

Balancing Act

LUMA ARLES – Two exhibition buildings at the Parc des Ateliers, Arles, F

Client
LUMA Foundation

Design Architects
Gehry Partners LLP and
Selldorf Architects, New York

Building parts Les Forges und
Mécanique Générale:
Selldorf Architects, New York

Architect of Record
C+D Architects

Sustainability consultant
Transsolar KlimaEngineering

Landscape Architect
Bureau Bas Smets

Planners
Structural and MEP:
Terrell Group
Lighting Consultant:
Studio ZNA
Acoustic Consultant:
Cabinet Lamoureux Acoustics
Fire Prevention:
Casso Associates

Drawings building:
Courtesy of Selldorf Architects

Graphics in the text:
Transsolar

The Parc des Ateliers is built in a former locomotive maintenance yard in an industrial area south of the historic city centre in Arles. Now, the complex is a place for exchange between artists, visionaries and the public. The program for the LUMA Foundation in Arles was developed by a core group of art consultants, curators and artists (Tom Eccles, Liam Gillick, Hans Ulrich Obrist, Philippe Parreno and Beatrix Ruf among them) and since its launch in 2014, the works of many artists have been exhibited, reflecting one of the three areas of interest of the LUMA Foundation: art, human rights and environment.

The Parc des Ateliers consists of six existing industrial buildings, five of which are being renovated by Selldorf Architects. Two have been completed and have had their openings celebrated as part of Rencontres, an internationally renowned photography exhibition: Les Forges in 2014 and Mécanique Générale in 2016. These buildings are the subject of this article. The complex also includes a sophisticated and innovative “Art Resource Building” by Frank Gehry that is currently under-construction. The central element of this new building is a 56-meter-high tower, clad in metal blocks and protruding from a fully glazed drum-shaped enclosure. A park designed by Bas Smets unites the different buildings and is open to the public.

Goals for energy efficiency and sustainability at the Parc des Ateliers
The LUMA Foundation intends for the Parc des Ateliers to be an outstanding project both architecturally and in terms of energy efficiency and sustainability. As the project climate engineer and sustainability consultant, Transsolar formulated ambitious goals to

reduce the primary energy demand by 60% when compared to a building meeting the legal energy requirements and to avoid all use of nuclear power.

Decreasing energy consumption by this magnitude is achieved by implementing significant passive and active measures. The remaining energy demand is then supplied by renewable sources.

Passive measures require deliberate integration with the architecture and necessitate early cooperation between the architect and climate engineer. Active measures also necessitate careful consideration of HVAC system design and need to be compatible with the architectural concept.

Context sensitive climate engineering
In Les Forges and the Mécanique Générale, Transsolar proposed the following essential passive measures, which were embraced by Selldorf Architects. These were:

- improvement of the building envelope
- usage of thermal mass
- supplying daylight through openings in facade and roof
- highly selective glass
- external operable shading
- natural ventilation and air movement.

The following active measures were implemented in collaboration with the architects and HVAC engineer:

- floor activation for heating and cooling
- displacement ventilation with efficient heat recovery
- thermal stratification.



Semi-outdoor space next to Les Forges

Photo: Hervé Hôte, Courtesy LUMA Foundation

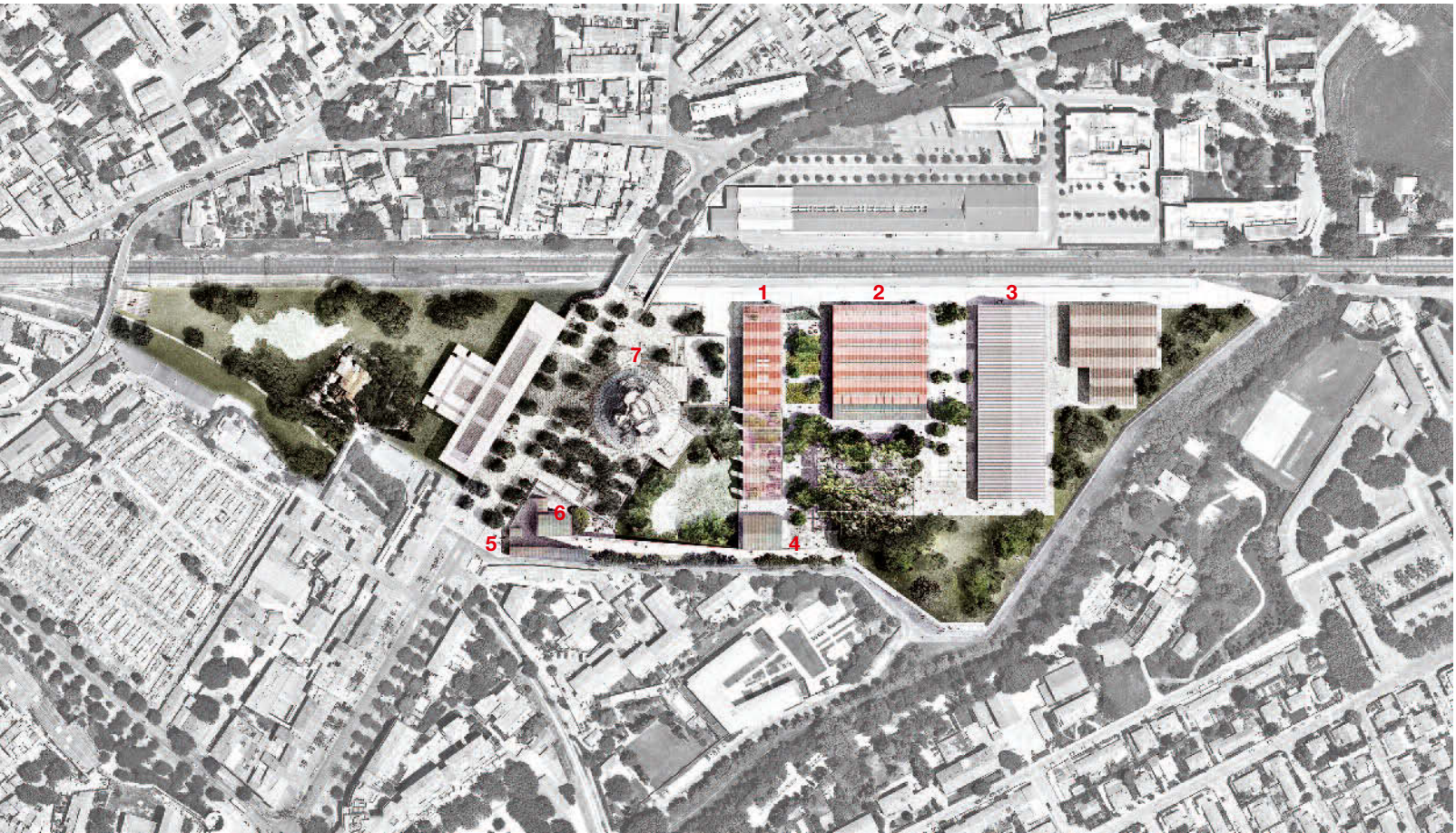


Photo: Courtesy of Selldorf Architects

Site plan
1 Les Forges - Exhibition 2 La Mécanique - Exhibition 3 La Grande Halle - Multi-purpose 4 La Formation - Dance Studio and Artists' Residence
5 La Maison du Projet - Café and Visitor Center 6 Centre Médico-Social - Hotel 7 Art and Research Center

Thermal stratification allows for the cooling of only the lower, occupied layer of air in large, tall spaces. Energy use is therefore targeted at cooling areas with people and not the entire volume of air. In Arles, the cooled air needs to encompass the exhibits as well and therefore the height of the cooled layer was extended to about five meters. The combination of radiant cooling and displacement ventilation provides a high level of comfort for the visitors, fulfills the curators’ needs and ensures optimal conditions for exhibits. In addition, a low primary energy supply system was developed and will be commissioned upon completion of the new Gehry building. The energy supply system uses “eco-oil” produced in the Camargue in a combined heat and power plant (CHP) as well as a 2,500 m² photovoltaic system.

The authors



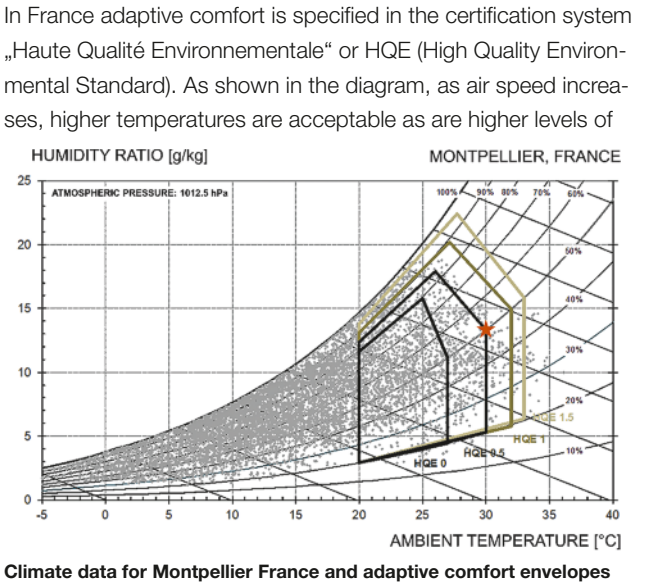
Dr. Katrin Müllner
Katrin works for Transsolar in Munich as an expert in integrated design with emphasis on system analysis and daylight simulation of complex buildings. After earning her Diploma at the Technical University of Munich with a specialty in renewable energy, she earned her doctorate in the Department of Biology (Photobiotechnology) at the Ruhr University in Bochum on photobiological hydrogen production with the green alga Chlamydomonas reinhardtii.



Dr. Wolfgang Kessling
With 25 years of experience in innovative ventilation systems and energy-efficient buildings, Wolfgang has been one of the two directors of Transsolar's Munich office since its founding in 2003. For several years now, his team has been working intensely on methods for climate assessment and improvement of urban outdoor comfort, especially in hot, humid climates.

Client brief and integral planning
A critical look at the boundary conditions and assumptions for design criteria by Transsolar resulted in a substantial reduction in installed equipment. Mechanical systems are typically sized for the most extreme occupancy scenario and result in the system being greatly oversized for the actual load during much of its operation time. In Arles, high maximum visitor density and internal loads were challenged and more realistic numbers proposed. After discussion, it was decided to design the mechanical ventilation systems in Les Forges and the Mécanique Générale not for the very rare case of maximum density of only 5 m²/person during an event, but for the case of an exhibition with 12 m²/person.

Adaptive comfort
In simplified terms, adaptive comfort means that occupants of a naturally ventilated building have different expectations of thermal comfort than occupants of a fully air-conditioned building. Generally, the higher the average outdoor temperature, the higher the accepted indoor temperature. Adaptive comfort standards also recognize that people can make choices that influence their comfort level, for example, by selecting various levels of clothing depending on environmental conditions. The variety of options to increase thermal comfort, most notably the ability of increased air movement to compensate for higher air temperature and relative humidity, are also a part of the standards.



relative humidity. The comfort envelopes are shown for air speeds from 0 m/s (HQE 0) to 1.5 m/s (HQE 1.5) in steps of 0.5 m/s. The conditions indicated in the diagram by a star – those with a temperature of 30° C and a relative humidity of 50% - are perceived as uncomfortable without air movement. With a gentle breeze, as can be created by natural ventilation or fans, higher temperatures as well as higher levels of relative humidity are still perceived as comfortable. The HQE allows air velocities of up to 1.5 m/s, which fits well with other international standards.

In general, in a Mediterranean climate like Arles, good thermal comfort in summer can be created by means of sufficient thermal mass, good protection against solar gains, natural ventilation and additional air movement.



Les Forges & the Mécanique Générale
The architect Annabelle Selldorf is renowned for her context-sensitive renovations. Her view of the refurbishment of the two industrial buildings Les Forges and the Mécanique Générale is the following: „The project combines the original industrial architecture of the 19th century with the current cultural use as an exhibition site. The original structure could be retained and as a plus, a new balance is created between inside and outside. The genuine steel structure is restored. The skylights are enlarged and rearranged. Well-proportioned light-flooded rooms are the results; they have a clear partitioning.“

Description of the buildings
Both buildings, Les Forges and the Mécanique Générale, are located between the Grand Hall and the new Gehry building. Les Forges' area is 120 m by 25 m and consists of 12 bays, six of which are open to the sky. The adjacent four bays are dedicated gallery spaces. The previously one-story building with a height up to nine meters is now divided by a mezzanine accessed by a central staircase. The two northeast bays house the energy supply system of the entire Parc des Ateliers. With the addition of a seventh bay, the Mécanique Générale now covers an area 70 m by 60 m. Five bays are used as one single exhibition space while the other two mostly serve as a work shop.

Comfort and climate concept
For Les Forges and Mécanique Générale, an integrated comfort and climate concept was developed. The aim of this concept was to offer visitors and users a high level of thermal and visual comfort, and to create optimal conditions for the exhibits. This was achieved by various elements, described below, which act on



Facade Les Forges

Photo: Courtesy of Selldorf Architects

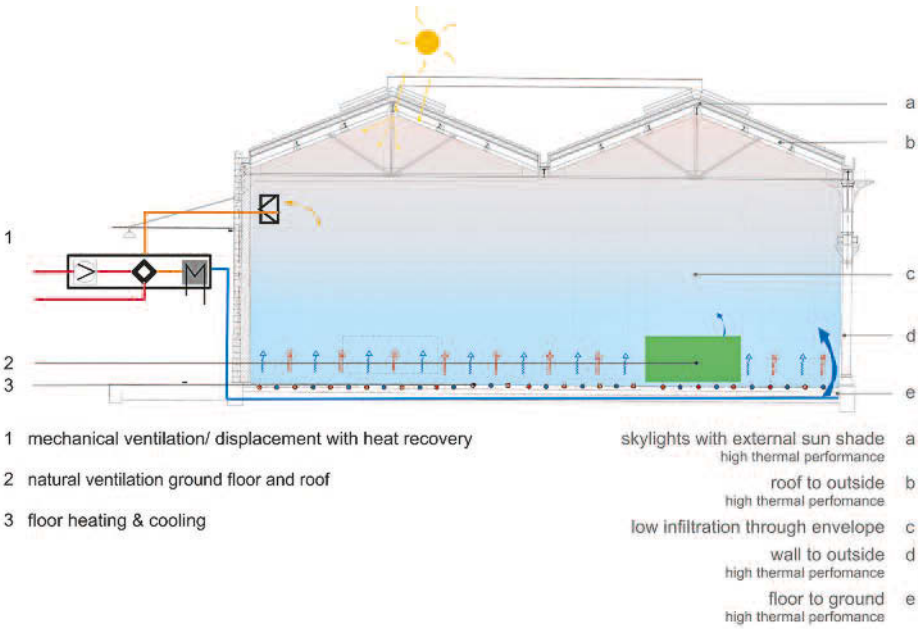


Les Forges – exhibition space

Photo: Hervé Hôte, Courtesy LUMA Foundation



Ground floor



Comfort and climate concept of Mécanique générale

radiant as well as air temperatures and provide for good daylight availability.

Improving the building envelope
The building envelope has been completely renovated. The simple, non-insulated roof was replaced entirely. The original structure was maintained, but limited the maximum possible weight of the roof. The resulting installed thermal insulation achieves a u-value of 0.24 W/m²K. The walls were carefully reworked and were to be preserved in their original form. Therefore, they were insulated from inside to achieve a u-value of 0.25 W/m²K. The original single-pane glazing was replaced by highly selective double glazing with a visual transmission of 50% and a g-value of 25%. External operable shading above the skylights allows the use of solar gains in winter, but shields the space from glare and heat in summer. Since Arles is in a very windy area affected by the Mistral, special attention was paid to the reduction of infiltration, with corresponding details in the implementation of the roof and facade. The floor was completely renewed and insulated (u-value of 0.25 W/m²K) and made thermally active through underfloor heating and cooling.

Daylighting
Both Les Forges and the Mécanique Générale achieve excellent daylight autonomy. In Les Forges, the existing space was divided in two by the addition of a mezzanine level. This upper level is lit by both skylights and windows along the façade, while the lower level is lit primarily from the perimeter. A central atrium links the two spaces and allows additional daylight into the central area of the lower level.

The Mécanique Générale is a large space that is almost square in plan and requires the external walls to be available as display area. Daylighting is therefore achieved through linear skylights, which permit daylighting of the interior spaces and create the glare-free and uniform light required by exhibition spaces.



Photo: Hervé Hôte. Courtesy LUMA Foundation

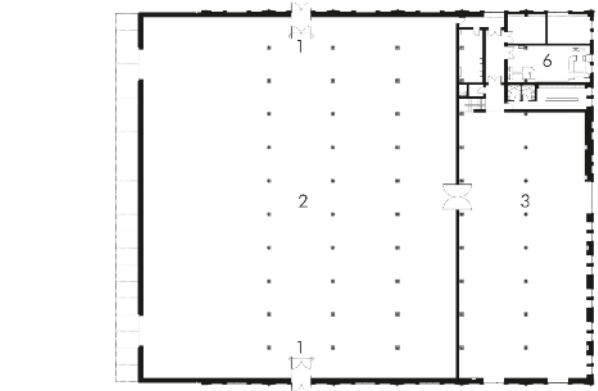
Concept for natural ventilation
At Les Forges, the operable windows are used for daytime natural ventilation and nighttime flushing. To use the façades of the Mécanique Générale as exhibition space, special openings were developed to allow fresh air to flow underneath the façade and enter the room via a floor grill.

The openings for natural ventilation are dimensioned to allow sufficient ventilation in the case of an event with high visitor density. During normal operation, the volume of air to be supplied by natural ventilation is adjusted to match fresh air requirements. Both the stack effect and the strategic operation of openings according to the prevailing wind direction are used to ensure sufficient airflow during periods of natural ventilation. Exhaust air in both buildings is discharged through the roof.

Decisions regarding sizes and location of openings were made in coordination with the architect and interior designer to avoid conflict with the exhibition concept. For example, the placement of

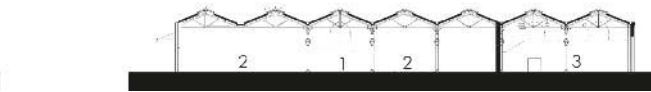
Building plans La Mécanique Générale

- 1 Entry
- 2 Gallery
- 3 Workshop
- 4 Cafe / Bar
- 5 Courtyard
- 6 Mechanical



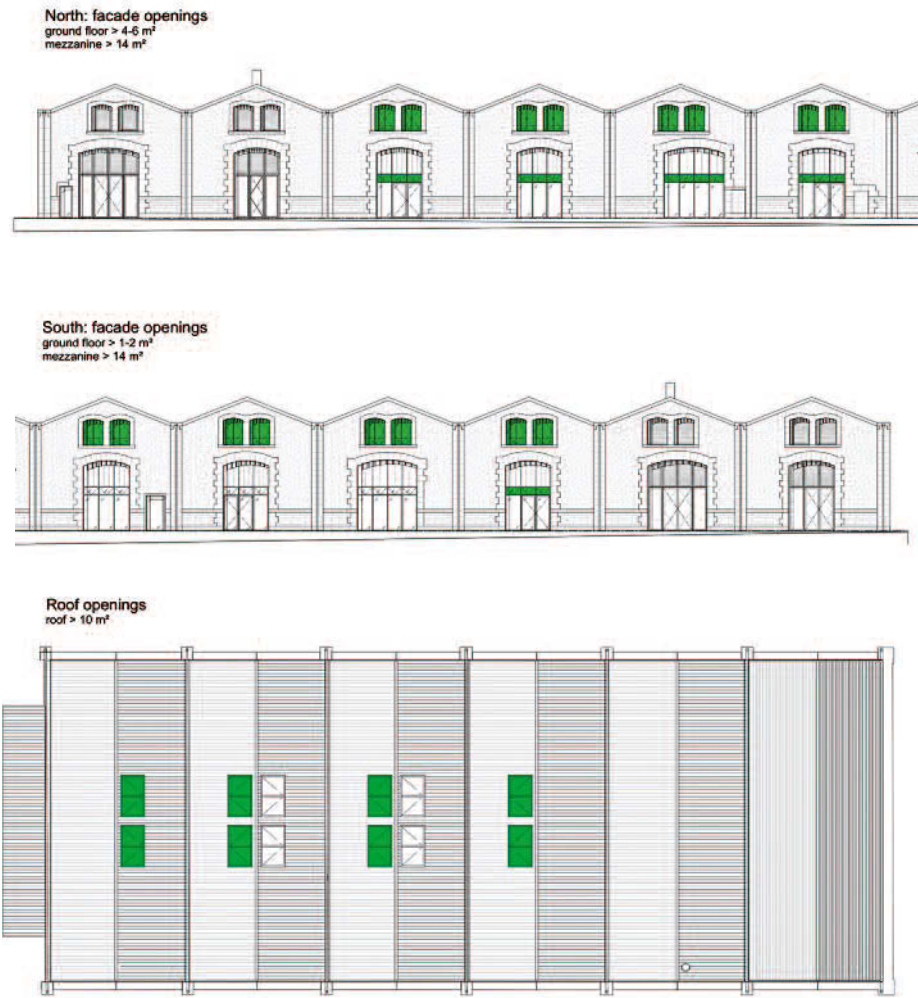
Ground plan

- 1 Entry Vestibule
- 2 Gallery
- 3 Workshop



Section

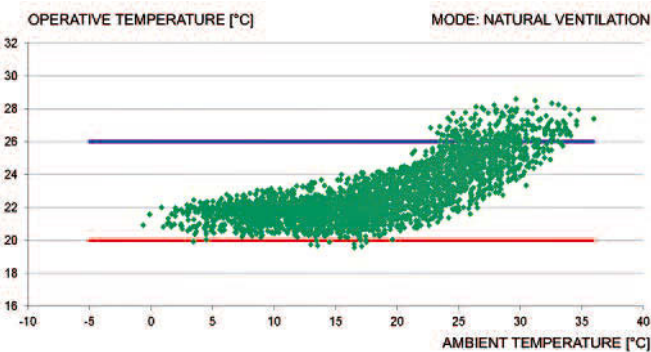
The supplementary structure references the volume of the existing historic industrial building La Mécanique Générale, interprets its form and completes the sequence strikingly.



Location and size of openings for the natural ventilation in Les Forges

façade openings allows for successful natural ventilation despite the possibility of varying arrangements of partition walls in the mezzanine of Les Forges.

Thermal comfort
The ventilation concept allows for different operation modes depending on outdoor conditions, with natural ventilation having priority over mechanical ventilation. On mild days, when temperatures are between 12 °C and 25 °C and absolute humidity less than 11 g/kg (about half the annual operating hours) the building can be ventilated naturally. Mechanical ventilation is used during the winter months to benefit from heat recovery and reduce heating energy demand. Humidification is not provided.



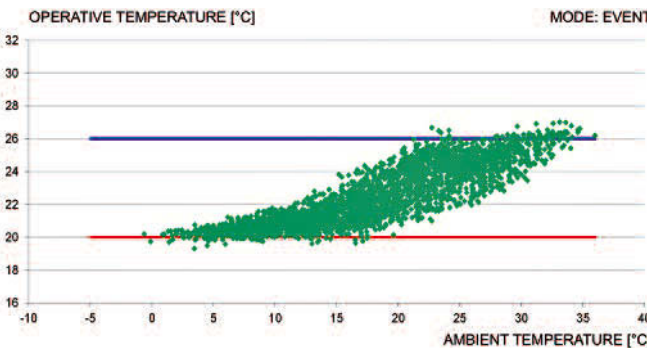
Thermal comfort with natural ventilation in summer, shown for the Mécanique Générale

As designed, the natural ventilation mode provides sufficient comfort for nearly the entire year. Annual simulations show that if operated exclusively in this natural ventilation mode, operative temperatures rarely exceed 28° C, the upper boundary of the comfort range defined by the adaptive comfort standard.

While designed primarily for efficient winter operation, the mechanical ventilation system can also be used to increase comfort for the visitors during peak summer by providing cooled and dehumidified air (dew point 12°C). The system operates by means of displacement ventilation and is sized for occupant loads of 120 people and 250 people at Les Forges and the Mécanique Générale, respectively, which represent typical exhibition scenarios.

In rare cases, natural ventilation can be combined with mechanical ventilation to provide enough fresh air for peak occupancy rates up to 270 people in Les Forges and 550 people in the Mécanique Générale exhibition area.

The diagram shows that in this combined mode, even in case of an event, an operative temperature of 26° C is seldom exceeded and excellent thermal comfort is provided.



Thermal comfort at events

Operating experience at Les Forges 2014
Les Forges was temporarily opened for the Rencontres in the summer of 2014 after only three months of renovation. At that time, the building envelope had been completely renovated, the external sun shading installed, and the floor activation connected to a temporary cooling supply. The mechanical ventilation had not yet been installed. During the following months, the missing elements were retrofitted.

The first summer was used to measure the system performance with only natural ventilation and floor activation. The diagram shows the operative room temperatures measured during August 2014 (green) superimposed on the predicted operative temperatures (grey).

The average outdoor temperature in August was 23.4 °C and ranged from 15.0 °C to 36.3 °C. The operative room temperature varied in a very small range between 19.9 °C and 24.9 °C. The records also showed that in August 2014 the occupant densities during exhibitions were significantly lower than those originally proposed during the planning phases as design loads.



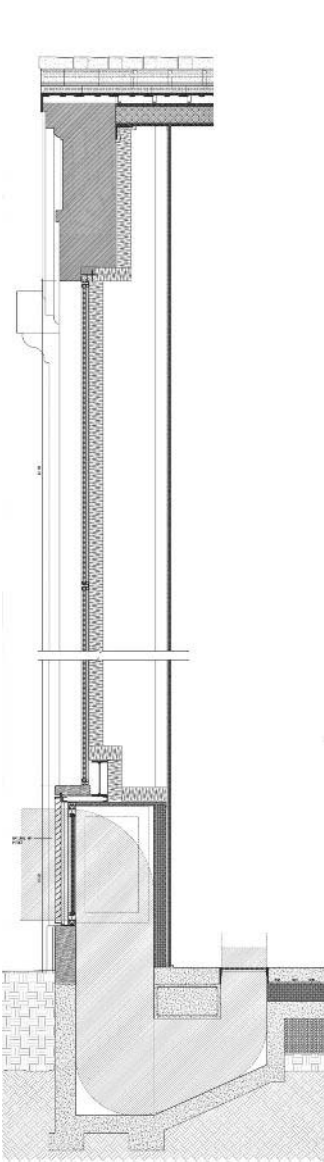
Structure in the exhibition hall Mécanique Générale

Photo: Hervé Hôte. Courtesy LUMA Foundation

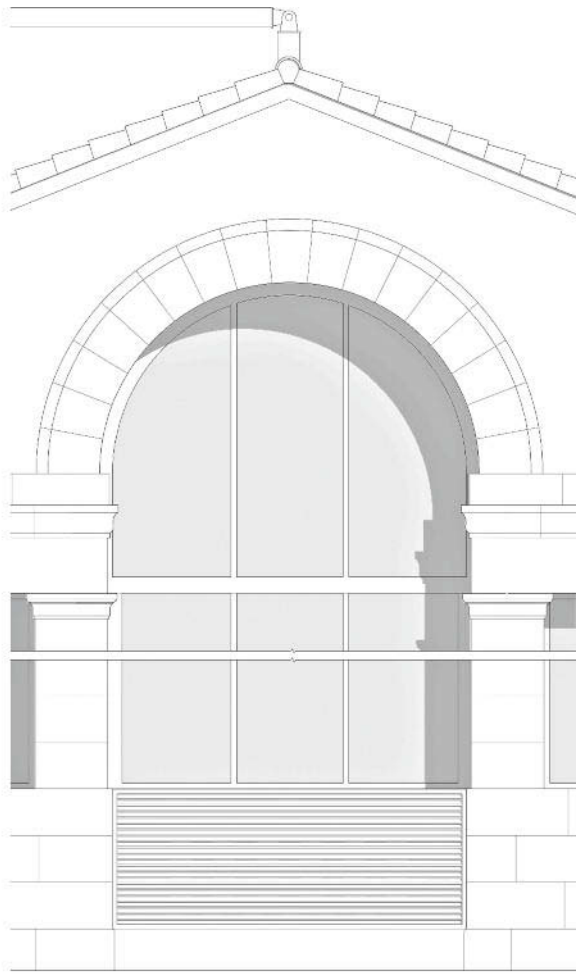


Mécanique Générale: Installation 'Systematically Open?' New forms of Lionel Roux's contemporary image production.

Photo: Courtesy of the artists and LUMA Foundation



Section and view of natural ventilation openings developed for the Mécanique Générale



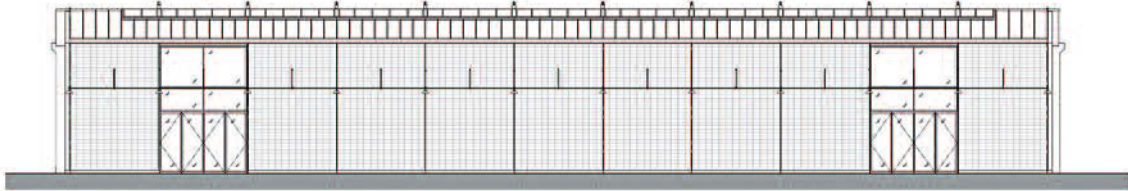
Roof > 16 m²
North elevation:
Facade openings > 8 m²



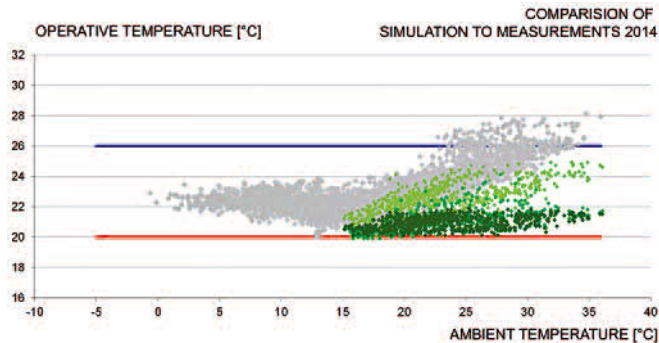
South elevation:
Facade openings > 8 m²



West elevation:
No facade openings for natural ventilation



Location and size of openings for natural ventilation in the Mécanique Générale



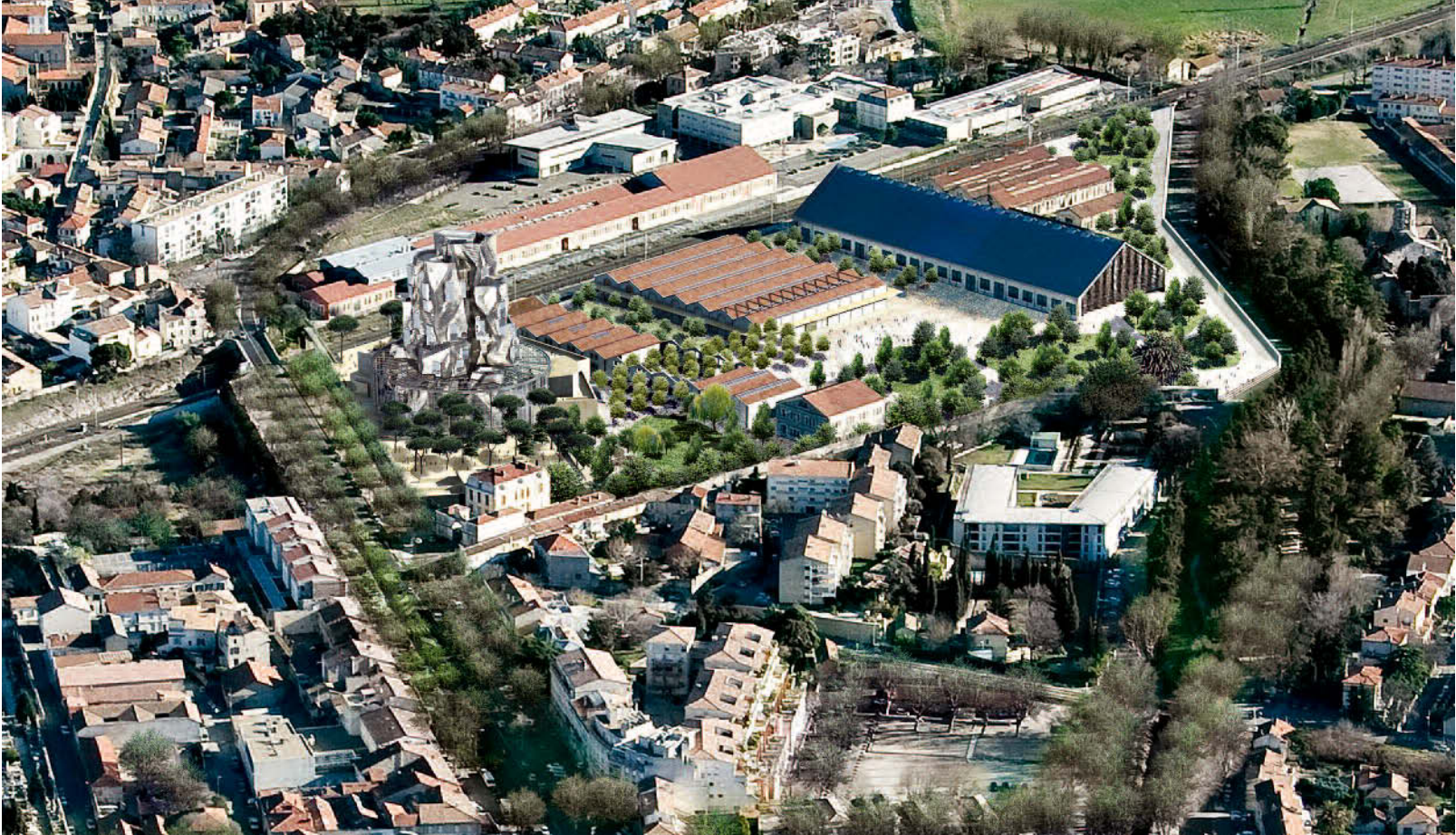
Simulation and measured temperatures for Les Forges in summer 2014

Both measurements and user feedback have confirmed that the concept is functional and supported the implementation of the same concept - natural ventilation with floor activation - at the Mécanique Générale.

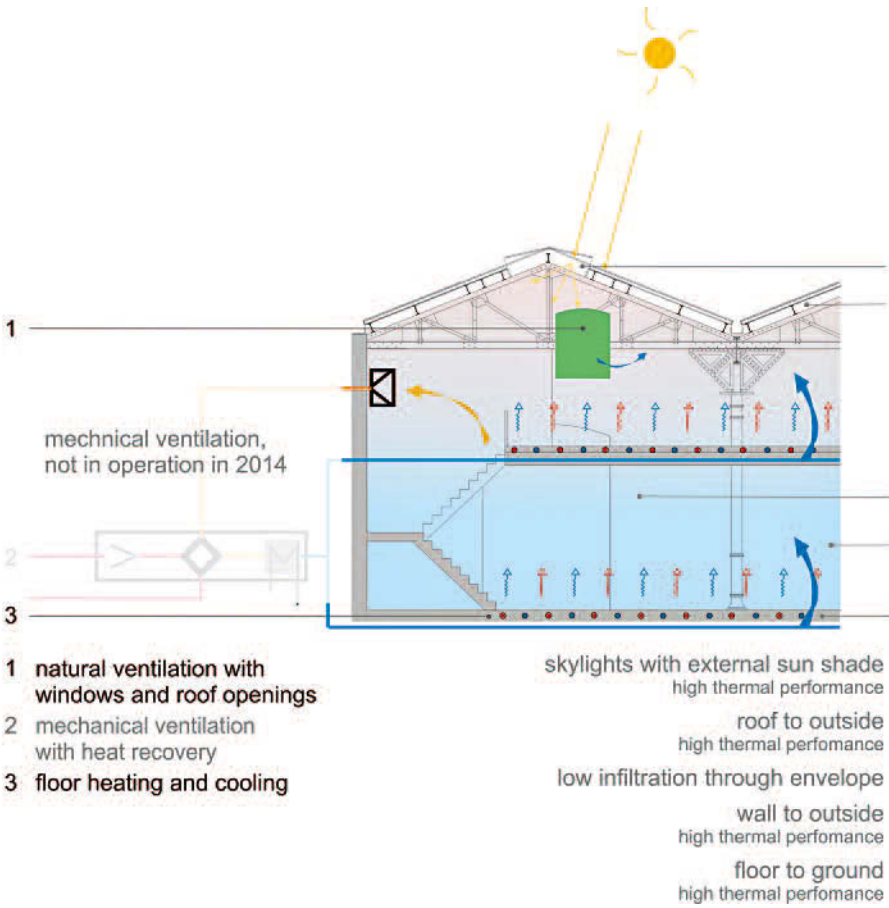
Experiences at the Mécanique Générale during 2016 operation The opening of the Mécanique Générale was in the summer of 2016. For design reasons, the activated floor was temporarily covered by wooden panels several centimeters thick. Despite the resulting reduced performance, thermal comfort - even at the opening event with a high number of visitors - was very good.

Experience in the operation of both buildings has shown that a context sensitive and sustainable climate concept based on a passive optimized building envelope, natural ventilation and floor activation can achieve satisfactory conditions for the exhibition of art and an excellent level of user comfort.

Katrin Müllner and Wolfgang Kessling, Transsolar, Munich



Animated aerial view of the entire complex with the 'Gehry Tower'



Comfort and climate concept in summer 2014 for Les Forges

LUMA ARLES Renovation and new construction
Date: 2014-2018
Luma Arles is a new contemporary art center that brings together artists, researchers, and creators from every field to collaborate on multi-disciplinary works and exhibitions. Located south of Arles' historic city center, the project repurposes the industrial ruins of a 16-acre rail depot and introduces a new public park. Selldorf Architects is part of a core team of designers including Frank Gehry and Bas Smets working on the complex. In addition to contributing to the overall master plan, Selldorf Architects is designing the renovation and conversion of two former rail structures into new exhibition facilities. The project balances the original 19th century industrial vocabulary with the Center's new contemporary purpose. The original structures were maintained while creating a new balance of indoor and outdoor spaces. Steel columns and trusses are refinished and skylights relocated and expanded, all in service of creating well-proportioned spaces with natural light and clear circulation. A new open-air courtyard includes a café and will be a communal gathering space for presentations and concerts. Les Forges, the original foundry building, contains two levels of gallery space totaling 31,500 sf. The restored Mécanique Générale is a 48,000 sf structure containing exhibition space and artist workshops. A new bay creates a 65' column-free span in the historic space. The modern addition's exposed steel frame, concrete façade, and zinc roof create a resonant contrast with the existing structure.

SELLDORF ARCHITECTS