Creating a Post-Carbon Station

Raphaël Ménard

AREP editions

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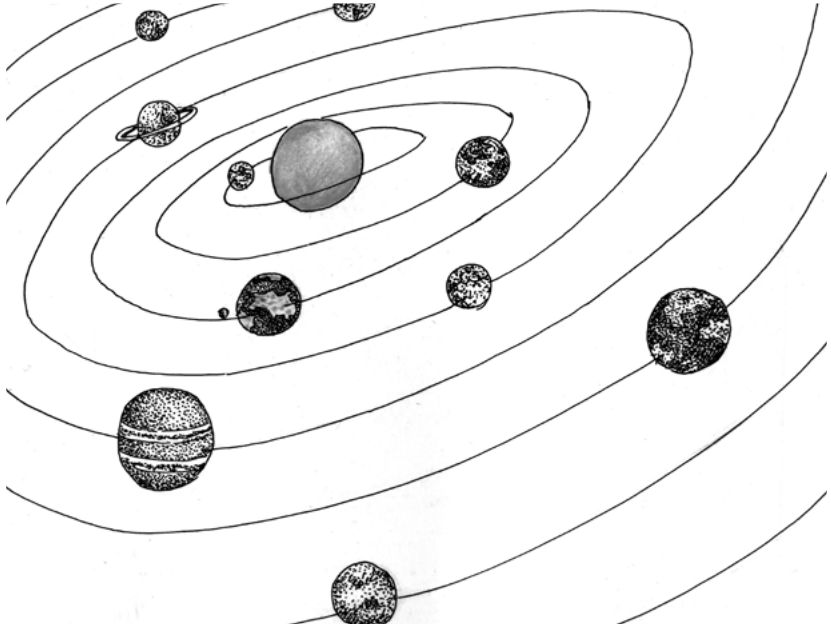
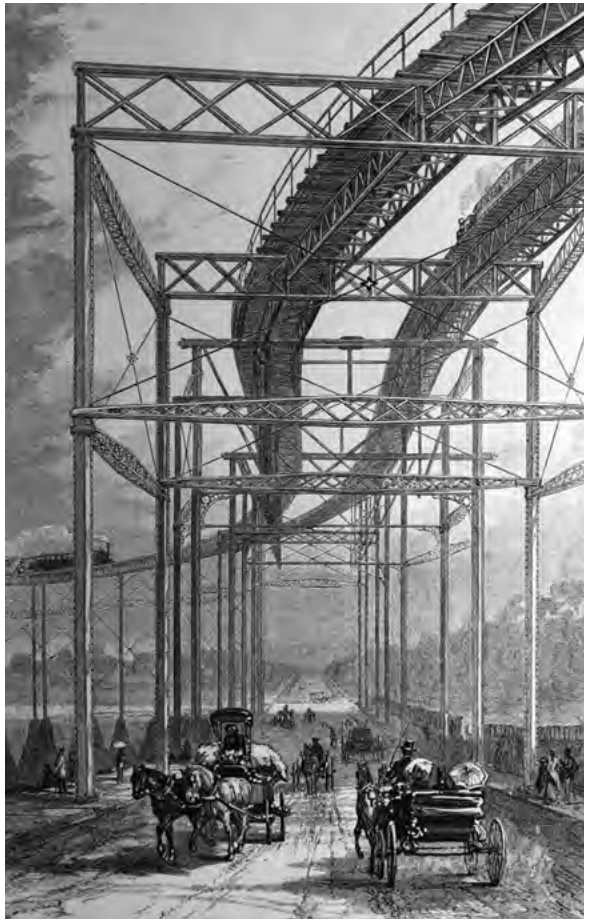


"Railway stations first appeared with the Industrial Revolution and have developed in parallel with all the societal changes that have taken place over the past two centuries. This parallel process has a global dimension; the Earth and its inhabitants have reached a historical turning point, the epilogue of our thermo-industrial civilisation. We need to successfully move through this transition because we are facing both a critical situation and a tipping point: biodiversity is collapsing, the climate is changing at a vertiginous pace, planetary resources are sorely stretched while serious ecological disruption is on the rise (atmospheric, soil and ocean pollution, uncontrollable pandemic risks, etc.). These crises provide tremendous opportunities to repair our world and must call forth all human energies. Creativity is stimulated by constraint, and here at AREP we are committed to this forward movement, to the full extent of our ability. AREP is a multidisciplinary firm that has been building contemporary railway stations in France and around the world for over twenty years. Today, the company has set itself a new mission: to create a post-carbon future. With this goal in mind, I am venturing down some avenues, testing hypotheses about the future of stations, namely post-carbon stations, in order to keep this extraordinary history alive."

Raphaël Ménard

Urgency



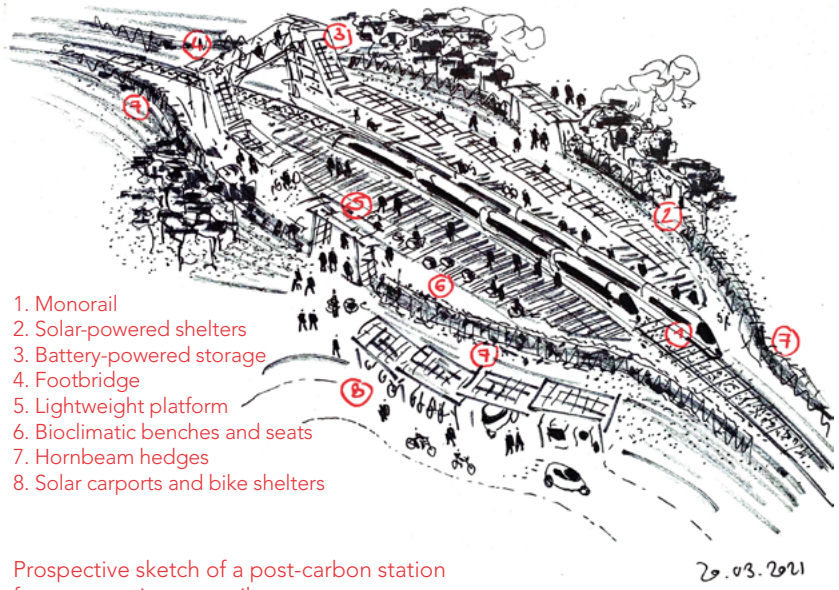
The West Side Elevated Railroad at 110th Street, New York, 1881.

Creating a Post-Carbon Future

In 2002, Paul Crutzen, an atmospheric chemist and Nobel Prize winner in chemistry, popularised the term Anthropocene to designate the geological era that began towards the end of the Enlightenment and which was marked by the irreversible human imprint on Earth. The year 1784, with the patenting of the steam engine by James Watt, is considered by Crutzen to be the starting point of the Anthropocene. In fact, the history of stations would not have existed without this invention, which was born out of thermodynamics, then an emerging science, that would become the magic potion of our thermo-industrial civilisation. More than two centuries later, we are waking up in a daze to the fact that the unbridled use of fossil fuels has sent the climate off the rails. Our extractivist civilisation with its unrestrained exploitation of land and subsoil has led to dramatic loss of biodiversity. We have reached this tipping point after an era of almost unlimited access to energy and materials, where we have paid little attention to the countless consequences on living organisms and the climate[1].

The first warnings sounded amidst the long boom, but now the countdown is on to arrest the collapse. The next few years will be crucial for achieving carbon neutrality; the next few months will be crucial to weaning a civilisation off hydrocarbons and non-renewable resources. In 2020, fossil fuels still accounted for more than 80% of global consumption. The challenge is enormous. For designers of the built environment, this awareness is historic and the shift goes beyond architecture alone; it concerns landscape as much as urban planning, design and engineering. Our knowledge, inherited from a victorious modernity, has become obsolete, ineffective and sometimes harmful. Bernard Stiegler was even more vehement when he wrote: "An increasing number of engineers participate in technical processes whose functioning they ignore, but which are ruining the world."

[1] I recommend you reading John McNeill's book *Something New under the Sun. An Environmental History of the 20th - Century World.* New York: Cambridge University Press, 1992.



Prospective sketch of a post-carbon station for gyroscopic monorails.

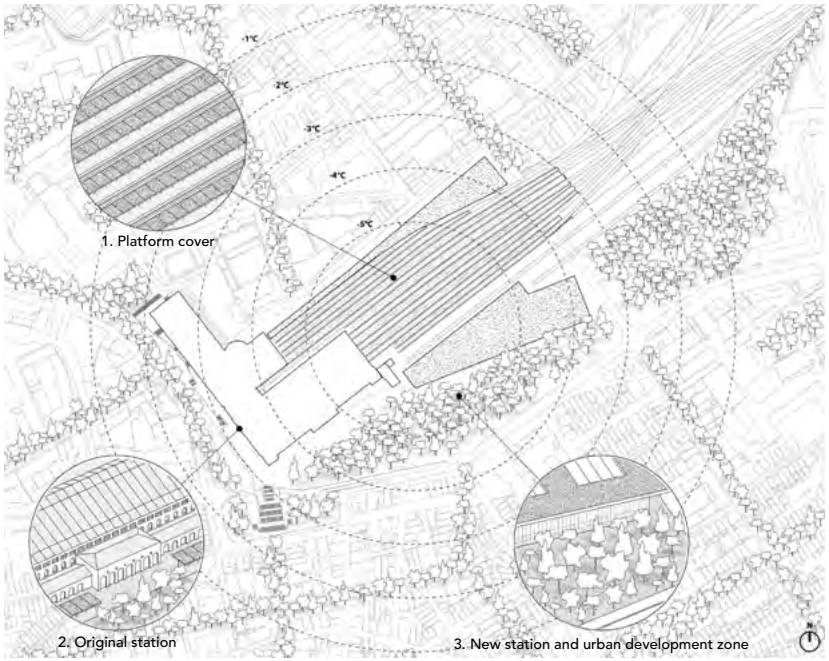
Five challenges

This revolution affects all the art and technique involved in urban planning and construction.

For more than 20 years AREP have taken on the responsibility for conceiving projects and acting as thought leaders, to help our clients on the path towards green transition. We are a global actor in architecture, urban planning and design and, as such, our know-how and projects are at the interface between construction and mobility, two sectors that account for more than half of all greenhouse gas emissions. Over the past two years, we have developed and implemented our "EMC2B" (Energy, Materials, Carbon, Climate and Biodiversity) comprehensive approach. We are aware of our role as the "chief thought leaders", the "environmental delegates" for a post-carbon future. Our aim is to help our clients meet the following five challenges by providing simple, elegant and sustainable solutions.

1. Energy: How to wean ourselves off hydrocarbons and recreate a planetary garden of exclusively renewable "energy crops". The movement is underway, but we need to step up the implementation of the threefold approach "frugality - efficiency - renewables" at all stages of any given project, and, of course, within the perimeter of train stations. This point will be addressed later on.

2. Materials: How to stop draining non-renewable resources, how to build and transform the built environment in a low impact way by reusing materials or using bio-sourced and geo-materials. The use of virgin materials should be the exception in the coming years.



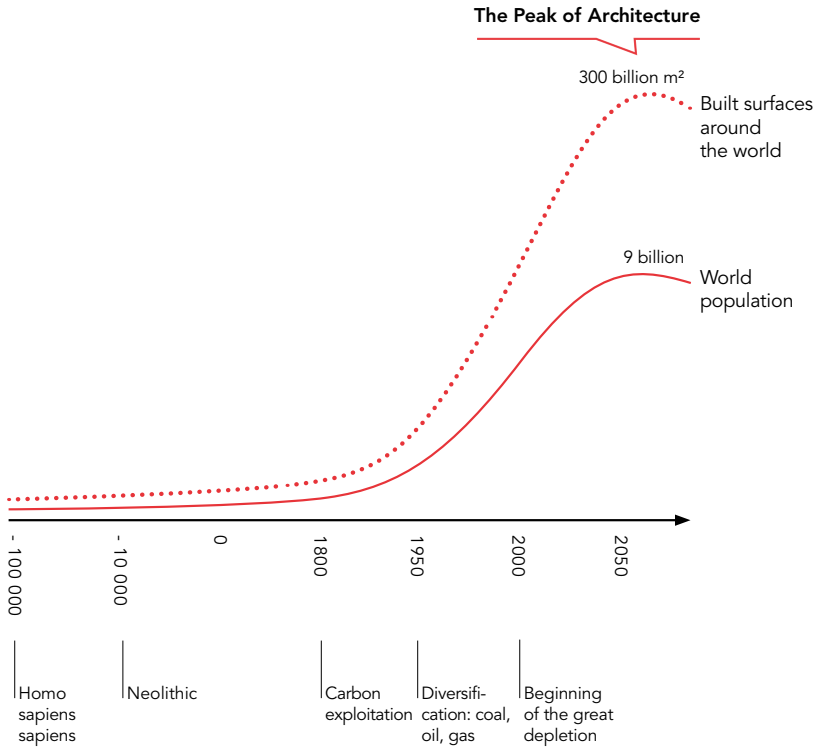
The post-carbon station: Marseille Saint-Charles station as an area of experimentation by the year 2050 and as a future climate shelter.

3. Carbon: How the imperative to achieve carbon neutrality by 2050 is changing the way we live, inhabit spaces, consume, and travel. The need to reduce the carbon footprint of construction must be reflected in the guidance we offer to our clients by questioning the extent of the work to be undertaken, and even its relevance.

4. Climate: How to anticipate the effects of global warming, whether this means dealing with heat waves, the increase of natural risks or the need to adapt spaces in order to preserve health and comfort[2].

5. Biodiversity (undoubtedly the major challenge): How to do our very best to prevent the sixth mass extinction and the loss of natural landscapes, whatever the scale of the project, as well as how to ensure that living organisms are taken into account throughout the life of the project.

[2] Health requirements will have to be taken into account more fully.

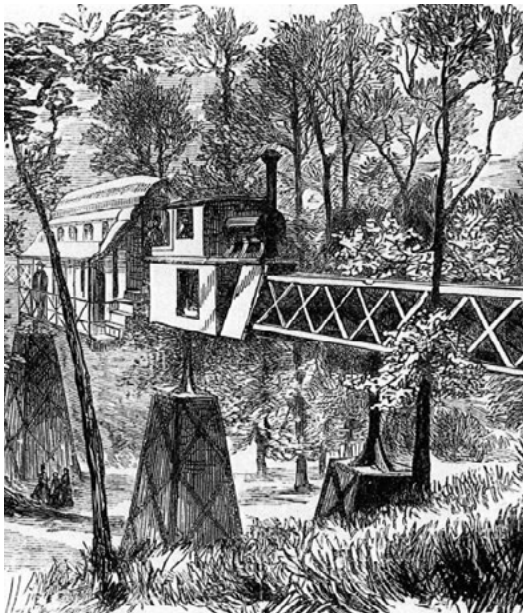


The Peak of Architecture

Each project intervention must be analysed in the light of these five challenges. Every actor, whatever their role (project owner, project manager, operator, etc.) must champion and promote these goals throughout the discussions and negotiations about the project. Unfortunately, the vast majority of contemporary projects still fail to fully meet these challenges, and this also includes the way projects are organised, which is often "out of touch" with and lacks awareness and integration of the above-mentioned challenges. And yet, our role is crucial since we are committed to transforming reality: a project is made up of people who work together throughout the development and life cycle of a building, a team who strive to accommodate sometimes conflicting goals, priorities that vary according to interests, areas of expertise and diverse time and space scales. This new paradigm puts "design under constraint" and marks the end of unwarranted, and sometimes improper, choices. These conflicting constraints are not alienating and are never pointless. They spark the creative energy and the desire to push the boundaries further. This is a fascinating subject and forms part of the process of building with a passion for detail and attention to the realisation of the project.

Even without this systemic upheaval, architecture would still face another shock. Ever since Vitruvius, architecture has been a growth-oriented discipline, associated with economic development and territorial expansion. For centuries, it has focused on the number of new buildings that join the existing building stock. It is my hypothesis that we will soon hit the peak in terms of building stock and a maximum in terms of "covered" spaces worldwide, mainly due to the global demographic transition. This milestone, this limit, is a revolution. Out of necessity and due to the pressure for changes, both in knowledge and technique, architecture will shift its focus to what already exists and place emphasis on knowledgeable deconstruction.

The Post-Carbon Challenges for Stations

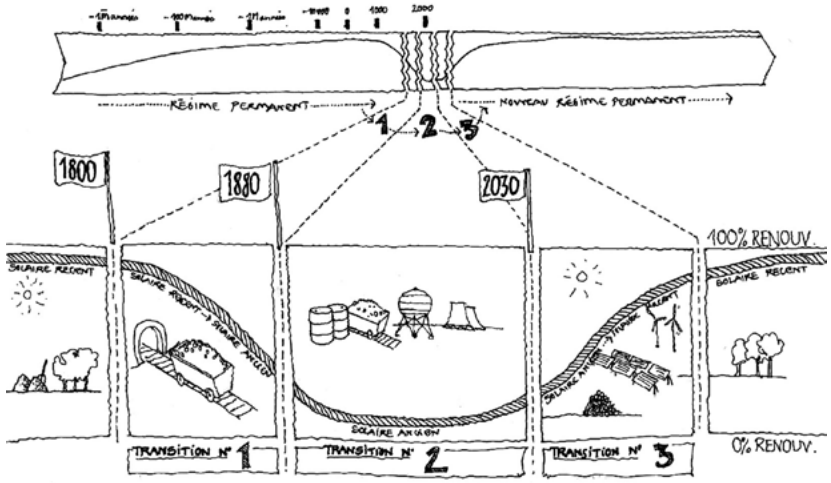


The Elevated Railway across the Ravine.

Reinventing Stations

Now that we have set the general framework and outlined the multitude and importance of the above-mentioned shocks, we need to explore how the latter translate when it comes to railway stations. What are the consequences of this new paradigm on stations being viewed as a central subject matter? Railway stations are quite a recent type of development if we consider the history of architecture as a whole. They form part of the railway ecosystem, which is being praised nowadays for its environmentally friendly aspects at a time where *flygskam* is a buzzword and promises are being made to ban combustion engines in the years to come. However, being a member of this virtuous family is not enough: stations must play their part and will undoubtedly have to change, but their intrinsic properties can be the power engine in this urgent environmental shift.

For more than twenty years and through different types of projects, AREP has been exploring the interaction, the dialectic between built form and environmental issues. This relationship has a long-standing history in architecture and urban planning. During the 20th century, research into bioclimatic housing resulted in various forms and material expressions, such as the typical bioclimatic architectural form of an isolated compact cube punctured with a few windows. In their own way, station operators in France and AREP have explored the capital relationship between architecture and energy. One example is the Bellegarde-sur-Valserine station in the Ain Region: with its immense solar dome, supported by a wooden framework, it constitutes a sort of bioclimatic Pantheon and gigantic Trombe wall characterised by hemispherical geometry.



Getting back on the path towards a 100% renewables-powered world; the kind of world that existed before the fossil fuel parenthesis.

100% Renewable-Powered Train Stations

Railway stations are the offspring of the Coal Age. The train sheds with their large volumes are related to combustion technology and their form was designed to discharge fumes properly, to ensure effective ventilation of the covered spaces, and to limit air pollution within the station. During the Age of Steam, before rail electrification, the station was also the place where the locomotive tender (a small rail vehicle hauled by the Age of Steam locomotive carrying coal and water to produce the steam that kept the engine running over long distances) was refuelled. Water tanks and coal yards were often located close to the station and the rail tracks. Some stations still offer reminders of this era, such as the water tower next to the Saint-Pierre-des-Corps train station in Tours. As far as railway production was concerned, train stations acted like some sort of "filling station", a service point where steam locomotives could be replenished and recharged.

Today, train stations provide a splendid opportunity for the energy revolution to happen and an occasion to reinvent a 100% renewable world, as was the case before the advent of rail transport[3]. Renewable energies capture the energy of flow, and need space to be harnessed. The French train stations, including their platforms, can offer nearly ten million square metres to the natural elements. Marlène Dolveck, Managing Director of SNCF Gares & Connexions, and I are aware of this potential, and we have drawn up an ambitious plan to solarise the platforms and passenger buildings and to renovate the train sheds by installing enclosures that generate energy. By 2025, we plan to deploy almost three hundred thousand square metres worth of solar panels. Harnessing these type of claddings and adapting them to each specific case in an elegant and economical way constitute a real architectural challenge.

[3] Back then, the energy supply came mainly from biomass and occasionally from wind and water power.

Opposite: Pedestrian access under the sunlight filtered through solar panels. Besançon Franche-Comté high-speed train station, France.

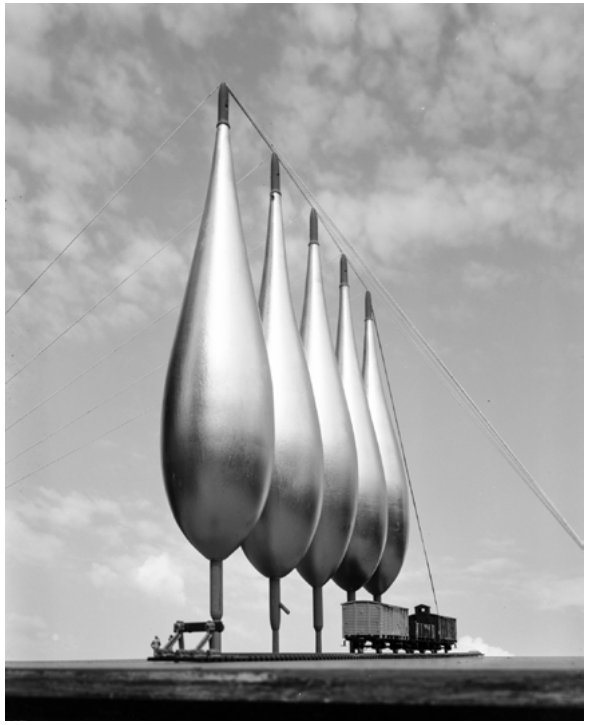
Below: Solar rooftop of Stains-La Cerisaie station, Île-de-France.

Car park under a solar canopy. Nîmes Pont-du-Gard high-speed train station, France.

The potential is enormous, and the stations of tomorrow will be more frugal, more efficient. Having moved away from fuel oil and fossil gas, they will certainly be able to produce much more energy than they consume, especially electricity. The Nîmes Pont-du-Gard station, with its eight thousand square metres of solar canopies, is a fine example, as are several stations in the Paris Region that have already been incorporating these simple and robust components into their architectural envelope for several years. The AREP teams adopt the same solutions when they work with other clients abroad, especially in China and across Europe.

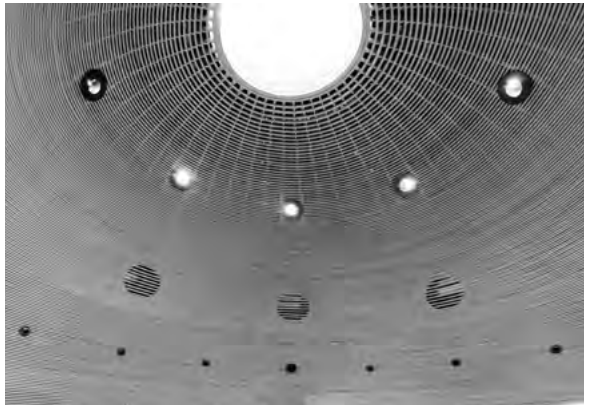
In the future, stations and the railway networks will form part of a mobility system that, just like buildings, will be energy-positive: renewable energy will be produced on site and the amount of energy produced will outweigh the total energy consumption of stations and trains running on the network, including the energy consumption related to intermodality. We have sketched out this realistic perspective in a short motion design video called "Powers of Train", which points out that the one hundred thousand hectares of railway land could probably receive almost one hundred times more solar energy than the needs of the entire SNCF Group.

With regard to energy, reinventing the station embraces even more issues and compels us to think about the potential for it to act as an energy hub. Operation-wise, this involves recovering braking energy, recharging train batteries, supplying trains with hydrogen or biogas. On the station's forecourt side, this involves storing and distributing carbon-free energies to other modes of transportation. The interaction of train stations with other forms of mobility, such as horse-drawn carriages, trams, metro, private vehicles, has never stopped changing over time. Our challenge today is to further develop the relationship that stations have with fossil fuel-free forms of mobility. Station buildings have proven their ability to adapt. Tomorrow, we need to rebuild the entire transportation chain, upstream and downstream, from the departure point through to the destination, in such a way as to make it entirely devoid of petrol, diesel and fossil fuels in general. This involves the recharging of bicycles, electric vehicles, but also buses powered by biogas and green hydrogen.



To create this energy hub, this new "filling station", both the form and the technical architecture of stations must change. What will be the form of power batteries and storage facilities and how will they be integrated? Gravity-based energy storage systems? Battery charging racks that would supply the electric tenders of future trains with energy? Biomethane tanks processing organic waste from the station and its hinterland? These questions inspire new ways of expression, halfway between Frei Otto's research work and the photos by Bernd and Hilla Becher. What type of roofs and surfaces should we design to collect solar energy (or wind energy when this is relevant) effectively in train stations, in an effort to architecturally master these technical aspects? What if renewable energies were a central focus of architecture instead of being just a, sometimes inelegant, patch placed on top of what already exists? Finally, how can we develop spaces in such a way as to ensure that these energies are efficiently distributed to the various types of mobility? It is clear that the scope of technical exploration is enormous. The railway station of the future is undoubtedly both a hub of sustainable mobility and a nexus of the energy transition, lying at the point where mobility networks meet energy networks.

Opposite: Model of grain silos by the Frei Otto Studio.
Lightweight structures for storage.
Rolling Masterplan, Jägnefält Milton Studio.



Station Materials

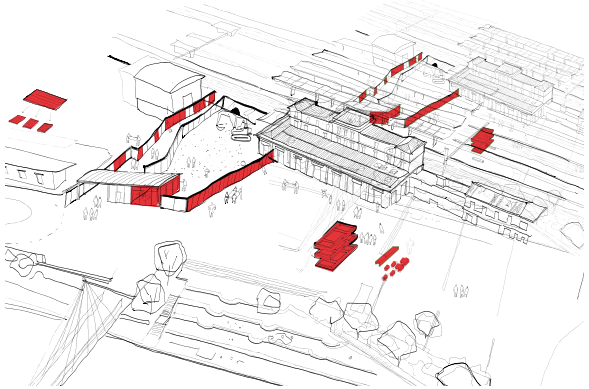
In addition to energy, train stations also have to deal with the criticality of certain materials, starting with concrete, the icon of an all-conquering modernity, that has been consuming sand from rivers and the seabed unimpeded and unsustainably[4]. Throughout their history, which is also an extraordinary adventure in construction, train stations have been a testing ground for the major advances in the use of cast iron, steel and glass in architecture over the past 150 years. At the turn of the 2000s, the French stations sustained this avant-garde momentum and experimented with innovative construction methods, thus enhancing the prowess of engineers and architects. One example is the extension of the Strasbourg train station in 2007, designed by Jean-Marie Duthilleul. Its immense glass shell enclosure features a highly sophisticated and lightweight structure that combines high-strength steel and curved glass panes with cutting-edge spectrophotometric properties. Another example is the Lyon Saint-Exupéry train station, a neogothic expression of concrete and steel by Santiago Calatrava.

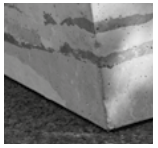
Opposite: Under the wooden dome of the bioclimatic station in Bellegarde-sur-Valserine, France.
Skillful geometry of glass and steel for the glass roof of the Strasbourg station, France.

[4] More about this in the documentary by Denis Delestrac, *Sand Wars*, 2011, ARTE France, Rappi Productions, La Compagnie des Taxi-Brousse.

Stone concrete wall. Nîmes Pont-du-Gard high-speed station, France.

Will we be able tomorrow to continue in this direction, this approach, these architectural choices? They sometimes resemble a French version of the High-Tech movement, the Anglo-American movement of the late 20th century. Its advocate, the late Peter Rice, the engineer who worked with Renzo Piano and Richard Rogers on the bold design of the Pompidou Centre (Beaubourg), had already anticipated the shift towards bio-sourced materials by exploring the merits of wood and solid stone long before his untimely death in the early 1990s. Nowadays, the Colombian architect Simón Vélez, whose work makes extensive use of bamboo, calls for a "more vegetarian architecture". In fact, the next stage will not be marked by a return to the vernacular, but rather by a local and contextual approach to the materials that make up the building: Gilles Perraudin no longer uses anything else but stone from the project's region; Martin Rauch is reintroducing us to building with earth and rammed earth. AREP has also embraced the material-related turn, demonstrated in the splendid variable section beams of laminated wood of the Lorient train station or in the "local concrete", which is composed of local aggregates, used for the ochre-orange wall of the Nîmes Pont-du-Gard train station. Throughout the world, countries are currently building their high-speed infrastructure. This is obviously the case in Asia and especially in China, where the hundred or so AREP employees design vast train stations extensively using wood in some cases.





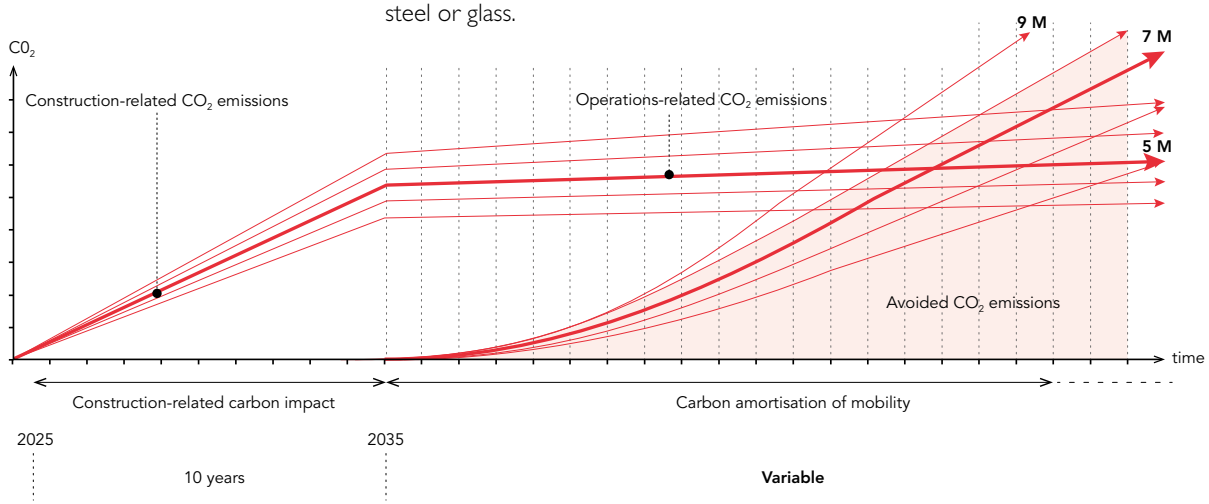
Over the next few years, we will have to amplify and generalise this movement: materials such as plant fibres, locally-sourced earth and stones or reusable materials will become the norm, the new construction mainstream. This is another exciting and extremely stimulating constraint. Like the chef who has to compose a dish with a set of specific ingredients, the designer of this century is no longer omniscient and in a top-down prescriptive stance, being in command of the materials to be used for building. Let's make do with what we have, let's foster know-how while keeping in mind that the existing stations offer much already! A young team at AREP launched a brilliant initiative called RÉAP, which explores all the possibilities for reusing rail material waste, such as railway sleepers, catenary isolators, etc. The agenda lined up for the future is very inspiring. For example, what will a large passenger hall entirely made of reused or renewable materials look like in the future? How can station furniture be reused and get a second lease of life? How can we increase platform heights without using mortar and rubble? How can we build forecourts and public spaces without materials that are sometimes extracted thousands of miles away? Once again, stations will be the laboratory for this new adventure in construction, by reviving the local know-how and restoring pride in each region.

Opposite: Reuse in action showcased by two projects in Seine-Saint-Denis, France. The new temporary access to the station is made of reused materials.
Modulo RÉAP: Reused concrete street furniture.

Lionel Walden, *Cardiff docks,* 1894.

The Carbon Metabolism of Train Stations

The third challenge after energy and materials is in relation to carbon. Throughout their history, railway stations have been major sources of carbon dioxide emissions: what is the amount of accumulated CO_2 on rail land from the combustion related to steam, oil and diesel locomotives over time? How many million tonnes of carbon dioxide have been released by chimneys and exhaust pipes located in the areas around stations? How much coal, oil and gas has been used to heat the waiting areas, as well as the back-of-house spaces for the station's general manager and the operating staff? This carbon accounting, this poor performance over time in terms of emissions, is not devoid of consequences. In addition, beyond this operations-related emissions, what is the construction-related carbon debt? How many CO_2 emissions have been generated by the construction of all these train stations? In an era where the spans of station roofs were large, of grand constructions, of monumental stations, the debt was undoubtedly substantial. It would be an interesting exercise a posteriori to establish the carbon budget for the Paris-Nord train station at the turn of the 1860s, by assessing, for example, the emissions generated by the construction of the famous cast iron columns designed by Hittorff. It is important to remember that back then, industrial processes were far less efficient than they are today and generated many more emissions per kilogram of material, whether it was cast iron, steel or glass.



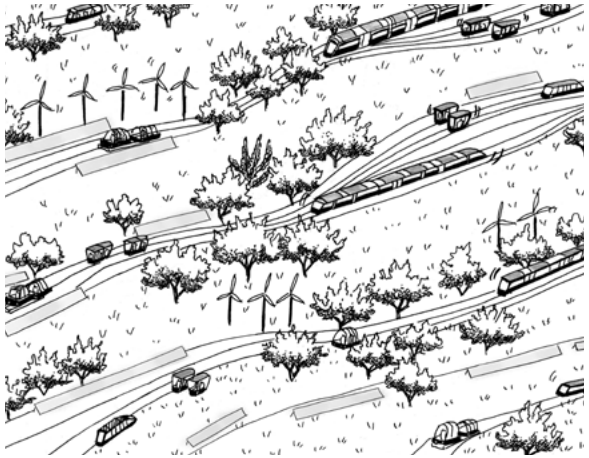
Opposite: Graph of the cumulative CO_2 emissions generated by the transformation of a station and its subsequent operation, compared to the emissions avoided as a result of modal shift and the choice of rail over more carbon-intensive transport. The different scenarios reveal the potential uncertainties, and therefore the sensitivity to the "energy payback time" of the post-carbon station. The question of "embodied carbon", which is induced by construction and transformation, is essential in order to guarantee the shortest energy payback time.

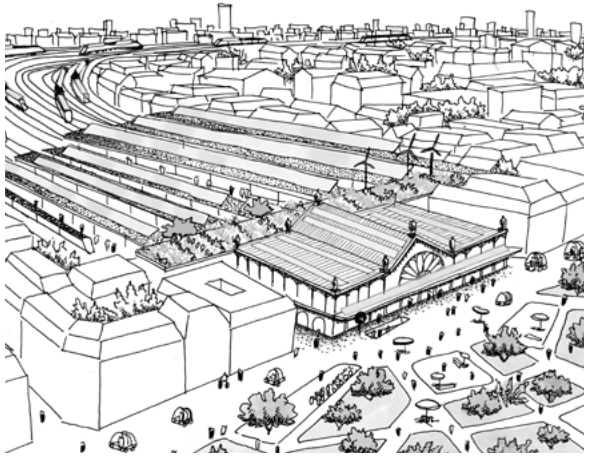
Nîmes Pont-du-Gard high-speed train station, France.

Clearly, the stations of tomorrow will need to have the least possible environmental impact. The timing could not be better because over the coming decades, it will be more about transforming and rehabilitating existing buildings rather than constructing new ones, which often accounts for greater amounts of embodied carbon. By and large, in France, the amortisation of embodied carbon per visitor is still about[5] 50 grams of CO_2 when the entire carbon footprint is taken into account, i.e. both the emissions related to the operation and those induced by the construction and transformation of the buildings. We must ensure that this "marginal carbon cost related to station use" tends towards zero as soon as possible, so that train stations can achieve carbon neutrality by 2050.

How can architects and land operators overcome the time-related conflict between permanence and frugality? In a contemporary version of the tale of the Three Little Pigs, the question is: should we build in a low impact manner for a limited period of time, or, on the contrary, should we build in a sturdy manner and thereby take a heavy-handed approach, so that the buildings last longer? This dilemma linked to the overall economic and ecological cost of the project is at the heart of our preoccupations. Obviously, each answer is local and the amazing railway heritage is an opportunity to make these rationales coexist. On the one hand, we must undertake major transformations in the large metropolitan stations. On the other hand, the changes made to these buildings, which are sorts of miniature cities, must be reversible. And the Covid-19 crisis has reminded us that we need to be humble in our projections[6].

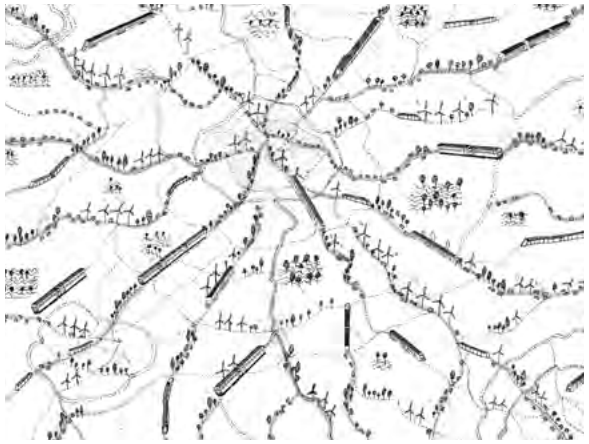
[5] Around 200,000 tonnes of CO_2e annually for Scopes 1, 2, and 3 for about four billion visitors per year.
[6] R. Ménard, "Milou in March. Where do we go from here?", 18 March 2020, Pavillon de l'Arsenal.

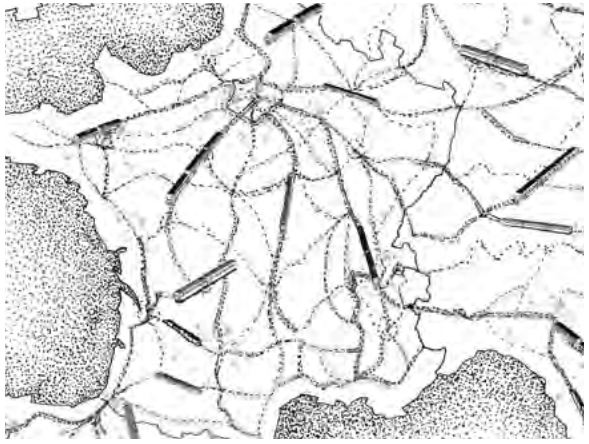




Finally, in the case of railway stations, the carbon question is more complex than a "simple" life cycle assessment. It involves related issues, such as carbon storage in the building, or the capacity of the landscape project to sequestrate atmospheric carbon. If we want to explore the question holistically, we must also consider the emissions induced by intermodality. Regarding carbon dioxide storage, it is useful to bear in mind that the benefit of building with bio-sourced materials is twofold: not only they generally release less carbon dioxide than conventional materials such as concrete and steel, but they also allow to sequestrate carbon (known as "biogenic") in the building for a long time. Therefore, by using plant-based materials for both buildings and fittings, railway stations can morph into "carbon banks".

Opposite: In 2030, train stations are real energy hubs ensuring the production, distribution and storage of carbon-free energy. They are home to all renewable energies. They store and distribute the produced energy to users, services, the neighbourhood and all modes of electric mobility. Excerpt from the film *Powers of Train*.





As a transition to the remaining two challenges, I would like to mention that train stations extend far beyond the mere passenger building: their platforms, surroundings, forecourt and streets are also spaces to be greened and have the potential to act as carbon dioxide sinks due to the metabolic activity of trees and plants, which absorb and store CO_2. This avenue should, therefore, not be overlooked and should be inclusive of the extended railway land, where millions of trees can grow, in compliance, of course, with the rail safety rules. These planted areas will also provide building materials, thereby creating an effective convergence between carbon and material challenges.

Left page: The SNCF-owned land receives almost a hundred times more solar energy than the entire Group consumes. It can be used to develop biodiversity, anticipate the effects of global warming, and absorb and store carbon. Excerpt from the film *Powers of Train*.

Opposite: Prospective sketch of a pollinating train.

Atocha Renfe train station, Madrid.

Havens of Wildlife and Climate Shelters: Stations as Points of Reference

Recently, when SNCF Gares & Connexions and its subsidiary AREP redesigned the Rennes train station, a bold choice was made. According to the concept developed by FGP, the built environment supports the forecourt while several thousand square metres of this bustling area in Rennes have been grassed over. The project contributed to bringing biodiversity back into the city, as well as to mitigating the urban heat island effect. A different region, a different context: the new Nîmes Pont-du-Gard garden-station in South France. This project has been designed in harmony with the landscape, incorporating beautiful plant species while blending in a complex site.

Our goal is a holistic one: to take care of the living things both around and within the train stations. Think of the large train stations with their majestic glass roofs that are reminiscent of the vast 19th-century greenhouses and are invaluable for creating a protected environment for plants and seedlings, as it is the case in the splendid Atocha train station in Madrid, home to a lush interior garden. The future challenge will be to design solutions for the station platforms that reconcile rail operations with the introduction of biodiversity and the greening of platforms. To achieve this goal, a great idea would be to swap the metal fences enclosing the stations with living screens, such as hornbeam hedges, also known to provide wildlife habitat.

[7] The architects and town planners Ferrier, Gazeau and Paillard.

Mist cooling system in Montpellier Saint-Roch station.

In terms of well-being, the plant cover brings hygrothermal benefits to outdoor spaces as it helps in their adjustment to high temperatures. Evapotranspiration from sources such as tree canopies increases thermal comfort and locally mitigates some of the effects of global warming. Because of their composition, historic stations are often massive buildings with thermal inertia, due to their thick masonry walls. The conditions in the underground passages are even milder as they benefit from the thermal stability of buried soils. In this respect, underground stations will be havens of thermal comfort during heatwaves, as the temperature is almost constant. Because of these features, the stations of the future could once again be designed as destinations for people who seek comfort during heatwaves or high summer temperatures. It is true that train stations have historically been designed, then transformed, to deal with the problem of thermal comfort in winter and to reduce the discomfort caused by draughts. AREP is at the forefront of this essential theme, designing zones where thermal comfort is optimal due to furniture and platform shelters. We should bear in mind that no matter how greenhouse gas emissions evolve in the future, global warming is unavoidable. We know that there will be an increased frequency and amplitude of extreme weather events. If we add to this an aging population, all too accustomed to air-conditioning, we understand why stations will have to provide their visitors with increased thermal comfort all year round.

In order to achieve this shift, we need to reinvent the space layout of train stations and demonstrate creativity when designing low-impact and frugal station furniture and fixtures: water features on the forecourt, indoor water curtains, suspended fans in large spaces, bioclimatic outdoor benches, station forecourts with a variable albedo, white paint on roofs and exposed areas, etc. The AREP teams have already investigated these and other related themes, such as adiabatic cooling via misting, which we first deployed in the Marseille Saint-Charles station and then in other stations (for example, the Montpellier Saint-Roch station) or cooling through earth cooling tubes, implemented in the Besançon high-speed train station. Let's dream of this "climatic generosity": tomorrow, we will be heading to train stations not only to take the train, but also because we feel good there when the weather is a bit hot. Stations will become the new village squares, an urban centrality where people will go to read a book or meet their grandchildren on a hot day. They will be a destination and an alternative to over-air conditioned, energy-consuming and uncomfortable spaces.

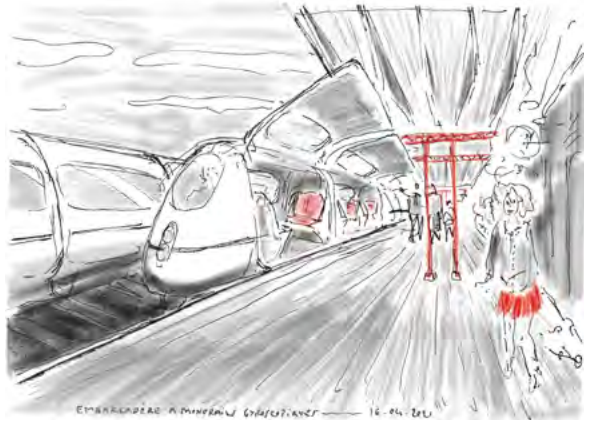
The Essence of Stations

Boarding an intercontinental night train.
Excerpt from the film *Powers of Train*.

A Forum for a Post-Carbon Future

The five "EMC2B" challenges outline a vast field of investigation for developers, constructors, and operators of future stations. Our belief here at AREP: To create a post-carbon future. However, we should not forget the cultural dimension of the more than 3,000 stations throughout France. Train stations remain extraordinary places in terms of attendance, and over time, they probably hold the record for the number of people who have looked at them or walked through them. From the very beginning, stations have been protected public spaces, covered passageways, like Lille-Flandres or Lyon Part-Dieu train stations. The openness to pedestrians has always been prevalent. Even if the stations of tomorrow seek to be exemplary with respect to ecological challenges, they are above all public spaces, meeting places, concentrations of transition. Train stations are places where this issue can be exposed in all its diversity and this can trigger as many exchanges and debates as the number of train stations itself (more than 3,000). By reinventing railway stations, we renew their attractiveness and get people to take the train more often.

Louis Brennan, Gyroscopic monorail, 1909.



Platform for gyroscopic monorails.

The Age of Light Mobility

Today, the ecological shift is challenging and the Gilets Jaunes (Yellow Vests) crisis has illustrated the tension between environmental imperatives, social inequalities and regional planning. In fact, the current model of individual mobility, especially in rural and suburban areas, remains largely dependent on fossil fuels. Mobility options and the current imagination are still rooted in the twilight of heavy cars, including low-cost cars, which, year after year, always end up costing too much. Mobility must undergo a revolution, probably even more radical than that of the built environment. We have to admit that most of our current means of transport are far too heavy, burdened over the years by the gadgets that car manufacturers have been successfully selling us. It would have been much wiser to produce post-carbon, light and compact 2CV or Citroën 4L, but no doubt profits would have been lower.

On the railway side, light rail is on the rise but rail operators can still do better. At AREP, we are very interested in the exciting questions of industrial design. We ask ourselves questions about light mobility in the same way we do when we design our buildings with the Holy Grail of the "lightweight structure" in mind: structures that are lighter than the loads they may be required to withstand. Through this "mobility infrastructure" analogy, we outline concepts that focus on small mobile architectures, in order to reinvent the individual mobility experience, but also on comfortable, lightweight and attractive trains for the future. There is an urgent need to devise alternative visions to the technophile fantasies of the Hyperloop, the exaggerated version of trains running through a vacuum. This scenario clearly moves away from the promise for popular mobility and poetic travels. Given the size of the new tubes to be built, we can reasonably have our doubts about the proper integration of these infrastructures into the landscape.

A library-station.

A Palimpsest of Programmes

I will add another angle to this forward-looking journey: the intensity of station use and the mix of programmes. I mentioned earlier what car design is missing out. In order to support this statement, all we have to do is point out the incongruous use of cars: a car runs 5% of the time and stays put 95% of the time. What inefficiency for so much technological complexity! Stations are far more efficient, as they are generally open 70% of the time. But we could be more ambitious and expect that train stations, which are genuine real estate assets, can operate longer and not just when the trains are running. Make things happen in the stations, reinstate the magic: maybe keep stations open through the night? Revive the "programmatic palimpsest"? Rem Koolhaas theorised bigness and the concept of "programmatic critical mass". In the very big stations, the revival of night trains and of trans-European lines could provide relevant pretexts. At the more common scale of regional planning and of small stations, we need to think about how these places can become hybrid places instead of simple additions. The station can also be a library, an upcycling centre, a bike workshop, a marketplace for small scale local producers to bring produce directly from farms to people's plates.

The challenges and scenarios I have outlined are purposefully enthusiastic and of an activist nature. Today, more than ever, we need new narratives. Our era is in dire need of inspiring collective possibilities. The health crisis has been a major upheaval, affecting traffic forecasting models. It is probably still too early for this to be confirmed, but we are undoubtedly approaching the peak of global mobility. How will stations fit into this trajectory of stability or possible decline in traffic and passenger flows? Are we moving towards fewer and smaller stations to match the scale of use? This is a legitimate question, and there is no doubt that some buildings will prove to be too large given their actual use, but the idea of the programmatic palimpsest can provide solutions, so that this built capital can be made profitable. The "1001 Stations" initiative is a great demonstration of this idea and provides inspiring examples from throughout the country.

The Station of the Future

The station of tomorrow outlines and brings about the age of light and positive mobility, but it also stimulates the dynamics of reinventing a light network that provides comprehensive transport coverage and contributes to moving around people and goods smoothly. With this in mind, there is no doubt that there will be more than five thousand stations in France in 2050! And if this is the case, what will they look like? In a way, using an iconoclastic animal analogy, "stations as subject matter" are somewhat similar to the dog species within the canine family; we sometimes find it difficult to imagine that the chihuahua and the saint bernard belong to the same species. Transposing this idea to our case, what are the similarities between the Paris-Nord station and the small train stop in the middle of the forest of Fontainebleau? This reminds me of a beautiful paragraph by Louis Kahn, who, questioning the essence of school, wrote in *Silence and Light:*

"Schools started with a man sitting at the foot of a tree who didn't know
he was a teacher, talking to other people who didn't know they were his pupils.
(...) Later, buildings were erected and the first school came into being".

So let's use Louis Kahn's metaphor. Perhaps all we need to remember is that the idea of the station came about when a train stopped and passengers wanted to get on and off the carriages. This threshold probably represents the essence of how stations emerged. This "platform" emergent from the need for a landing space, this long, narrow space, bears strong spatial and emotional power. From those platforms, stations were born.
Like a small electric train, these concluding thoughts bring us full circle to the origins. It is up to us to reinvent the stations of tomorrow with passion and to fully embrace this highly exciting field of investigation, this history in perpetual rebirth!

Study model of the platform and its solar cover.

About Raphaël Ménard

Raphaël is Chairman of the AREP Management Board. He began his career at RFR in 1999. He participated, in particular, in the design of the Simone de Beauvoir footbridge in Paris and the glass roof of the Strasbourg train station. In 2003, he founded Elioth, a team of designers specialising in low-carbon innovation. Elioth was acquired by the Egis group in 2011, where Raphaël headed the strategic foresight department in addition to his operational functions.

In 2014, he created 169-architecture, a laboratory for experimental architecture. Raphaël has theorised his practice in numerous publications, including his thesis "Energy, Matter, Architecture", which he defended in 2018. Since 2013, he has been teaching in the Master's programme on Post-Carbon Architecture at the Marne-la-Vallée School of Architecture.

In 2020, Raphaël was appointed Director of Architecture and Environment within the SNCF Gares & Connexions Executive Committee. What he brings to AREP: his commitment to capitalise on the intelligence for the common good that has been gained over the past twenty years in order to conceive sustainable cities and large regional areas accessible to all and pleasant to live in.

Inventing a post-carbon future.
AREP headquarters in the former Panhard car plant,
which was remodelled by the AREP teams.

About AREP

Founded in 1997, AREP is a multidisciplinary firm. A subsidiary of SNCF Gares & Connexions, its mission is to invent a post-carbon future. AREP operates and innovates in all the fields that are essential to the renewal of architecture and places, covering everything from architectural, urban and landscape design to engineering, including design, programming consulting services and project management.

AREP is strongly committed to promoting ecological transition, in particular through its EMC2B framework, providing practical solutions to meet the pressing challenges of the ecological emergency. AREP has nearly 1,000 employees from 30 different nationalities based in France and abroad and is ranked first among French architecture practices by revenue.

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Graphic design and layout
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Photo credits and illustrations
APUR (p. 10) ; AREP (p. 18, 28) ; D. Berg/AREP (p. 2, 34, 36, 44, 50) ; D. Boy de la Tour/AREP (p. 24, 32) ; Campwillowlake/istock (p. 6) ; C. Cligman/AREP (p. 20) ; B. Clouse (p. 4-5) ; C. Delettre/AREP (p. 20) ; DR (p. 16) ; Getty Images – Photo Josse/Leemage (p. 30) ; The History Collection/Alamy stock photo collection (p. 46) ; M. Huriez/AREP (p. 54) ; M. Lee Vigneau/AREP (p. 24, 26, 40, 56) ; R. Ménard/AREP (p. 8, 12, 37, 46, 48) ; Mira/Alamy stock photo collection (p. 38) ; NASA (p. 14-15) ; D. Pelofi/AREP (p. 20) ; B. Pudill (p. 42-43) ; G. Robinne/AREP (p. 52-53) ; saai I Archiv für Architektur und Ingenieurbau (KIT), Werkarchiv Frei Otto (p. 22) ; SNCF Réseau (p. 31) ; Studio Jägnefält Milton (p. 22).

Print in France
ISBN : 978-2-9579206-1-7

www.arep.fr

"*Railway stations first appeared with the Industrial Revolution and have developed in parallel with all the societal changes that have taken place over the past two centuries. This parallel process has a global dimension; the Earth and its inhabitants have reached a historical turning point, the epilogue of our thermo-industrial civilisation. We need to successfully move through this transition because we are facing both a critical situation and a tipping point: biodiversity is collapsing, the climate is changing at a vertiginous pace, planetary resources are sorely stretched while serious ecological disruption is on the rise (atmospheric, soil and ocean pollution, uncontrollable pandemic risks, etc.). These crises provide tremendous opportunities to repair our world and must call forth all human energies. Creativity is stimulated by constraint, and here at AREP we are committed to this forward movement, to the full extent of our ability. AREP is a multidisciplinary firm that has been building contemporary railway stations in France and around the world for over twenty years. Today, the company has set itself a new mission: to create a post-carbon future. With this goal in mind, I am venturing down some avenues, testing hypotheses about the future of stations, namely post-carbon stations, in order to keep this extraordinary history alive*".

Raphaël Ménard

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