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Smart infrastructure and green mobility: the new paradigms of global sporting events.

Smart infrastructure and green mobility: the new paradigms of global sporting events
Smart infrastructure and green mobility: new paradigms for global sporting events

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Summary

The engineering of mega sporting events has evolved from an operational approach to a systemic, sustainability-oriented model, in which fleet decarbonization and the circular economy in overlay infrastructures play a central role. This transformation integrates technological innovation, efficient resource management, and strategies for reducing environmental impacts, consolidating mega-events as platforms for experimenting with sustainable solutions on a large scale.

Keywords: mega-events, decarbonization, sustainable fleets, circular economy, temporary infrastructure, logistics engineering, sustainability, overlay.

Introduction

The organization of mega international sporting events, such as the Olympic Games and World Cups.

The world has historically established itself as a strategic field of innovation in engineering.

Logistics and urban planning. Over the last few decades, a transition has been observed.

progressive operational models focused exclusively on efficiency and delivery.

functional for more complex approaches, driven by environmental performance, by

Systemic resilience and resource optimization. In this context, sustainability has ceased to be...

It went from occupying a peripheral position to assuming a structuring role, influencing

directly influencing the design, execution, and legacy decisions of the interventions.

This paradigm shift reflects the incorporation of more technical and scientific criteria.

rigorous, aligned with global decarbonization and sustainable development agendas. A

The engineering of mega-events thus begins to operate under an integrated logic, in which aspects

Environmental, energy, and logistical aspects are considered simultaneously and in a way...

interdependent. The result is the consolidation of more efficient and adaptable solutions, capable

to respond to the growing demands for impact reduction and value maximization.

generated.

In this scenario, two critical domains stand out that synthesize this evolution: the

large-scale decarbonization of transport fleets and the adoption of economic principles

circulating in temporary overlay infrastructures. Both represent strategic vectors of

transformation, requiring the convergence between technological innovation and advanced management of

resources. In this way, contemporary mega-events begin to act not only as

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complex logistical operations, but also as platforms for experimentation and dissemination.
of sustainable solutions on a global scale.

1. Decarbonization of Large-Scale Fleets in Olympic Areas

Decarbonizing fleets at mega-events represents a paradigm shift in
Applied transportation engineering. Traditionally, operational priority fell on the
Reliability and redundancy are prioritized, with little regard for emissions. However, the growing
Regulatory and social pressure to reduce carbon emissions has driven the adoption of
Zero-emission vehicles (ZEVs), especially from the 2010s onwards. This transition requires
not only technological replacement, but also a complete reconfiguration of systems
Logistics.

From an operational point of view, the scale and complexity of the Olympic perimeters impose...
Significant challenges. The simultaneous management of thousands of vehicles, with multiple profiles of
Mission and priority levels require highly integrated systems. The introduction of ZEVs
introduces critical variables, such as limited autonomy and the need for frequent recharging, which
They directly impact route planning, asset allocation, and level assurance.
service elevators.

The supporting infrastructure constitutes another critical vector of this transformation. The deployment of
Fast charging networks in temporary environments require electrical engineering.
robust, capable of handling peak demand and local network constraints. Furthermore, the
The integration of energy management systems (EMS) and fleet management systems (FMS) becomes essential.
to optimize the use of resources, allowing for real-time monitoring and decision-making.
data-driven decision.

Finally, the life cycle analysis of vehicles and the associated energy matrix reveals that...
Effective decarbonization depends on a systemic approach. Eliminating emissions alone is not enough.
local; it is necessary to consider the production of the vehicles, the origin of the electricity used and the
final disposal of critical components, such as batteries. Thus, fleet engineering in
Mega-events are now incorporating advanced environmental assessment tools and strategies.
Risk mitigation, establishing a new standard for operational sustainability.

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2. Circular Economy in Overlay Infrastructure

The overlay infrastructure, composed of temporary structures essential to the operation of Mega-events have historically followed a linear model of production, use, and disposal. The paradigm, while efficient in terms of speed of implementation, has proven unsustainable. from an environmental and economic perspective. Starting in the 2010s, a transition can be observed towards Circular models, in which reuse and waste reduction become central objectives. of the engineering process.

This conceptual evolution implied a profound change in the design phase. The adoption of Principles such as Design for Disassembly (DfD) and modularity allow structures to be disassembled and reused with minimal loss of value. The selection of materials also underwent taking into account recyclability and durability criteria, favoring solutions such as systems Modular steel and engineered wood structures. In this way, the overlay ceases to be an asset. ephemeral and becomes integrated into broader production cycles.

The dismantling and redistribution of assets is one of the biggest challenges. operational aspects of the circular economy. Unlike the linear model, in which the focus is on During installation and use, the circular approach requires detailed post-event planning. includes reverse logistics, temporary storage, transportation, and identification of new uses for components, whether in other events or in permanent applications.

Additionally, the implementation of the circular economy demands innovation in business models. business and contracting mechanisms. Replacing the acquisition logic with models Leasing and service-based models allow suppliers to retain responsibility for asset lifecycle. This approach encourages efficiency and innovation at the same time. which reduces costs and environmental impacts, consolidating a new dynamic in the value chain. of mega-events.

3. Conceptual Evolution

The evolution of the circular economy applied to mega-events can be understood as a progressive process of technical, regulatory and cultural maturation in engineering of temporary infrastructure. Initially, the events were designed according to a logic strictly linear, in which the main objective was to meet operational demands. within tight deadlines and with cost control. In this context, sustainability was

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marginal or non-existent, and overlay structures were treated as disposable assets, with little concern regarding their fate after the event.

The so-called linear phase, predominant until the early 2000s, was characterized by Maximizing deployment efficiency, often at the expense of performance. environmental. Engineering prioritized quick solutions, easy to assemble, but with low Durability and limited reuse possibilities. As a consequence, large volumes Waste was generated at the end of the events, resulting in significant environmental impacts. and in additional costs associated with the final disposal of the materials.

Starting in the 2000s, driven by regulatory advances and the growing With environmental awareness, the mitigation phase begins. During this period, the introduction of new technologies is observed. of practices aimed at reducing waste and recycling materials. Although still embedded in With a predominantly linear logic, this phase represents an important advance by incorporating Environmental criteria in planning and execution processes. Mega-events such as the Games The London 2012 and Rio 2016 Olympic Games played a significant role in this process, by establishing sustainability goals and implementing structured management programs waste.

From 2015 onwards, a new approach was consolidated, characterized by the full adoption of principles of the circular economy. This phase goes beyond mitigating impacts and proposes a Systemic reconfiguration of overlay engineering. Concepts such as Design for Disassembly. (DfD), modularity and full asset reuse are now incorporated from the phase of project, allowing the structures to be disassembled, reconfigured and reinserted into new ones. Use cycles with minimal loss of value. Circularity ceases to be a secondary objective and It then guides the entire asset lifecycle.

More recent events, such as the 2024 Paris Olympic Games, exemplify this consolidation. by setting ambitious targets for reducing emissions and maximizing the reuse of materials. In these cases, the overlay is designed as part of an integrated asset system. whose lifespan transcends the event itself. Engineering begins to operate in a predictive manner and Strategic, articulating technological innovation, circular business models, and advanced management. of resources.

Finally, this conceptual evolution reflects a broader shift in the role of mega-events in contemporary society. From punctual and resource-intensive interventions, they are becoming understood as platforms for experimentation and dissemination of sustainable practices. A In this context, the circular economy not only reduces environmental impacts but also generates...

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economic and social value, contributing to the construction of a lasting legacy aligned with
global sustainability challenges.

4. Design Engineering for Reuse

Incorporating the principles of the circular economy into the development of infrastructure.
Overlay requires a methodological reconfiguration from the project conception phase.
Unlike traditional approaches, which focus on immediate performance.
and the cost of implementation, the reuse-oriented design introduces a lifecycle perspective.
A broader perspective on life. This implies considering, from the outset, not only functionality during the
the event, but also the possibilities for dismantling, reconfiguring, and reintegrating the assets.
in new operational contexts.
In this scenario, modularity emerges as one of the fundamental pillars of engineering.
Design focused on reuse. Standardization of components and adoption of systems.
Modular construction allows for greater operational flexibility, reducing construction time.
Assembly and disassembly, minimizing material waste. Structures designed under this principle.
In principle, they can be easily adapted to different spatial and functional configurations.
expanding its potential for reuse in multiple events or applications
permanent.
Another critical factor relates to the selection and specification of materials, which are now being guided...
based on sustainability and circularity criteria. The use of recyclable, reusable or...
with low environmental impact, such as modular structural steel, aluminum and engineered wood,
This contributes to reducing emissions throughout the asset lifecycle. Furthermore, durability...
The strength of these materials is a determining factor in ensuring their integrity over time.
Multiple usage cycles reduce the need for replacement and disposal.
Finally, asset traceability becomes a central element in reuse engineering.
The adoption of advanced digital systems, integrated with asset management platforms, allows for...
Continuous monitoring of the condition, location, and usage history of each component.
This approach enables efficient reverse logistics strategies and facilitates decision-making.
in the post-event phase and consolidates the transition from temporary structures engineering to a model
Focused on the intelligent and sustainable management of resources.

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5. Dismantling and Redistribution Logistics

The phase of dismantling and redistributing overlay assets is one of the most critical moments. In the operationalization of the circular economy in mega-events. Traditionally underestimated. In the planning phase, this stage requires the same level of technical rigor and detail. applied to the initial assembly. The complexity lies in the need to preserve integrity. of the components, ensuring that they can be reused without compromising performance. structural or functional.

The sequencing of the disassembly is a central aspect of this process. The definition of a structured logic of demobilization, based on the interdependencies between the elements Construction planning is essential to avoid physical damage and material loss. This planning should... consider not only technical aspects, but also logistical constraints, such as accessibility, availability of equipment, and synchronization with other activities of Event deactivation.

Furthermore, the logistics of transporting and temporarily storing assets require solutions. efficient and integrated. The movement of large volumes of materials, often in Shorter timelines require coordination systems that minimize costs and environmental impacts. Storage, in turn, must ensure adequate preservation conditions, avoiding Degradation of components and ensuring their readiness for future reuse.

Identifying and enabling final destinations for the assets represents the final step. from this cycle. Strategies such as reuse in other events, commercialization, donation to projects. social projects or their incorporation into permanent infrastructure depend on prior planning and Collaboration with multiple stakeholders. In this context, the use of digital technologies, such as BIM, is crucial. (Building Information Modeling) and integrated asset management systems, becomes indispensable for providing traceability, transparency and efficiency at all stages of process.

6. Convergence between Decarbonization and Circular Economy

The convergence between fleet decarbonization and the circular economy in infrastructure. This represents a natural evolution in mega-event engineering. These two axes, although Although distinct in their technical nature, they share common goals related to efficiency in resource use, emissions reduction, and legacy maximization. The integration of these These approaches allow for the development of more robust and sustainable solutions.

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An example of this convergence can be seen in the reuse of supporting infrastructure.
to mobility, such as electric charging stations. Designed according to circular principles, these
Structures can be dismantled and relocated after the event, integrating into urban networks.
permanent. Similarly, the vehicles used during the event may be incorporated.
to public transportation systems or corporate fleets, increasing the return on investment.
investment.

From a systems perspective, this integration requires the use of advanced tools.
planning and simulation, such as digital twins and integrated systems modeling. These
Technologies enable the evaluation of complex scenarios, the identification of synergies, and the optimization of decisions.
throughout the entire asset lifecycle. Engineering thus begins to operate according to a logic
Predictive and adaptive, aligned with the principles of sustainability.
In terms of legacy, the convergence between decarbonization and the circular economy transforms the
Mega-events as catalysts for innovation. Solutions developed to meet the demands.
Specific aspects of these events can be replicated in urban and industrial contexts, contributing
for the global transition towards low-carbon economies. In this way, mega-events leave
They are no longer temporary interventions and are now playing a strategic role in transformation.
Sustainable cities and infrastructure.

Final Considerations

The historical evolution of mega-event engineering reveals increasing technical sophistication and
An expansion of the scope of responsibilities. The decarbonization of fleets on a large scale and
Implementing the circular economy in temporary infrastructure presents not only challenges.
operational, but also strategic opportunities to redefine global standards of
sustainability.

From a scientific point of view, these topics require interdisciplinary approaches that combine
Transportation engineering, materials science, energy management, and environmental economics. From
From a practical standpoint, they require continuous innovation, collaboration between multiple stakeholders, and
Adaptability to complex and dynamic contexts.
Ultimately, the mega-events of the 21st century cease to be merely sporting spectacles.
to become platforms for experimentation and dissemination of sustainable solutions on a large scale.
scale, with impacts that transcend the time and space of the event itself.

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