EVS32 Symposium

Lyon, France, May 19-22, 2019

Enedis's fleet of electric vehicles: an asset for air pollution control

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Executive Summary

In partnership with local authorities and the Pollutrack company, real-time pollution monitoring is carried out by ENEDIS in the heart of cities such as Paris or Lille or of valleys that are particularly sensitive to pollution such as the Arve Valley in the French Alps. ENEDIS makes its fleet of electrical vehicles available for installation of mobile sensors with more than 400 vehicles in France. The pollution measured is linked to the "fine particles" with a diameter of less than 2.5 micrometers (PM 2.5) and at a pedestrian breathing level. The strength of the on-board sensor is to locate the endogenous pollutant sources in order to eliminate it but also to offer real-time alerts and optimized routes based on pollution.

Keywords: sustainability, ZEV, EV, pollution, emissions, instrumentation, fine particles

1. Fine particle pollution, a scourge affecting all of France

Albeit invisible, airborne pollutants are nonetheless a real danger. A recent study by the France Public Health agency estimated the number of annual deaths at least 48,000 [1], i.e. 9% of national mortality.

Fine particles: a real and as yet little-known danger

The France Public Health agency study is based on the concentration of fine particulate matter known as "PM2.5", the smallest classified particles. "PM2.5 particle have an average aerodynamic diameter of less than 2.5 µm (PM stands for "*Particulate Matter*").

These particles are particularly harmful, as they can penetrate all the body's organs through the blood stream via the lung alveoli, causing chronic inflammation that can lead to cardiovascular disease or cancer.

Monitoring this secondary fine particulate matter for health purposes is all the more important because when these airborne particles are formed, they combine with other noxious particles, in particular semi-volatile polycyclic aromatic hydrocarbon (PAH) and black carbon, also emitted in quantity, notoriously by diesel (and which for instance blacken the snow alongside mountain roads). The secondary fine particulate matter also combines with metallic nanoparticles from brakes, making their inhalation pejorative, in the medical sense of the term.

Until 2008, only PM10 particles were the subject of European and French regulations. And yet, ten years later there are still far fewer stations monitoring PM2.5 than stations monitoring larger particles regarded as less noxious.

Asia and North America are primarily focusing on PM2.5, so it is high time that Europe refocuses on these particles that affect city dwellers' health the worst, by following the World Health Organization 's recommendations, which are more demanding than those of Brussels.

A complex localized phenomenon but also at times widespread

Even though the essential problem is still the concentration of PM2.5 in the central districts of metropolises, where the greatest number of city dwellers are exposed to it, air pollution is a complex phenomenon that warrants very localized but also widespread monitoring.

Urban pollution regularly arises when ammonia-laden air masses from the countryside *(from manure spreading)* reach towns and cities and collide with NO_3 gas, the oxidized nitric phase of NO_2, emitted in quantity by diesel engines. The chemical recombination of these two gases gradually results in ultrafine, very fine PM1.0 and fine PM2.5 *secondary* particles that make up dangerous fractions of airborne particles. So it is essential not just to monitor the central districts, where these particles are most likely to be inhaled, but also the outskirts of towns and cities, the advantage being that the location and moment of formation of secondary fine particulate matter can be determined, and its time and geographical tendency can be monitored, essential information for future predictive models.

Local authorities get involved

The case of the City of Paris

As the Climate Plan of the City of Paris highlights [8], on the particular question of air, the data is not restricted solely to Paris but covers Greater Paris and the Île-de-France region. This is because Parisians and users can be exposed to pollution emitted from outside the city.

In Île-de-France 5 airborne pollutants have been recorded that regularly exceed the boundary values or European regulatory quality targets: nitrogen dioxide (NO2), airborne particles (PM10) and more particularly fine particulate matter (PM2.5), ozone (O3) and benzene (C6H6). Of all these pollutants, only ozone is also a greenhouse gas (GHG). Unlike GHGs, which among other things include carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), airborne pollutants do not contribute to global warming (apart from ozone), but on the other hand have a direct noxious effect on health.

In 2016, 1.4 million inhabitants of Ile-de-France were exposed to air in breach of nitrogen dioxide (NO2) regulations, nearly half of whom were Parisians.

As for PM10 particles, 200,000 inhabitants of Ile-de-France were affected by an overrun of the daily threshold value, primarily along roads. According to the Senate's select committee report on the cost of air pollution published in 2015, suspended particulate matter, including fine particulate matter (PM2.5) and ozone (O3), cause the premature death of nearly 45,000 people in France every year. Air quality has been improving in Paris for more than 10 years. However, the concentrations of certain airborne pollutants are still too high at the moment.

Paris has set itself the goal of surpassing current European regulations by 2030, by complying with the recommendations of the World Health Organization (WHO) with regard to guideline values not to be exceeded for airborne pollutants, below which no harmful effects on human health or vegetation have been observed. Regarding air quality, the City of Paris has set itself the target that less than 10% of Parisians be exposed to threshold overruns in 2020[1], and no Parisians in 2024, by observing the boundary values for all pollutants.

In response to the air pollution health issue, the City of Paris wishes to pursue its efforts by striving to reduce background air pollution, but also act during pollution peaks and sporadic spells of pollution. In parallel, Paris is committed to raising awareness among Parisians and local stakeholders

[1] Nitrogen dioxide (NO2): 200 µg/m³ for more than one hour and an annual average of 40 µg/m³

about the right behaviour to adopt during pollution peaks and the measures to take to improve both indoor and outdoor air quality.

The European metropolis of Lille (MEL)

MEL is demanding in terms of air quality due to the significant health-environment challenges posed by such an urbanised (four towns with more than 60,000 inhabitants) and densely populated region (over 1.2 million inhabitants) crossed by a number of major roads (the A1 and A25 motorways, in particular).

MEL was one of the first cities in France to fund and implement, as from 1979, a local air-quality monitoring network. Despite the measures taken by MEL (ambitious urban travel plan, cycling plan, introduction of an "environment pass" that provides access to public transport during pollution peaks), background pollution remains high. MEL has exceeded the regulatory notification threshold 21 times, particularly regarding PM10, and the "persistent alert level" was reached 11 times in 2018.

MEL wishes to pursue and step up its efforts, particularly by creating a network of mobile sensors that would monitor PM2.5 pollution alongside the local monitoring network already in place.

Haute-Savoie, a sensitive area with regard to air quality

With densely populated urbanized area, very busy roads, especially in tourist and winter periods, a main traffic route to Italy that increases local road traffic emissions, and the extensive presence of industrial undertakings on valley floors, there are many and varied sources of pollution in the Haute-Savoiecounty . Furthermore, the relief and often stable weather conditions are handicaps for the dispersal of pollutants, leading to long-lasting build-ups of fine particulate matter.

However, air quality in this county, as in the rest of the region, is improving overall and sustainably. 2017 also marked a historic turning point that needs to be perpetuated. It was the first year during which no overrun of regulatory French and European values (annual and daily) was measured for airborne particulates in the region.

Nevertheless, the population's exposure to these particulates with regard to the thresholds recommended by the World Health Organization (WHO) is still significant. On the scale of the department, virtually all inhabitants breathe air with concentrations of fine particulate matter PM2.5 that do not comply with the recommendations of this health organization.

2. ENEDIS mobilises its fleet of electric vehicles alongside Pollutrack to tackle this pollution.

To help fight this scourge, ENEDIS has joined local authorities in a Health & Environment experiment that makes use of Pollutrack's measurement unit.

The state and local authorities have entrusted accredited air quality monitoring associations ("AASQA") with monitoring and providing information on air quality in the regions. The continuous measurements that can be taken by the Pollutrack system developed by PlanetWatch24 serve, among other things, to complement existing air quality monitoring systems by enabling the dynamic mapping of PM2.5 particles at breathing level to be developed.

ENEDIS, a local partner for energy efficiency in the regions and for their economic development

Enedis is a public service company that operates the electricity distribution network; it is present throughout mainland France with more than 1,000 sites, 88 territorial delegations and 25 regional divisions. By connecting the regions, the electricity distribution network is a vital contributor to regional solidarity, which makes ENEDIS an operator that is committed to a more responsible and cohesive future. This commitment is reflected in a sustainable development policy that is present at every level of the company's business plan and is based on permanent dialogue with its various stakeholders, including local authorities. Consequently, ENEDIS accompanies the economic development of the regions through its investments and partnerships (around 50,000 indirect jobs supported by its activities). ENEDIS also supports the energy initiatives of the regions by providing

its expertise to contribute to *Agenda 21*, to local energy policies, to positive energy territories for green growth, to urban travel plans, to the development of fibre and to "smart cities" projects. [3]

Finally, ENEDIS contributes to the fight against climate change and to preserving the environment by improving its carbon footprint (reduced-loss transformers, recovery and recycling of waste, reduction in the amount of energy used by its buildings and vehicles).

Regarding electric vehicles, ENEDIS has adopted a proactive policy aimed at making ENEDIS a benchmark industrial partner for all parties involved in electric transport, in order to jointly construct the solutions needed for its large-scale development.

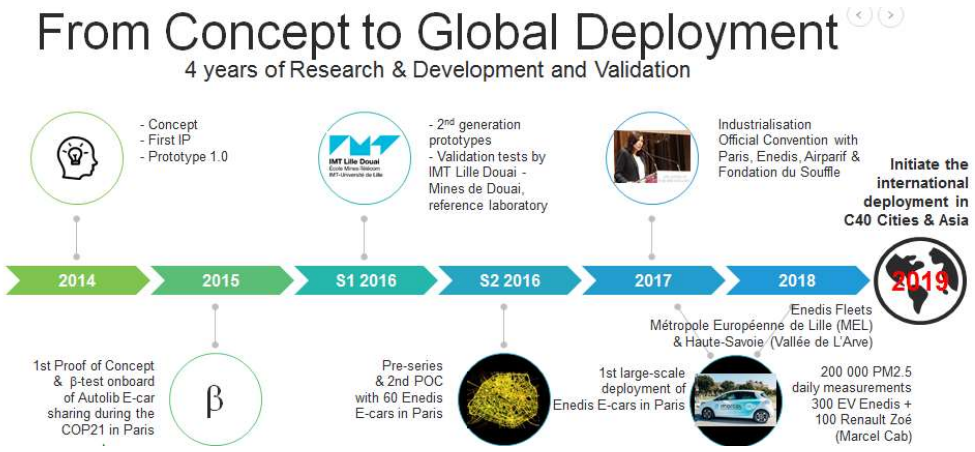
In particular, more than 10% of its vehicles are electric; 1,835 electric vehicles (EVs) out of a total of 17,800. ENEDIS thus has the second largest industrial electric fleet in France.

ENEDIS aims to electrify its entire fleet of service vehicles within 11 years. In particular, in restricted traffic zones or low emission zones, ENEDIS aims to have 100% of the fleets concerned electrified 5 years after these zones were declared; as is the case for the Paris fleet. Concerning the rest of the thermal engine vehicle fleet, the vehicle policy implemented for 8 years aims to upgrade the fleet with more energy-efficient vehicles. ENEDIS contributed to the emergence of a new EV offer in 2011 and to Ademe's Infini Drive call for expression of interest, which set out to specify the components of an EV recharging infrastructure.

Pollutrack, a tool for steering local environmental policies

Pollutrack has been formed to swiftly remedy the disparate fine particle measurement systems by providing a flexible and financially affordable method.

Pollutrack was established in June 2017, following three years essentially under cover of steady development & maturation of the concept – including a successful β-testing and POC during COP21 - within the framework of a Think Tank at the interface of Health & Environment, PlanetWatch24. [4]



During these three years, a high degree of confidentiality was indeed duly maintained at all stages to stay away from most radar screens while pursuing the development of the concept till attaining a highly advanced phase before the full disclosure of qualified results.

Having demonstrated its concrete contribution to air quality control, Pollutrack was officially announced by the Mayor of Paris in May 2017, generating significant media coverage.

This announcement was immediately followed the very next day by an appeal from the official health agency ANSES insisting on the urgent need to focus on fine particles PM2.5 and monitor their presence with increased spatial and temporal resolution. [7]

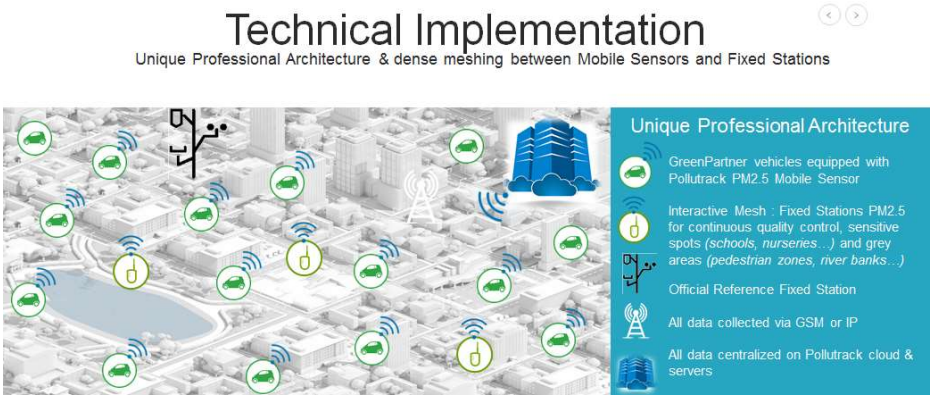
A disruptive technology: laser microsensors.

Surfing on the new revolution triggered by the recent availability of lower-cost laser-based microsensors that make the monitoring of environment now steadily accessible on a larger scale, Pollutrack represents a major step forward in fine monitoring of pollution at breathing level:

- It brings the new possibility to identify, monitor and ultimately reduce recurrent hotspots of urban pollution, from jammed crossroads to air vent *(underground parks & subways, especially those close to schoolyards and nurseries),* including all kind of industrial & traffic contributions.
- It brings the indispensable tool to all major cities to define Low Emissions Zones and monitor all progresses locally achieved. It also provides the private sector with the necessary tool to properly tackle issues related to urban pollution and its clearance.
- After having gathered millions of precise measurements, it will provide key information to industry at large, real estate players, smart city planners, communication agencies, insurances, health management organizations, etc.
- And ultimately, it will also provide invaluable real life information to all persons at risk or simply biking & practicing sports in-town, who will be then in the capacity of limiting their own individual exposure at all time and especially during peak periods.
- To date, it is the only patented system capable of monitoring pollution at street and breathing levels, thanks to its mobile sensor network embarked onto corporate fleets, with an accuracy approaching GPS definition.
- First of its kind, the Big Data generated by Pollutrack will be the very source of a wealth of new applications and products at the fast-growing interface of Health & Environment.

The advantage of mobile sensors and the implementation conditions

Each Mobile Sensor brings huge numbers of highly accurate data exceeding what dozens of Fixed Stations could hardly produce together. In other words, the mobile use of microsensors mounted on professional fleets of vehicles, therefore duly controlled on a daily basis brings the unprecedented advantage of Real Life Qualified *Measurements* in such quantity that it can be subsequently used in a sophisticated Big Data A.I. environment. Maps and dashboards based on actual measurements and not only the existing mathematical models constitute the royal path towards true predictivity, to the direct and immediate benefit of all citizens.



Pollutrack is destined to become a real-time tool that accurately identifies the endogenous sources of pollution, in order to control it in concrete terms and thereby reduce the average pollution in a city while managing peak episodes to best advantage. Eventually, Pollutrack will also identify densely-populated districts particularly exposed to pollution that warrant being classified as Low Emission Zones (LEZs). Ultimately the history of Pollutrack measurements will be used to monitor and document the improvements achieved in these LEZs.

Air quality monitoring agencies

The three accredited regional air quality monitoring associations (AASQA) - Airparif for the City of Paris, Atmo Haut de France for MEL and Atmo Auvergne-Rhône-Alpes for Haute Savoie - are, of course, involved in the partnership.

As organizations that are approved for monitoring and informing about air quality, the regional observatories are interested in any experiment that produces data liable to further knowledge or tools that analyse air quality in the region within their remit. To give an example:

- For over 10 years Airparif has developed expertise in portable and mobile pollution devices, through its metrology laboratory and in conjunction with European organizations like the Joint Research Centre of the European Commission. This expertise also concerns on-board pollution measurements to measure the exposure of Parisians according to their modes of transport; many studies have been carried out in this respect for over 20 years.
- With regard to the Pollutrack experiment, Atmo Auvergne-Rhône-Alpes and ATMO Haut-de-France compare the experimental data with that of accredited monitoring stations. This tests the limits of the metrological validity of these measurements with a view to improving the Pollutrack system and the overall representativeness of the output data. In parallel, Atmo's mission is to better define the work needed to ensure optimal use of this experimental data within the framework of the public monitoring service.

The AASQA are part of the national monitoring scheme, which enables them to make a connection with experiments carried out in other French territories and with the LCSQA, the central air quality monitoring laboratory and coordinator of French research in this field, and which brings together the expertise of Ineris, the National Testing Laboratory and IMT Douai/Lille.

The partnerships in place – ENEDIS's commitment

Paris

On Wednesday, 14 February 2018, the mayor of Paris, Anne Hidalgo, signed with ENEDIS, with the air quality monitoring organization in Île-de-France, Airparif, with Fondation du souffle and with PlanetWatch24, a partnership agreement to consolidate the Pollutrack system, which aims to measure the level of PM2.5 fine particulate matter in real time and at the level of the flow of traffic and at breathing level. ENEDIS finances the initiative and provides its fleet of electric vehicles for the installation of mobile sensors. Pioneer of the operation, the ENEDIS Paris fleet of nearly 300 vehicles was fitted with sensors in late 2017 and early 2018.

The European metropolis of Lille (MEL)

As part of the "Energy and digital transition" partnership signed in July 2018 by Métropole Européenne de Lille (MEL) and ENEDIS's regional division for the Nord-Pas-de-Calais region,

ENEDIS has undertaken to equip approximately a hundred of its electric vehicles with on-board Pollutrack sensors: [5] in June 2018, 57 electric vehicles were fitted with sensors to test the capabilities of the various tools and take initial measurements. In June 2019, all 100 ENEDIS electric vehicles fitted with mobile sensors will travel all the roads and streets of the MEL region.

The aims set by the system's stakeholders include:

- identify black spots in the territory and take corrective action if the source of pollution is clearly identified,
- nurture and complete the Metropolis's "air quality" action plan, among other things by selecting and monitoring Low Emission Zones,
- further develop the MEL's capacities in terms of information and awareness-raising among the inhabitants and users of the Metropolis.

Haute Savoie

Haute-Savoie is the third region in France that is testing this system. Its distinctive feature is that it tests its effectiveness in a mountainous department.

This partnership was inaugurated on 19 September 2018 on the occasion of the national air quality day, ENEDIS, Atmo Auvergne-Rhône-Alpes and PlanetWatch24 through the "Sillon'Air 74" project, to contribute to providing real-time data on air quality in Haute-Savoie.

As for Paris and Métropole Européenne de Lille, a fleet of 70 ENEDIS vehicles fitted with Pollutrack microsensors now travel the length and breadth of Haute-Savoie's alpine territory to visualize levels of fine particulate matter PM2.5 on a map in real time. This data will be put at the disposal of the local authority. [6]

3. The results

City of Paris

In PARIS, 10 million laser measurements per month producing 1 million qualified data items, making 200,000 per week just with the ENEDIS fleet, which has recently been supplemented by the Zoe fleet of Marcel on-demand taxis (Renault).

Dynamic mapping at breathing level is updated more particularly in sensitive locations near schools or places frequented by the general public. Pollution "hotspots" near such sensitive locations have been identified, originating for instance from the air vents of the metro or underground car parks, crossroads, delivery zones used primarily by diesel-powered vehicles, but also bus depots, taxi ranks in stations, etc. These measurements supplement the data provided by the fixed monitoring stations of Airparif, partner of the operation.

These measurements are an essential complement to the modellings and will enable rapid development of predictive maps over several days.

The first tracking experiment was conducted on the occasion of the COP 21 at the end of 2015. The operation was prolonged for six weeks. The initial very conclusive results have led to an increase in the number of tracker vehicles throughout Paris to highlight urban pollution hotspots with sufficient particle size analysis and to help identify its endogenous sources.

Dynamic mapping at breathing level is regularly updated, particularly in sensitive district near schools or places frequented by the general public.

The European metropolis of Lille (MEL)

As for Paris and the Arve valley, the comparative data is still undergoing validation and processing by the community, the IMT of Douai and ATMO HdF with the assistance of Pollutrack. The initial lessons learned from these extensive tracking operations will be shared with the cities and regions concerned, so as to mutually enrich each lesson learned. It is this sharing that will accelerate the process and enable optimal management of sources of PM2.5.

The first half of 2019 is a period of co-construction of the overall system of measurements involving the Metropolis, ENEDIS, PW24, ATMO Haut-de-France and the IMT of Lille-Douai. The IMT of Lille Douai in particular is the first expert centre to have tested ten Pollutrack sensors in parallel to check that they are consistent with one another, a substantive condition for validating relative measurement in order to compare exposure to PM2.5 from one point to the next, and more particularly from one street to the next.

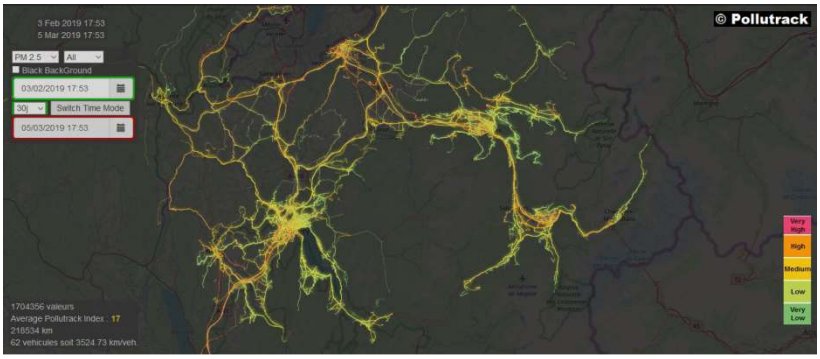
At this juncture, vector maps are already showing the traffic routes that merit particular attention. The measurements will be sent to MEL in map form, for initial rapid identification and simplified visualization of the areas most exposed to fine particulate matter (known as "hotspots"), while providing the opportunity to monitor the improvement of air quality in these densely populated districts.

Haute Savoie

In Auvergne-Rhône-Alpes, as part of a partnership with ENEDIS, Pollutrack measurements are now put at the disposal of air quality observatory ATMO Auvergne-Rhône-Alpes, which also provides a reference measuring station that ascertains the precision of Pollutrack measurements. The aim is to explore the potential of this new type of measurement, which could eventually complete the monitoring network in place and refine the maps of particles in the territory. Haute-Savoie and its alpine valleys like the Arve valley are indeed areas conducive to the build-up of airborne pollution. Precise maps are needed for a good understanding of these phenomena. The mobile measurements produced by the 70 ENEDIS vehicles that drive the length and breadth of this territory will thus significantly further knowledge of the concentrations of particulate matter alongside its major roads. ENEDIS thus helps improve air quality and the general interest in this alpine department.

The initial results are currently being processed and will no doubt be used to better describe areas sensitive to particulate pollution.

By way of illustration over thirty rolling days, the global vector maps and hotspots:



4. Conclusions

In partnership with local authorities, the air agencies, ENEDIS and Pollutrack, a real-time pollution map is produced with the aid of on-board sensors in ENEDIS's fleet of vehicles in the heart of cities like Paris, on the scale of metropolises like Lille or valleys particularly sensitive to pollution like the Arve valley in the French Alps. The measured pollution is fine particulate matter pollution, the average diameter of which is less than 2.5 micrometres (PM 2.5), regarded as the greatest health hazard. The strength of the system of on-board sensors is that it localizes endogenous sources of pollutants to control them but also to offer real-time alerts and optimized routes depending on the level of pollution at breathing height. Pollutrack will also enable metropolises to optimize their Low Emission Zones and monitor the progress each local authority has made in its urban pollution control measures.

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6. Authors

Jean Duplex is currently in charge of developing the study and development part of the "electrical mobility program" of ENEDIS. Jean Duplex was previously head of the department building all electrical balances on the distributing network ENEDIS and in charge of the relations between ENEDIS and French players of the electrical system. Jean Duplex is an engineer graduated from a French High School and has over 20 years of experience in customer relationship development, management of electrical systems and energy efficiency. He began his career and was a manager at EDF R&D in the design of hydraulic and thermo-hydraulic systems. Joining the EDF Group's marketing division, he built EDF's e-business offers and the first gas sales offers. During the 2005-2007 period, he was deputy director of the "business innovation" entity focused on the development of turnover of energy efficiency. He spent four years at the corporate audit of EDF Group.

Within ENEDIS, Dominique BERTIN is overseeing the deployment of electro mobility projects in Paris covering a large array of high profile projects from large scale roll out of infrastructure charging solutions for residential customers to the conversion of the Paris bus fleet within the Grand Paris infrastructure projects and in the perspective of the upcoming Summer Olympic Games. In his previous role, Dominique BERTIN was within the Smart Customers department of EDF Energy in the UK managing a team who supported the development of EDF Energy smart energy solutions for tomorrow's customers, cities and communities with the aim of helping local residential customers, industry and authorities to respond successfully to the environmental and energy challenges they faced throughout their low carbon journey. Before joining the EDF Energy R&D team in the UK, Dominique BERTIN was a project manager in aero engine engineering working for Snecma and General Electric Aviation in Paris and Cincinnati.

Eric Poncelet
A seasoned manager with extensive working experiences in Japan, Europe and the USA, Eric's background ranges from large multinationals to start-up environment.
Within the framework of PlanetWatch24, a Think Tank Factory at the interface of Health & Environment, he originally conceived Pollutrack at the suggestion of the City of Paris to measure fine particles pollution at breathing level, by means of large corporate fleets of EV equipped with laser sensors. Enedis group volunteered enthusiastically as a pioneering partner, rapidly joined in by Marcel and their Renault Zoe electrical cab fleet.
Pollutrack emerges as a major breakthrough for the monitoring of air quality. This disruptive Hotspot Tracker has already gathered millions of PM2.5 qualified data in Paris, Lille and now across the Alps area. A large international dispatch is currently on its way.
Education: MSc from Paris VI Pierre & Marie Curie University / Post-graduate degree in engineering & fine chemistry / MBA from ESSEC