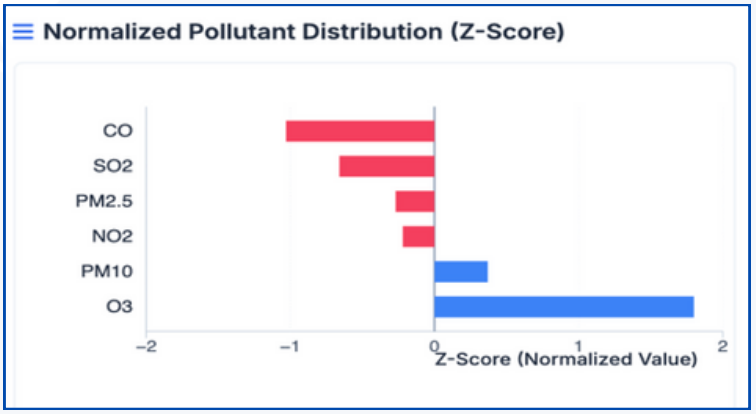


Building on our Milestone 2 prototype, we then added Radius and Blur sliders for precise control: upping the radius creates broader "heat blobs" for a high-level overview, while lowering it reveals sharper, localized hotspots, and adjusting the blur softens or sharpens the transitions between these areas. Together, these features turn raw measurements into an engaging, user-driven exploration of Europe's air quality.

BAR PLOT

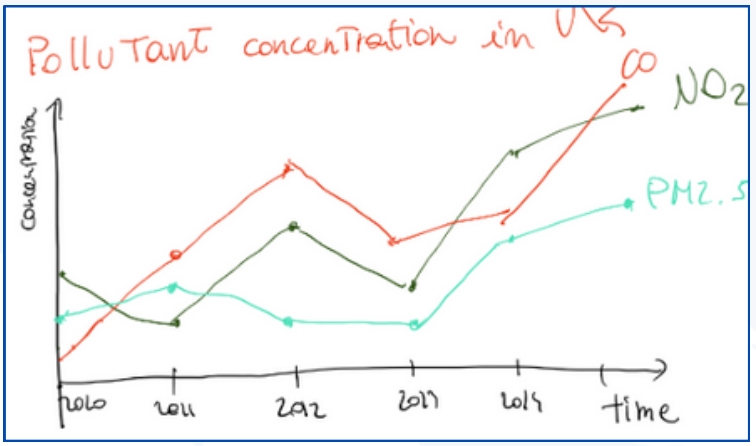
Our earliest paper prototype featured a vertical bar chart of pollutant concentrations normalized via Z scores, but when we moved to implementation we chose horizontal bars instead. This orientation makes positive and negative Z score values immediately intuitive, as bars extend to the right for above average pollution and to the left for below average, and it takes advantage of the screen's natural widescreen aspect, ensuring better readability and a more user friendly experience.

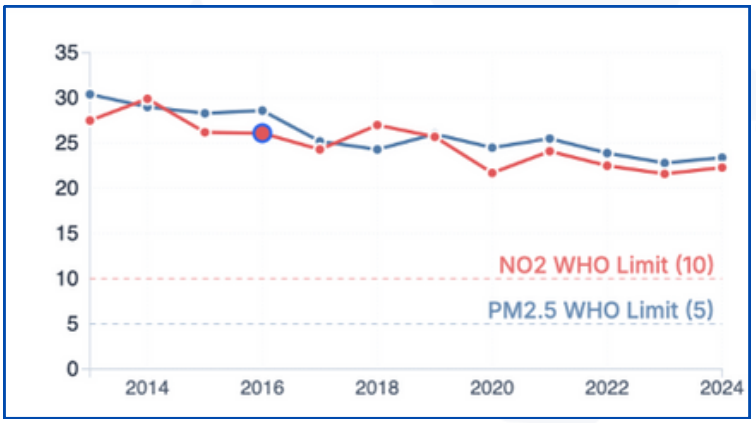




LINE CHART

After exploring the Z-score distribution, the next visualisation that we propose is a dynamic line chart that traces pollutant levels over the past year, revealing both long-term trends and seasonal peaks at a glance. Above the plot, simple checkboxes let you show or hide any of the nine key contaminants, so the user can layer multiple series for side-by-side comparison or focus on a single pollutant at its true scale. Two subtle horizontal lines mark the WHO's annual guidelines, highlighting moments when concentrations cross safe limits. This combination of interactive controls and standardized benchmarks makes it easy to interpret complex data and understand when air quality poses a public-health concern.

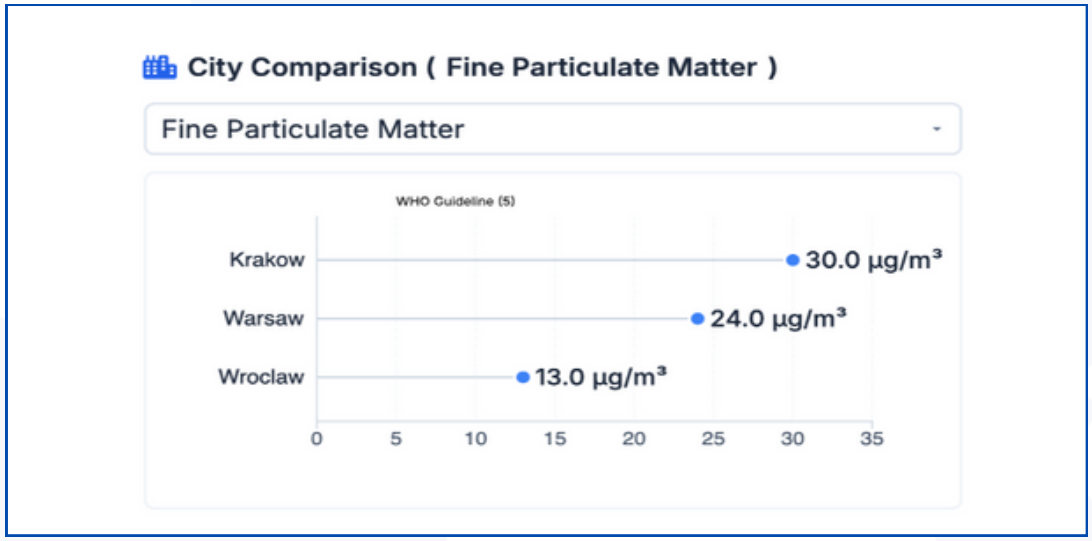




This line chart has stayed largely true to our original prototype, preserving its intuitive design while adding a final touch of interactivity. Now, when you hover or click on any data point on the line chart, a precise concentration value pops up, ensuring you never miss the exact figure, even if it lies outside the chart's typical range. This small enhancement turns a static trend line into a fully interactive exploration, letting the user dig into the details whenever curiosity strikes.

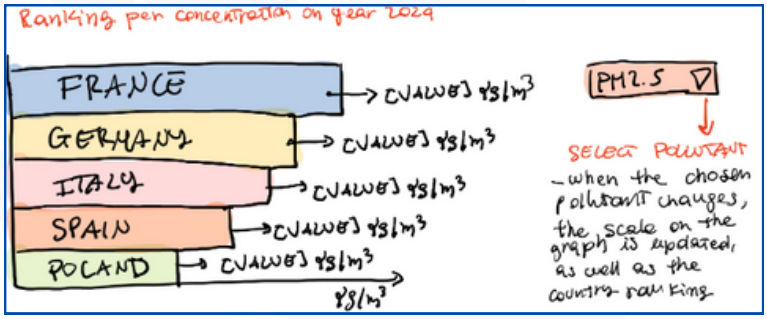
CITY COMPARISON

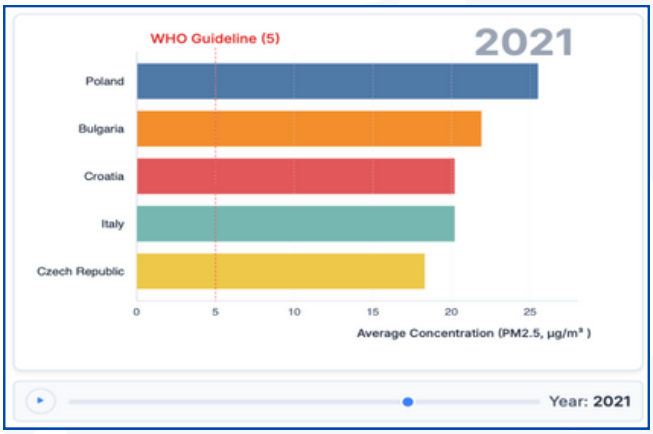
This final visualization, introduced later in development, follows our Milestone 2 concept by replacing bars with dot markers to lower visual density and add variety after the Z score chart. It embodies our cascading drill down approach from continent to country to city and presents a horizontal City Comparison plot that ranks urban areas by their average pollutant concentration.



Each location appears on the vertical axis, with its value plotted along the horizontal axis in µg/m³, instantly revealing which areas exceed safety thresholds. A subtle guideline indicates the recommended limit, while precise data labels eliminate guesswork and enable quick comparison. By guiding users from a broad overview to specific urban hotspots, this chart highlights regional air-quality disparities and empowers exploration of the most affected areas.

POLLUTTANT RANKING

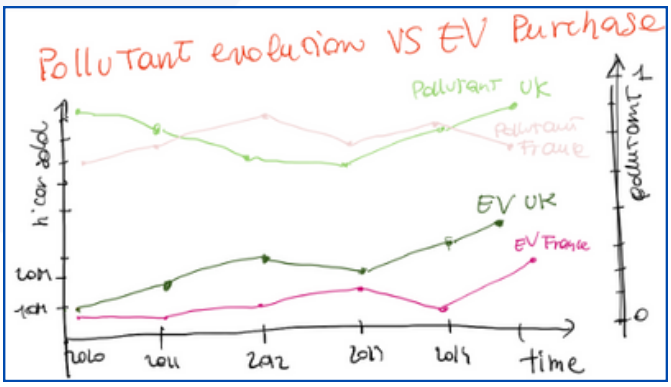


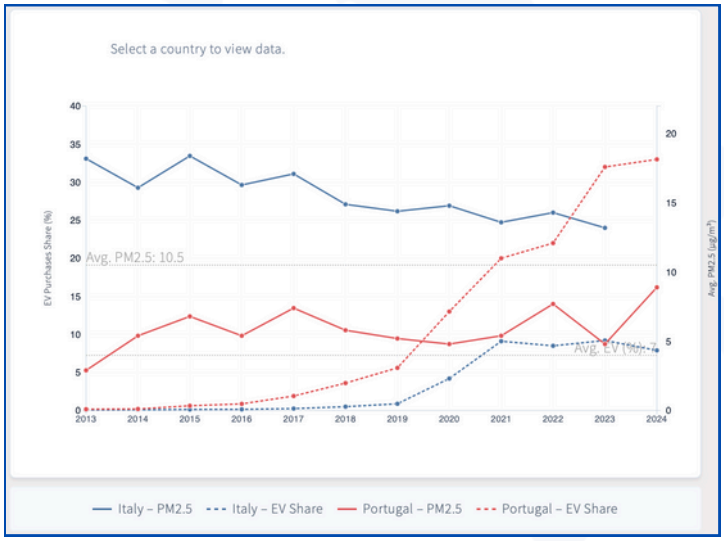


This visualization gives users a new perspective: after navigating from a Europe-wide view to countries and cities, they can dive even deeper by choosing a pollutant rather than a region. A dropdown menu lets users pick the contaminant of interest, which then drives a dynamic horizontal bar chart ranking the five most polluted cities each year. Compared to our initial sketchbook idea, a significant enhancement here is the introduction of a dynamic timeline evolution. Users can now actively control the playback of this animation, pausing and restarting it, or directly navigating to any specific year of interest. This added layer of interactivity fundamentally transforms the visualization, enabling a much richer exploration of historical trends.

ELECTRIC VEHICLES

In the final “Curiosities” section, users explore the link between clean transport and air quality through a dynamic chart that plots electric vehicle purchases against pollutant levels. One vertical axis shows EV purchase volumes while the other tracks pollutant concentrations, with shaded bands indicating the average over multiple years. By comparing two countries side by side, users can see how increases in EV adoption often align with lower pollution and how slower uptake corresponds with ongoing air quality challenges, underscoring how our transportation choices affect the air we share.





CHALLENGES

Bringing SmogSense to life wasn't without difficulty: we divided responsibilities between D3.js, which powered SVG overlays, and Leaflet, which managed geographic layers, then built a lightweight event system to sync tooltips and highlights; we tamed our heatmap controls by precomputing daily, monthly and yearly canvases offscreen so even midrange devices update instantly; we ensured legibility across desktop and mobile by using flexible CSS layouts and debounced resize handlers; and we met WCAG AA standards with semantic roles, ARIA labels and full keyboard support. At the same time we wrestled the 20 GB EEA AirBase Parquet dataset into submission by focusing on nine key pollutants, aggregating minute level readings into daily (and soon monthly) summaries, filtering out invalid values and converting Parquet to CSV then to compact JSON, shrinking it to a few hundred megabytes for seamless client side use.

FUTURE PERSPECTIVES

At SmogSense, we chose depth over breadth by focusing on the most vital air quality metrics and guiding users from a continental overview to country-level details, all complemented by rigorous data preprocessing and optimized rendering that delivers instant, interactive charts even on midrange devices. Looking ahead, SmogSense is set to evolve into a richer, more personalized air-quality companion by expanding its pollutant palette to include rarer but health-critical emissions, integrating predictive models that forecast air quality from weather patterns and historical trends, unveiling source-apportionment visualizations to reveal the contributions of traffic, industry or residential heating, and offering custom dashboards that let users tailor their pollutant mix and geographic focus.

PEER ASSESSMENT

SmogSense was the result of a collaborative effort and shared commitment. Each member contributed unique skills across different aspects of the project. **Lorenzo Drudi** led data acquisition, preprocessing, management and integration for SmogSense, sourcing and importing the raw dataset, developing Python scripts to clean and validate the data and integrating the processed data with the platform's interactive visualizations to ensure integrity and usability. **Beatrice Grassano** led visualization development and implementation using HTML, CSS and D3.js, structuring the markup, crafting styles, and engineering complex animations and interactions to transform visual designs into a robust, interactive frontend experience. **Emanuele Rimoldi** led visualization design, detail refinement and Process Book curation, ensuring each chart delivered clarity, usability and visual appeal, polishing visual details to elevate the user experience and meticulously documenting the project's journey and decisions. Our team fostered open communication and strong collaboration through regular brainstorming, code reviews, and shared problem-solving. This synergy helped us overcome even the toughest challenges.