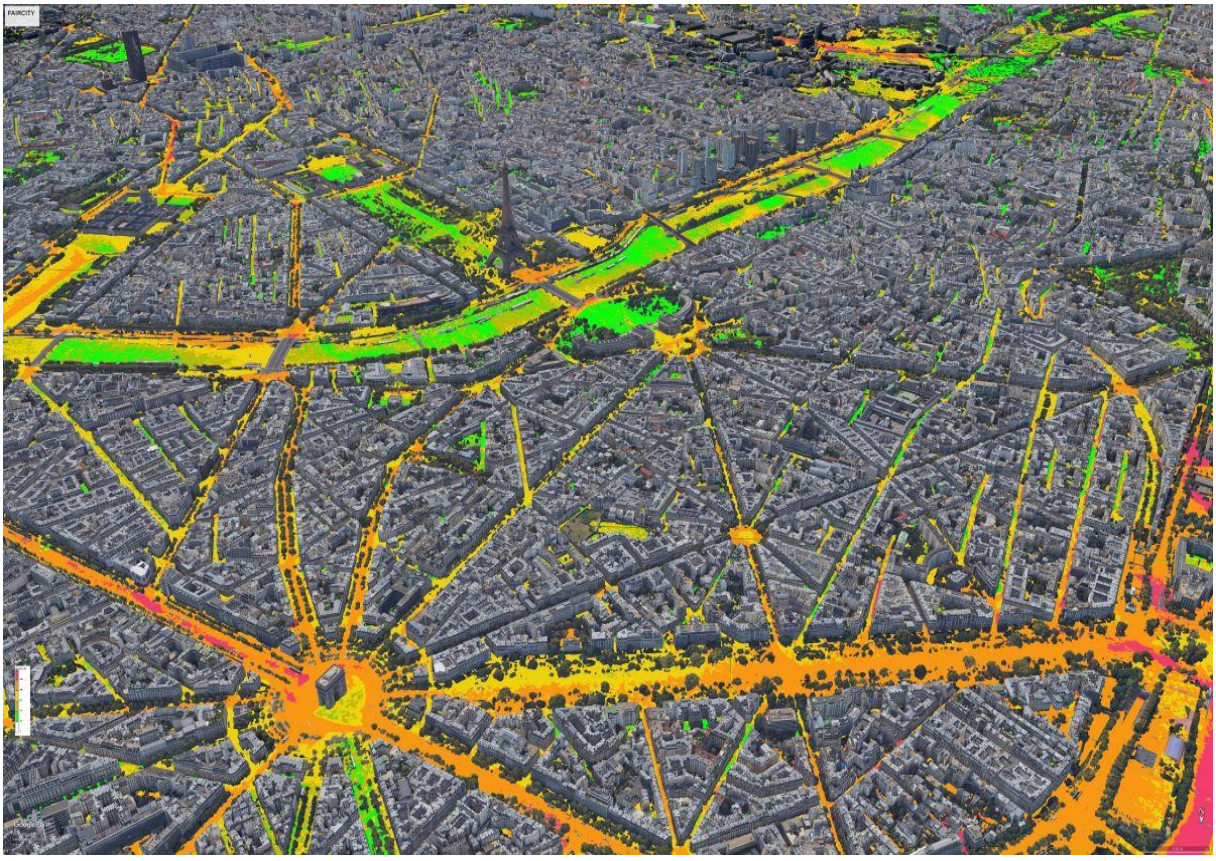
CENTRALE MARSEILLE

ÉCOLE CENTRALE LYON

# *Report on the SIRANE Project*

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## ACKNOWLEDGEMENTS:

First of all, we wish you a good reading of this manuscript and thank you for that.

We would like to thank everyone who contributed to the smooth running of the project as well as those who helped us in the writing of this report.

At the outset, we would like to thank Mr. Boiron for giving us the opportunity, in the form of this project, to address concrete issues in this area.

We would like to take this opportunity to thank Mr. Chi Vuong Nguyen, despite his busy schedule, has sacrificed his time and effort to keep us on track during our project and is very generous in terms of knowledge sharing.

# Introduction :

## 1. Context:

Residents of Lyon city are still exposed to NO2 concentrations that often exceed the established air quality standards. Most exceedances occur in the center of the city, mainly caused by traffic-related nitrogen oxides emissions originating from diesel cars.

Since the Traffic is one of the most source of pollution, it appears that having electrical cars would be the best approach to have less air pollution, in order to validate this hypothesis, we will focus on two study approaches, the first one is to use all the possible emissions and visualizing its results and impact, the second one is to see the impact of reducing Diesel cars by 25%, 50% and 75% (Replacing them by electrical cars), and visualize its impact on the air pollution.

To do this, we will use the SIRANE and QGIS software.

## 2. SIRANE:

SIRANE is a software for modeling air pollution in urban areas.

It has been developed for 15 years by the AIR-Atmosphere, Impact & Risk team of the Laboratory of Fluid Mechanics and Acoustics of the Ecole Centrale de Lyon.

It is used in more than 10 cities in France and Europe: Paris, Lyon, St-Etienne, Grenoble, Valence, Chambery, Annecy, Rouen, Le Havre, Milan, Turin.

## 3. Objective:

The objective of this study is to analyze the impacts of emissions reductions policy on the air pollution, using the three most pollutant sources, the traffic, industries and emissions from tertiary and backgrounds concentrations.

# ANALYSE 2: Traffic Emissions.

## 1. Results on the whole domain:

### 1.1. Description of The Methodology:

The first work to do is to run a SIRANE simulation without any emission reduction, to do this, first we have to change the path in the **COMMAND LINE** to the folder where SIRANE is located. Then, we have to run a simulation without any reduction as explained and the figure below.

```
C:\Users\DELL>cd C:\Users\DELL\Desktop\INPUT_EN\Run_SIRANE

C:\Users\DELL\Desktop\INPUT_EN\Run_SIRANE>.\sirane-rev128-win64.exe -LANG=EN INPUT_EN\Data.dat LISTING.txt
```

**Figure 1: Simulation without Reduction.**

To specify the emission reduction, we use the same **COMMAND LINE**, but we add the percentage of the emission at the end, here bellow an example of 25% of reduction.

```
C:\Users\DELL>cd C:\Users\DELL\Desktop\INPUT_EN\Run_SIRANE

C:\Users\DELL\Desktop\INPUT_EN\Run_SIRANE>.\Modif_Emis_Exe INPUT_EN Test Point 25
```

**Figure 2: Simulation with 25% of Reduction.**

### 1.2. Analysis of Results.

To analyze the results of the NO2 concentration variation, we will use two scenarios:

- First we will study the impact of three possible percentage of reduction (25%, 50% and 75%) on the total concentration.

- Second, we will visualize the concentrations on some given sensors positions.

### 1.2.1. Results on the whole domain.

- 25% Reduction:

After running a simulation on SIRANE with 25% of reduction, we used the QGIS software to analyze and visualize the results.
Here below the results of the analysis:

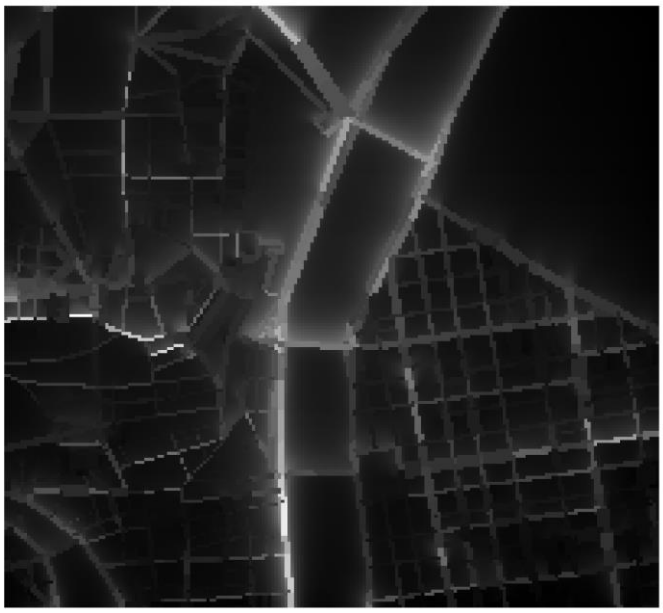


**Figure 3: Concentration of NO2 without reduction.**

In this figure, we observe that the NO2 is highly concentrated in the city center and next to roads, because of traffic and industry emissions.

After 25% of NO2 reduction, we observe that the reduction in the city of Lyon is uniform, which means that for 25% of reductions and taking in consideration all kind of emissions, the reduction is the same in the center compared to other places in Lyon, in this is because in city center, we have a high concentration due to traffic and outside city due to industry and other sources .

To explain this using QGIS, we calculated the **Ratio** of the 25% reduction out of concentration without reductions, and using the software we calculated the ration and many positions in the Lyon city, the Ratio is still uniform.

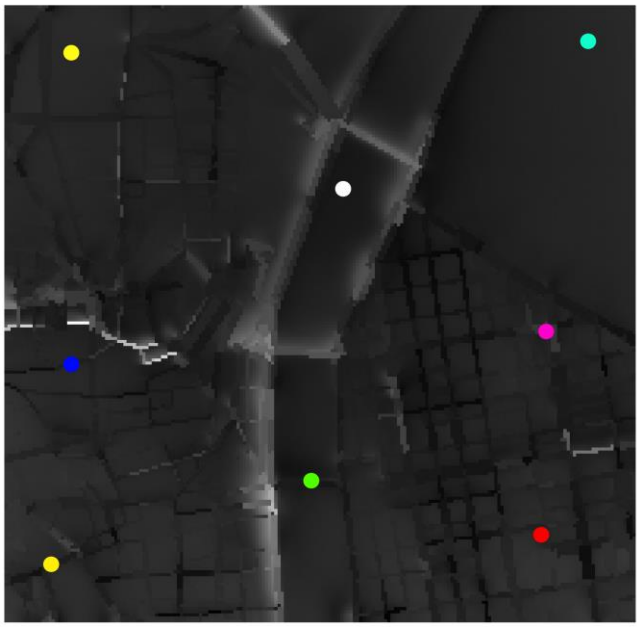


**Figure 4: Concentration of NO2 with 25 % reduction.**

In this figure, we took 8 different points in the map, we calculated the **Ratio** of the NO2 concentration in these points, and it varies between 72,2% and 72,4%.

We can explain this by the fact that we have too many sources of emission.

- 50% Reduction:

Like we did with the 25% of reduction, we used the same analysis on the 50% reduction and we found that in the Lyon city the Ratio of concentration varies between 46% and 45,1%, which means that the concentration is uniform and remains the same in the city for all emissions.

- 75% Reduction:

With the same deduction, the **Ratio** for 75% of emissions is uniform too.

### 1.2.2. Results on some specific sensors positions.

To analyze the impact of NO2 concentration on some specific sensors, we have to define these sensors and run a SIRANE simulation.

We have chosen in our approach 10 specific sensors positions.

In the figure below, the sensors we have chosen in our approach, while X is the x-axis in the city and Y is the y-axis of the position in the map of Lyon city.

| Id | X | Y | Z | Type | Fichier |
|---|---|---|---|---|---|
| Recept1 | 842850 | 6520872 | 2 | 1 | RECEPTORS/Recept_1.dat |
| Recept2 | 843042 | 6521589 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept3 | 842842 | 6520846 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept4 | 843046 | 6520834 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept5 | 843039 | 6520815 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept6 | 842865 | 6520272 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept7 | 842415 | 6520860 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept8 | 842145 | 6520969 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept9 | 842318 | 6520488 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept0 | 843231 | 6520615 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |

**Figure 5: Random sensors positions.**

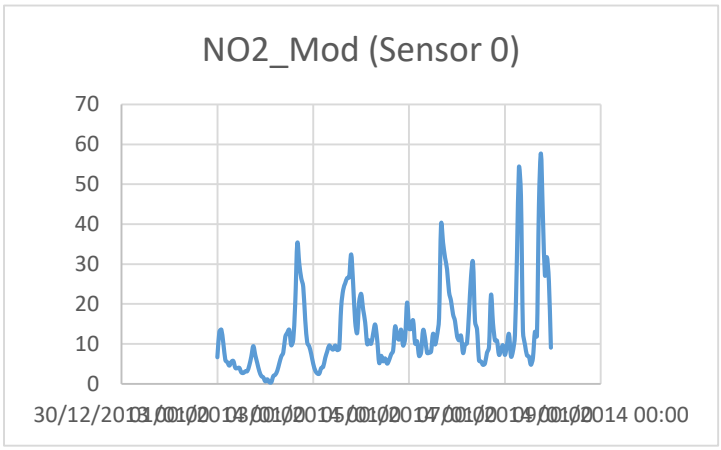
- 25% Reduction:

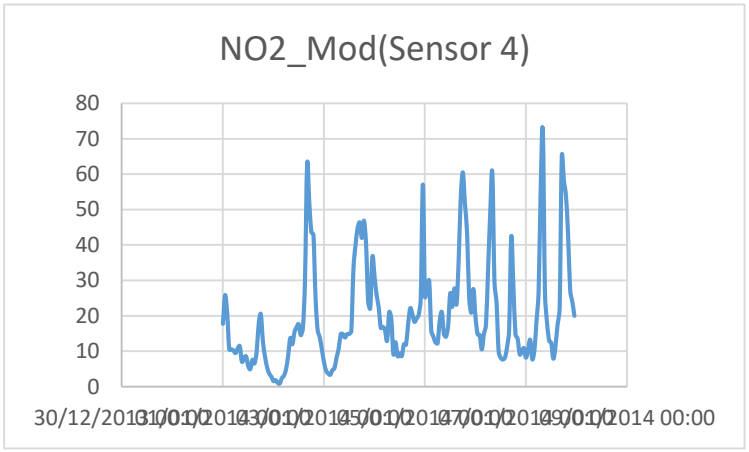
For a reduction of 25%, we will compare between 4 of these receptors in some different positions.

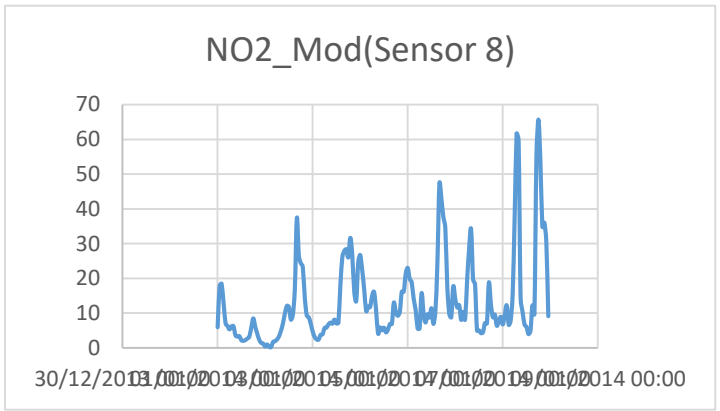
We will take the sensors 0,4,8 and 9, because they are in some boundary positions.

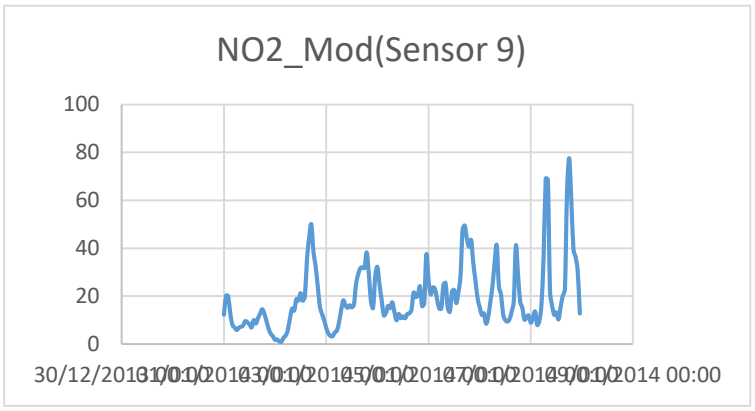
The next step is to visualize the variation of the NO2 concentration in these positions and compare the results in a time scale.

In the figure bellow, the variation of the concentration in the 4 sensors in a time scale of one week.




We can observe that in these different positions, the concentration is more or less the same.

We can also observe using one of these figures that the concentration at night is high compared to day.

The same approach is applied to a reduction of 50% and 75% too, it's the same the results.

## CONCLUSION:

We can conclude in this approach (Using all source of emission) that reducing these emissions will remain the same in every part of Lyon city, so in order to visualize a variation, we will focus in the next approach on reducing only traffic emissions.

# ANALYSE 1: Traffic, industries, emissions from tertiary and background concentration

## 2. Results on the whole domain:

### 2.1. Description of The Methodology:

In this approach, we will study the traffic emission, so the objective is to visualize the impact of replacing diesel cars by electrical cars in the NO2 concentration in some places in Lyon, so will first replace 25% of cars by electrical cars, then 50% and then 75%. So we will visualize and see the impact of this reduction, and compare it with the impact of reducing all emissions we did in the last approach.

In order to do the simulation of this approach, we will use the same methodology as part 1.

The difference in this part is to specify the emission type, which is in this case, traffic emission (Line emission).

### 2.2. Analysis of Results.

To analyze the results of the NO2 concentration variation, we will use two scenarios:

- First we will study the impact of three possible percentage of reduction (25%, 50% and 75%) on the total concentration.
- Second, we will visualize the concentrations on some given sensors positions.

#### 2.2.1. Results on the whole domain.

- 25% Reduction:

After running a simulation on SIRANE with 25% of reduction, we used the QGIS software to analyze and visualize the results.

Here below the results of the analysis:

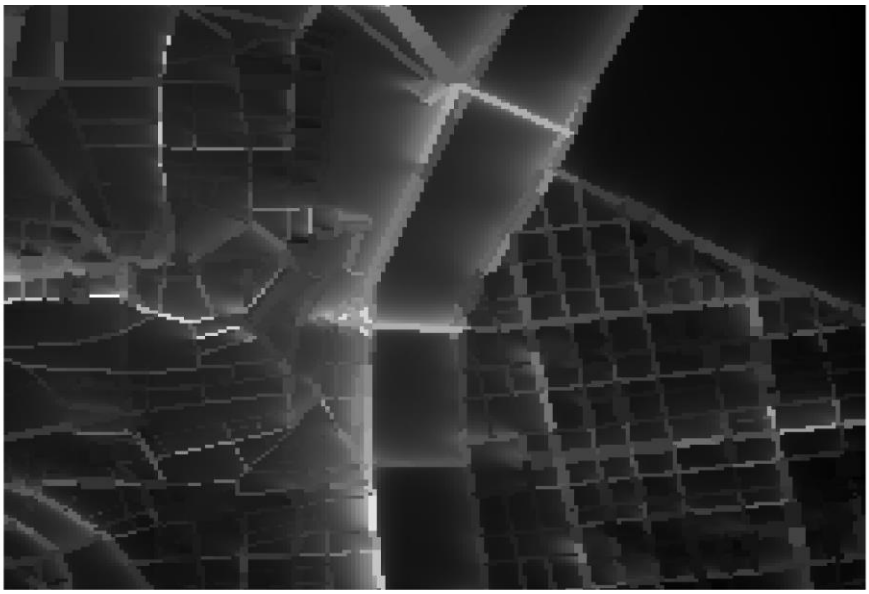
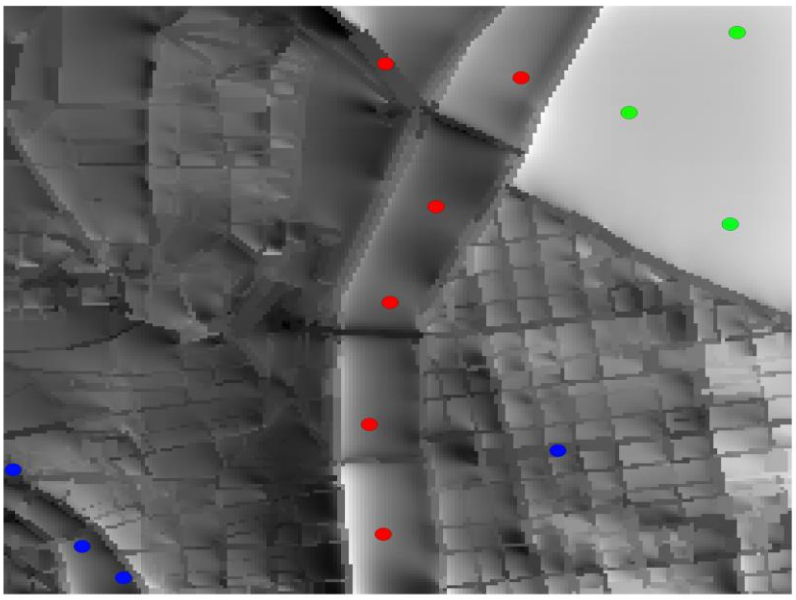


Figure 3: Concentration of NO2 without reduction.

In this figure, we observe that the NO2 is highly concentrated next to roads, because of traffic emissions (cars…).

After 25% of NO2 reduction, we observe that the reduction in the city of Lyon is not uniform, it varies from place to place.

To explain this using QGIS, we calculated the **Ratio** of the 25% reduction out of concentration without reductions, and using the software we calculated the ration and many positions in the Lyon city, the Ratio is still uniform



In the Ratio of the 25% reduction we observe that the concentration in not uniform:

- In the Green points: The reduction concentration varies from 0 to 15%, which means that reduction the diesel cars with 25% has no impact on this area, in this is due to the fact that in these areas the main source of pollution is not traffic.
- In the Blue point: In this zone the reduction of concentration is more compared to green points, it varies from 20% to 40%, which means that traffic causes pollution in these area, but it's not the only source and the mean source.
- In the red points: In the red zone the reduction is more than 45%, the majority of these points are main roads of the city, and it has a big concentration of traffic emissions, in these area, we observe that reducing number of cars will impact the concentration on NO2 emission in the area.
- 50% Reduction:

Like we did with the 25% of reduction, we used the same analysis on the 50% reduction.

With a 50% of traffic reduction, the reduction of concentration of NO2 is much bigger than 25%, it will reduce the percentage of concentration in some areas (RED ZONE) to more than 65%.

- 75% Reduction:

With a 50% of traffic reduction, the reduction of concentration of NO2 is much bigger than the last two approaches, it will reduce the percentage of concentration in some areas (RED ZONE) to more than 90%.

### 2.2.2. Results on some specific sensors positions.

To analyze the impact of NO2 concentration on some specific sensors, we have to define these sensors and run a SIRANE simulation.

We have chosen in our approach 10 specific sensors positions.

In the figure below, the sensors we have chosen in our approach, while X is the x-axis in the city and Y is the y-axis of the position in the map of Lyon city.

| Id | X | Y | Z | Type | Fichier |
|---|---|---|---|---|---|
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| Recept5 | 843039 | 6520815 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept6 | 842865 | 6520272 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept7 | 842415 | 6520860 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept8 | 842145 | 6520969 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept9 | 842318 | 6520488 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |
| Recept0 | 843231 | 6520615 | 2 | 1 | RECEPTORS/Receptors_without_measurements.dat |

**Figure 5: Random sensors positions.**

- 25% Reduction:

For a reduction of 25%, we will compare between 3 of these receptors in some different positions. One receptor from red zone, the other one in green zone in the last one in the blue zone.

For The red zone, we will choose the sensor 2, the sensor 8 for blue zone and the sensor 0 for green zone.

The next step is to visualize the variation of the NO2 concentration in these sensors and compare the results in a time scale.

In the figure bellow, the variation of the concentration in the 3 sensors in a time scale of one week.

We can observe that in Green zone, the variation is small, but then the concentration starts to increase, this is due to the movement of NO2 in the air.

In the blue zone (zone with normal variation and normal concentration), the concentration stays uniform, in this area we have movement of NO2 to the green area, but also movements from red zone, and because of that, the concentration remains the same with time.

In the red zone, the variation is high, but also the concentration is high due to traffic emissions (The red zone has more roads than the other zones).

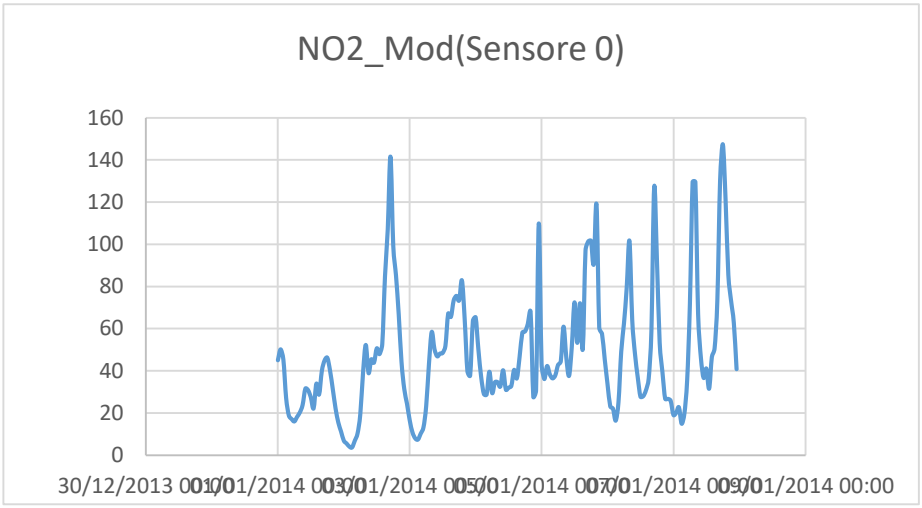


**Figure: Variation of concentration in sensor 0.**

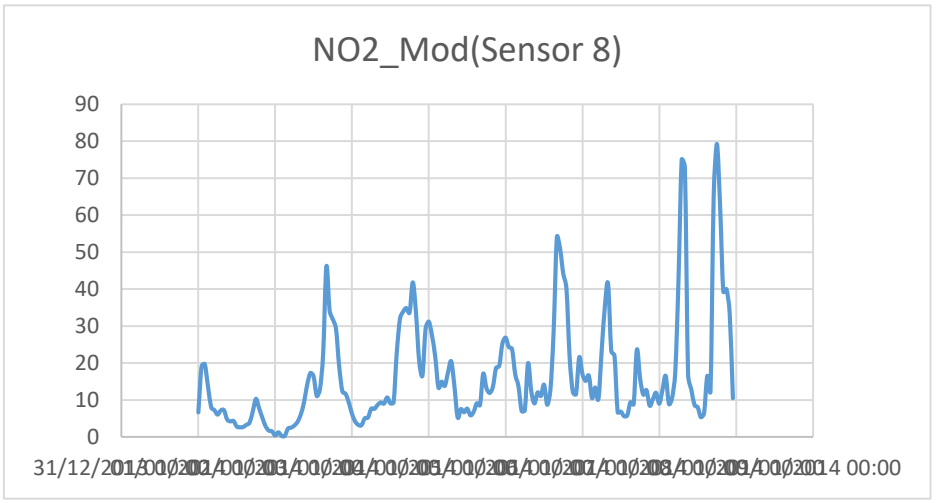


**Figure: Variation of concentration in sensor 8.**

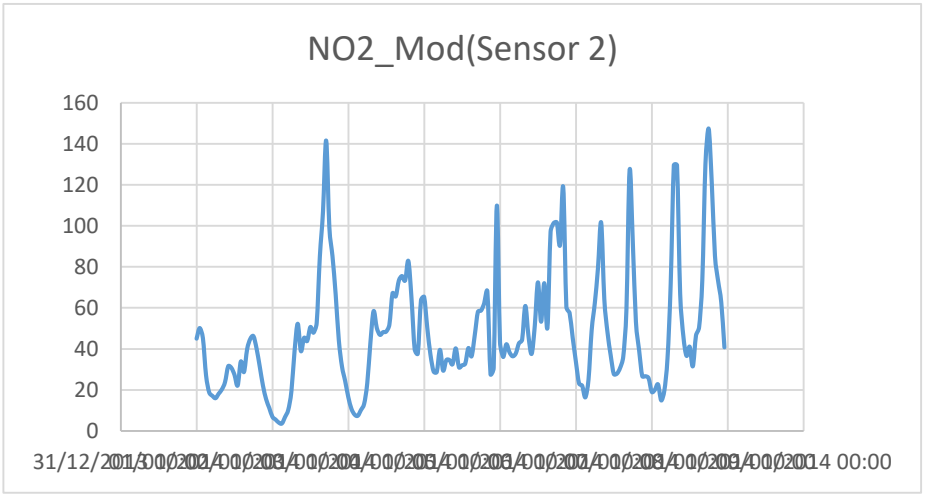


**Figure: Variation of concentration in sensor 2.**

We can also observe using one of these figures that the concentration at night is high compared to day (that is the reason why we have a variation in a small time scale.

The same approach is applied to a reduction of 50% and 75% too, it's the same the results.

## CONCLUSION:

We can conclude in this approach (Using traffic emission) that reducing these emissions will reduce the concentration of NO2 in the air, in this depends on the zone of Lyon.

The use of electrical cars can be a good way to reduce pollution, by reducing one of the main source of NO2 emissions which is the traffic.

The reduction of the traffic emission still not enough, because we have a movement of the NO2 from area to area (areas with less emissions can be more affected due to this movement).

We should think also about some other ways to reduce other sources of emissions (electrical cars for the traffic emission) in order to have less pollution and less movement.