TOWARD AN INNOVATIVE TEMPORARY EVENT STRUCTURE BASED ON BIOCLIMATIC PRINCIPLES

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ABSTRACT

In the context of temporary events, the use of structural systems suitable for short-term use is a key strategy in terms of organization. However, this type of ephemeral structure currently requires the implementation of significant resources, for which the characteristics of flexibility and economic efficiency most often prevail over considerations related to sustainability.

This lack of sustainability exists due to several attributes of a temporary building. Firstly, the distance between the place of storage and the one of use requires transportation, which can sometimes represent a significant share of consumption and environmental impacts. Furthermore, heat energy required to achieve an acceptable level of indoor comfort in a building with little or no thermal isolation is disproportionate to the short time of use. Finally, the materials used, in most cases, have a significant life cycle in terms of embodied energy required for their manufacture and respectively their disposal. However, many parameters are not as yet subject to specific studies. Contributing to remedy this lack, the present paper aims to evaluate the environmental impacts and lack of performances of current temporary event structures. In order to compare them with the expected performances of an alternative proposition –the On STAGE Project-, which refers to architectural quality and high level of comfort with an optimal use of resources and a minimization of environmental impacts.

Firstly, a detailed analysis of a typical ephemeral structure system is presented, through an assessment process, that takes into account not only environmental criteria calculated on the whole life cycle, Non Renewable Energy (NRE) and Global Warming Potential (GWP), but also the thermal and acoustic comfort. Then the set of results will be compared to the simulated values for On STAGE Project, and show that it is possible, through an integrated design process based on the principles of bioclimatic architecture and the use of renewable energy sources, to design a temporary structure capable of high level of comfort, preserving resources and reducing environmental impacts, in order to meet sustainability goals, even in the case of a short lifespan.

INTRODUCTION

In consideration of the especially significant number of cultural manifestations (festivals, shows, exhibitions, commercial, trade fairs, fairs, exchanges), sportive or political festivals, where the assembly of temporary structures is necessary, a tangible need regarding the material is manifested. Nevertheless, the consultation of all regional, national or international agendas, which appear on the media, induces an impression of the real growth in the event branch. The specific analysis, as measured by a country like Switzerland, shows this importance: the revenues generated by the event industry have increased regularly since 2003 by 6% per year (DESILVA, 2008). Furthermore, it is noted that the International Organization for Standardization (ISO) has published a new standard for organizers of events in order to increase integration of sustainability into their activities (ISO, 2012). This standard emphasizes in particular the need for certain temporary event constructions, thus avoiding oversized infrastructures in relation to actual needs once the event happened.

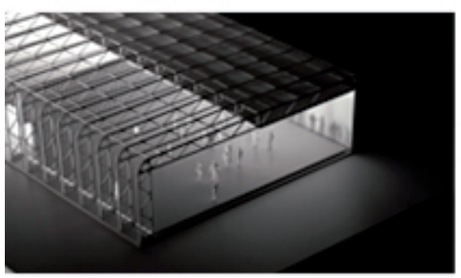
These figures highlight the interest in the planification of a sustainable alternative, which is characterized by a strong development potential, and therefore which should be designed in a sustainable way. Not only in terms of flexibility and speed of erection but also in term of inner comfort, thermal and acoustic performances, from architectural aesthetics point of view, or regarding gray energy needed for manufacture, use and transport and their environmental impacts. To do so this article observes, through a multi criteria evaluation of sustainability parameters, a typical structure system, representative of current practice. An useful assessment in order and set out the specific objectives for planning an alternative: the "OnSTAGE project" and compare it to the current practice. The “OnSTAGE project” is currently under development through a process of integrated design, that will provide a reliable base for the realization of an operational prototype by optimizing iteratively different dimensions of the project (APPLEBY 2011).

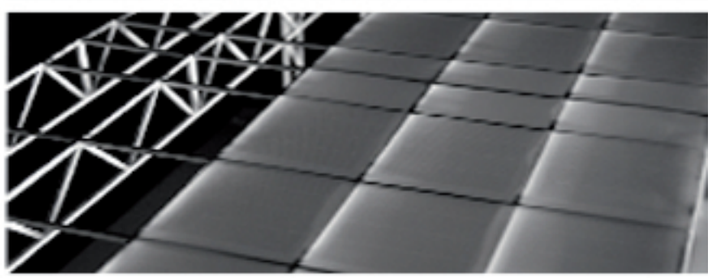
LIMITS OF THE COMMON PRACTICE

In order to comprehend more precisely the advantages and the disadvantages of the usual practice, a case study has been conducted on a representative model of this kind of temporary structure. A tent of classical fabrication had been specifically chosen, which harboured the main stage at the Cully Jazz Festival (Switzerland), destined for about 1000 viewers. This case study took place in April 2011. The results of these analyses are summarized below.

Thermal comfort

To assess the climate inside more precisely, four data loggers had been place inside and outside the tent during this one-week festival. The results clearly highlight typical characteristics of light construction. The fact that the tent hasn't any insulation or thermal sealing, made it very susceptible for the different temperatures outside, but especially for the influences of the direct solar radiation. Indeed the important variation of the monitored temperatures, at the beginning of the afternoon, on a sunny day and on a very cloudy day expresses the strong dependence of the inner climate on the direct solar radiation. A second peak in inner temperature had been registered at the end of the evening of the concert. The presence of one thousand viewers represents a huge energy input inside and may not be neglected and it is recommended to consider the users (viewers, musicians and technicians) in the objective for the improvement of the thermal comfort. These two major factors influencing the climate inside, which are the direct solar radiation and the internal heat gains, are furthermore not controllable by the operators. In case of the analyzed construction it remains difficult to compensate the climatic variations inside and however reach satisfactory thermal comfort (LAST et al. 2011).





Acoustic comfort

The acoustic comfort and emissions sound to the neighborhood is also influenced by the light construction. To evaluate the acoustic quality inside, the times of reverberation had been measured during a concert. The results indicate that it is possible to stay within the optimum area for jazz, but with one time measuring around the limits for the bass frequencies as a consequence of the light construction of the model. An optimisation of the model with big awnings made of cloth tensed across the ceiling of the tent, contributes to improve the periods of reverberation in order to reach a satisfactory level for the jazz. (LAST et al., 2011). During the analysis, a noise pollution had been detected in case of strong wind, resulting from the movement of the construction and the ceilings. This annoying noise is the result of the fact that cloth skin is not put under tension and therefore can float in the wind. This kind of repetitive noises can be really disturbant for spectators and musicians, especially when the sound volume of the concert is low. One last aspect is concerning the sound emissions outwards and inwards, that are very important and generate significant noise coming from inside for the neighborhood and coming from outside for spectators. However measured values on different positions in the neighbourhood are far above the legal limits. Even if this type of ephemeral use often benefits from a certain tolerance on the part of the neighborhood, a level that is so high reduces possibilities of implementation on certain sites (LAST et al. 2011).

Consumption of non-renewable energy (NRE) and environmental impacts (GWP)

Another aspect that is revealed by the assessment of current practice limits considering criteria of sustainability is the environmental impact of materials choices. Indeed the necessary grey-energy isn't subject to special verifications, especially regarding the influences on the environment. For example in this case study, aluminium is the main material used for the structure, as it offers interesting characteristics of lightness and hardiness, but it although requests a lot of energy during its production. As illustrate on figure 4, it represent until 63% of non-renewable energy (NRE) and 51% of global warming potential (GWP). In this way a better planning regarding the material use could optimize this aspect. Another environmental impact revealed by this assessment is the huge energy consumption required to heating system. To reach an acceptable inner climate during cooler periods, it is necessary to compensate the thermal losses of the casing of the tent by using temporary heating oil devices, whom energy is quickly dispersed due to the light construction (FUMEAUX and REY 2012)

TARGETED OBJECTIVES FOR THE "ONSTAGE PROJECT"

Regarding the analysis and the significant points mentioned above, the following targeted objectives are formulated:

1. Flexibility is the first objective. The project has to be able to offer adequate advantages for the current practice. Constructive modalities by elements offer an important level of modularity in term of size and comfort of the structure.
2. Comfort optimization of the planned structure must permit the users the optimal management of the thermal and acoustic comfort. The objective is to keep the inner climate in a comfortable zone, which is the same condition as outside and the occupancy rate (ROULET 2010).
3. For an optimal use of resources the project will include architectural bioclimatic principles, especially regarding the thermal insulation, protection from the sun, natural ventilation and passive refection, which allow the reduction of its energetic demand (warmth and cold) and the prior valorisation of resources that are locally disposable (AIULFI and REY 2010)
4. The project aims at establishing a basis of a concept of efficient economic exploitation of the structure. By rationalizing the process, the project has to reach an economic feasibility for the operator. The project aims at establishing bases of a financially balanced concept, regarding its lifecycle including an optimization of production costs and exploitation (REY and RYTER 2003)
5. The concept and the realization of the new infrastructure, likewise temporary and permanent, will include a special care for the architectural expression. The system will be well conceived in a way that it will contribute to the expression of a spatial coherence and offer a harmonic integration of the object in the different contexts where it will finally take place.

FROM A CONCEPTUAL VISION TO AN OPERATIONAL PROTOTYPE

Subsequent to the definition of the objectives of the project, a conceptual vision has been developed in order to set the basis of the constructive system and to specify the components that have to be developed in detail regarding the specific objectives mentioned. This conceptual vision is the basis of integrated design in the course of which the interdisciplinary competences of the different partners of the project (civil engineers, experts for thermal and acoustic, carpenters, specialists for photovoltaic and operators) have to optimize the conceptual vision.

Bioclimatic strategies and reduction of energy demand

The scheme of figure 1 shows the planned principle for the management of overheating situation at daytime. To avoid overheating, the conceptual vision includes architectural bioclimatic principles. A passive strategy which is based on the given space between the two layers of the casing, which is used as a sealed space that helps to deflect warm air by providing a tempered layer, which contributes to the thermal insulation for inside temperature's stability even in cooler periods. After reducing the needs of energy through bioclimatics strategies, the project implements a concept of comfort ventilation with heat recovery, coupled to a battery (hot-cold) powered by an air heat pump. A device tested in the field of sustainable buildings, but which apperars as a pionner experience in the field of temporary constructions. Finally, photovoltaic panels integrated into the roof structure (rigid / flexible technologies) provide renewable source of electricity.

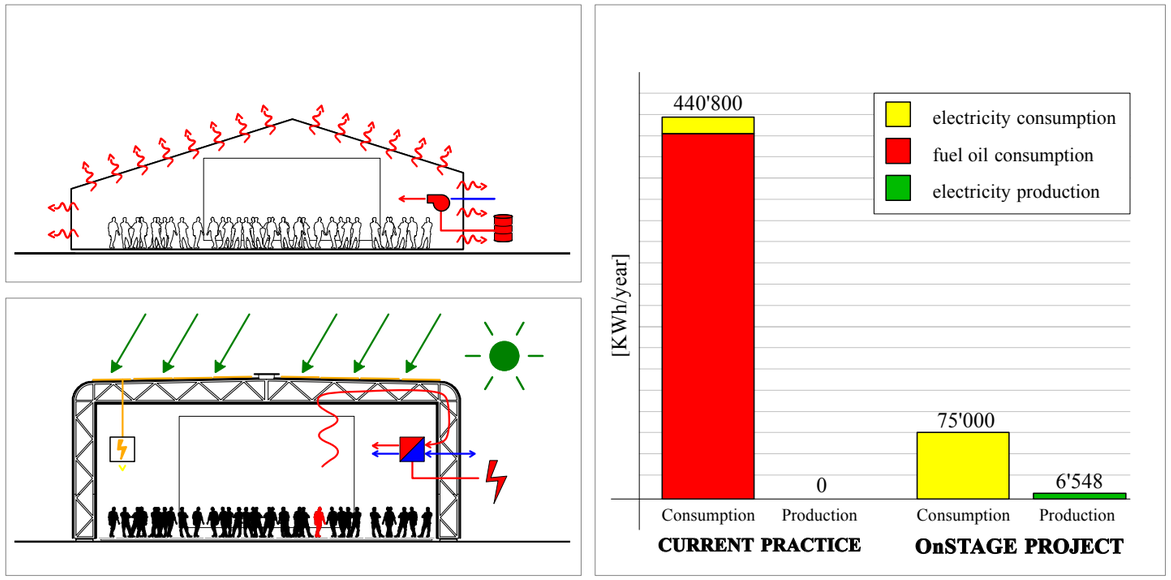


Figure 1 Comparison of energy consumed and produced (final energy) for annual use (100 days per year) for the conventional device and the project "On STAGE".

Inner acoustic quality and noise transmission

Regarding the acoustic and as illustrates on figure 2, the additional mass that is filled inside the acoustic panels will help to control the acoustic of the room better, especially in term of low frequencies. The double side acoustic panels (smooth and absorbent) avoid flexible inside skin configuration for an optimal acoustic diffusion according to size and need of use. For the reduction of the noise toward outside and inside the project proposes to add an acoustic skin of 10 kilograms per square meters to reduce sound emissions towards the envelopp up to 25 dB. It may therefore benefit from a certain tolerance from the neighbourhood, and increase opportunities for implementation on most sites.

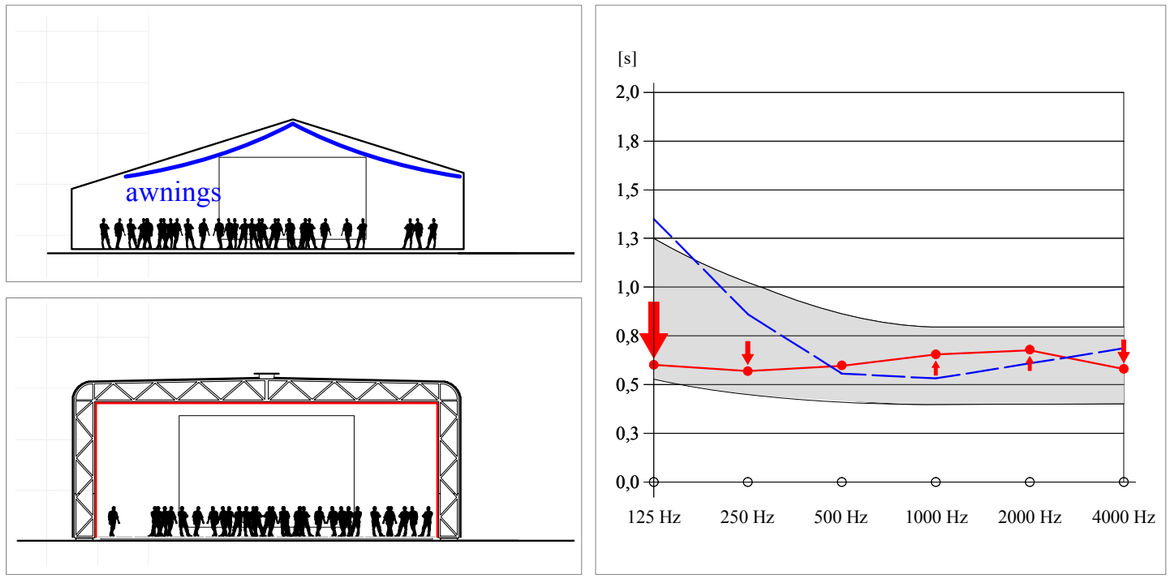


Figure 2 Comparison between current practice and the project "OnSTAGE". The additional mass that is filled inside the acoustic panels will help to control the acoustic of the room better. The double side (smooth and absorbent) acoustic panels allow the flexibility to optimise the acoustic quality of the concert hall.

Reduction of non-renewable energy and environmental impacts

Along with these measures at the operating energy demonstration project "On STAGE" is also characterized by a significant reduction in embodied energy and emissions of carbon dioxide. A guidance and estimated the graph shown in Figure 7 shows a comparison of the overall balance in terms of non-renewable primary energy (NRE), and CO2 equivalent emissions (GWP). Reduction between the conventional system and the demonstration project "On STAGE" is of the order of 60% for primary non-renewable energy (NRE) and 40 % for CO2 equivalent emissions (GWP) (FUMEAUX and REY 2012).

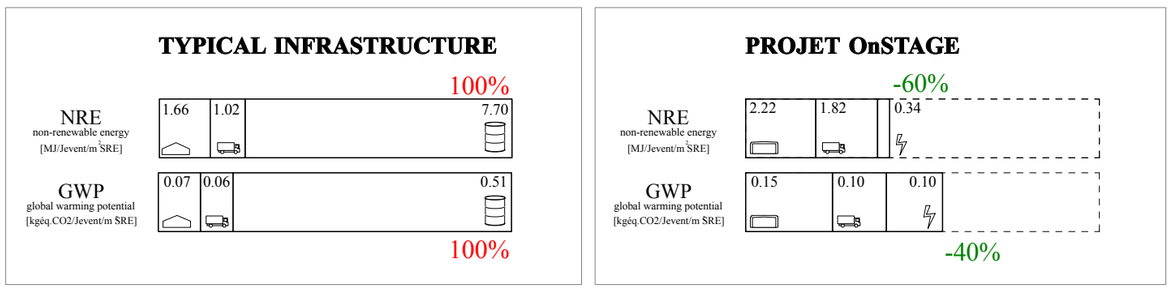
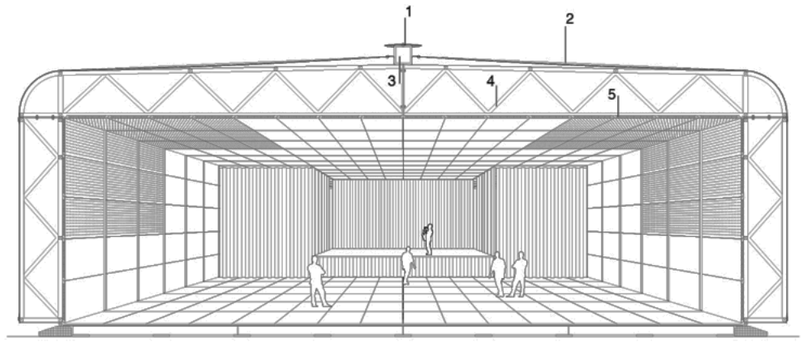


Figure 3 Comparing the estimated overall record non-renewable primary energy terms (NRE) and CO2 equivalent emissions (GWP) for the conventional device and the project "On STAGE".

CONSTRUCTIVE APPROACH

As shown in figure 4 below, the structure is composed triangulated frames, compounds of wooden elements, prefabricated in factory and assembled on site (ERNE Holzbau AG et al., 2013). On this structure are fixed, an inner casing of wooden panels and an outer casing made of PVC membrane. The modularity of the project is based on a small number of pieces, which can be combined for different sizes with variables of quality level. The project "On STAGE" so offers a dual flexibility.



PROSPECTS

Following this integrated design process it is possible to dispose of an operational prototype, for which feasibility is verified and demonstrated. The next phase of the project is to go deep each element imagined conceptual and technical level to achieve complete constructive study, to establish prefabrication plans and finally to build the structure. With these complementary steps, this integrated design process will lead to the realization of the first sustainable alternative for ephemeral event structures.

In the field of event-structures and linked profesionnal constructors, the project appears as a breakthrough achievement that offers a real alternative to the current practice. By the way, such a realization has some interest and should thus contribute to the evolution of common practices. The project "On STAGE" will have also impact the general public and the awareness of energy issues. Indeed, the project will be the main area of concerts for the next editions of Cully Jazz Festival, an annual event that hold on a history of over thirty years, on an established international reputation and on a public of about 50,000 visitors per edition. The project "On STAGE" and the results obtained in terms of reduction of environmental impacts will be integrated into the future communication strategy of the festival.

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