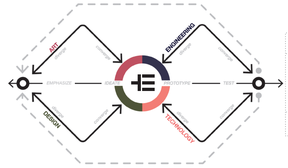
Artee

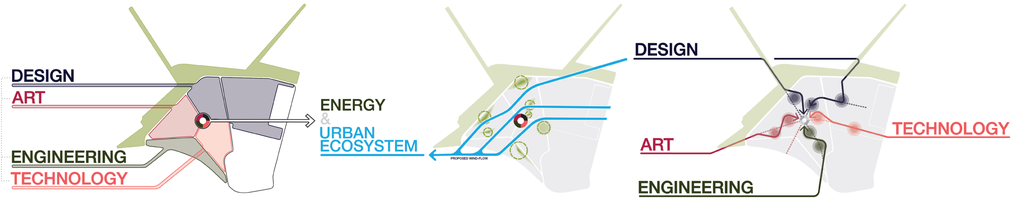
A holistic design approach incorporating the recognition of piezoelectric and daylight as a “renewable energy source” is crucial for our design proposal since it empowers an ecological perspective, architectural and engineering creativity, and last but not least social interaction. **Artee** aims to integrate art, design, engineering and technology concepts through architecture as well as to provide a solution that can enhance UN’s sustainable & liveable goals. The primary idea demonstrates a high-performance adaptive kinetic solar pavilion, sun-tracking solar thin-film towers and piezoelectric installations to optimize efficiency and power output and actively engage the community with physical activity and active living in urban environments.

The proposed design concept supports several of the UN sustainability goals. Clearly, “Affordable and Clean Energy” is supported as the energy produced is clean and can be used directly for the surrounding buildings (goal 7). Further, the novel adaptive kinetic solar pavilion and the sun-tracking solar thin-film towers can be extended to many sectors of the built environment (goal no. 8 – Decent Work and Economic Growth). The proposed ultra-light structures of the pavilion and the towers have a high grade of prefabrication which supports the decrease of labour-intensive work. The proposed innovative systems introduce materials and technologies that are used, for example, in robotics or mechanical engineering, advancing scientific research and improving the technological capabilities of industrial sectors (goal no. 9 – Industry, Innovation, and Infrastructure). The design proposal offers a self-sufficient solution that can weave renewable energy into our built environment using existing clean energy technologies - piezoelectric and solar - leading to a paradigm shift in how we design our built environments (goal no. 11 – Sustainable Cities and Communities).

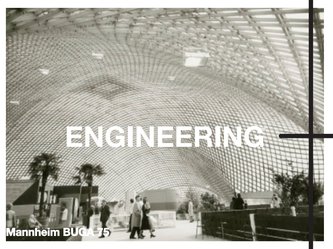
Mannheim Wind Strategy



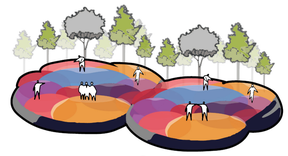
Concept & Competition Framework



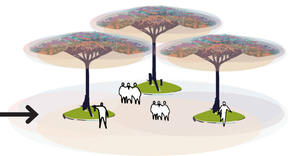
BUGA 75 - Concepts & Technological Framework



CONCEPTUAL TRANSFORMATION



DESIGN



ENGINEERING

ART

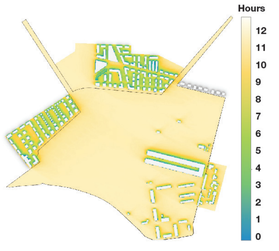
The design proposal aims to shape green energy production units in aesthetic ways at the intersection of art, design, engineering, and technology. Adaptive ultra-light kinetic structures and piezoelectric installations have been proposed on a residential and public scale to strengthen the relationship between community and green energy while at the same time optimising their energy efficiency according to the sun’s position. Organic solar thin-films were used due to their low environmental impact, flexibility, low production cost, and optimum energy efficiency.

With an adaptive pavilion placed at the crossing of the pathways, an open shelter for people to interact and exchange is set. The pavilion is covered with organic solar thin-film and, due to a pneumatical regulation, it is able to transform its shape to maximise the solar energy gain over the day and year. Its organic shape and material are remembered in the Multihalle, built for the BUGA 1975 in Mannheim.
Throughout the park, sun-tracking solar thin-film towers are aggregated, as shown. The tower’s pedals track the sun to maximise the solar energy gain, while at the same time, they provide shading for people. While closing, the pedals covered with organic solar thin-films form a double curved shape that increases the solar gain efficiency due to reflections of the sunbeams in between the surfaces. The sun tracking solar thin-film towers are proposed for usage in the German gardens as they work as single elements. They represent an aesthetic way of green energy production in an ultra-light and material-friendly system that can work as a single element on a residential scale, as well as be aggregated on a civic scale.
Throughout the park-side, three main zones are covered with inflated bubble-like cushions that are accessible to citizens and produce energy by their movement through a piezoelectric system. In addition, another type of piezoelectric area is created with flat and hard decks that produce energy from the vibration induced by the people. These areas can also be used for all kinds of events where highly dense people are expected (i.e. concerts, festivals, sports events, etc.) and giving chances for them to be green events while directly using the energy produced by the audience.
In order to increase the wind-induced cooling effect of the city centre, aerodynamically shaped hills are placed throughout the park, and all provided structures are openly formed. Structures like the main pavilion can create openings and decrease their size, like the sun-tracking solar thin-film towers. Furthermore, the aggregation of the hills is set not to disturb wind coming from the northeast, as they are elongated in this direction and smoothly curved to increase windspeed by decreasing the volume between the hills. It is essential to highlight that the park opens multiple opportunities to explore and redirect wind flow to the city centre by using landscape & urban design strategies.

The urban & landscape design response aims to incorporate previous proposals developed on the site. The overall design idea is based on four pillars: Design, Art, Engineering & Technology. These four pillars seek to develop, integrate and enhance the potential of design into sustainable and resilient strategies that can be applied in a large-scale environment. The new design for the park is divided into these four pillars that incorporate different technologies such as Tensairity, Flexible Solar Cells and Piezoelectric. These technologies have been developed in the form of single modules that complement the overall design and into a main central structure. The main pavilion enables the park to host more significant events by taking advantage of the rapid assembly and disassembly process applicable to this pneumatic pavilion.

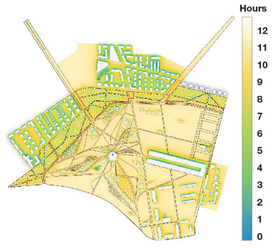
Urban Design Framework

Environmental Site Analysis



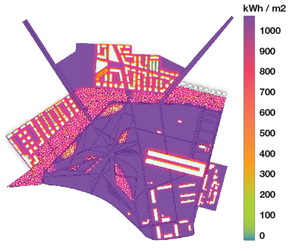
Sunlight hour - Predevelopment

Current site receives average sunlight hour of **8.77** hours.



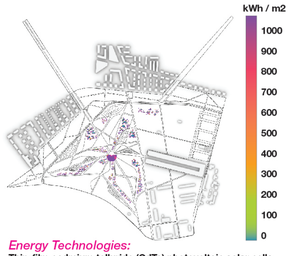
Sunlight hour - Proposed Design

Proposed design receives average sunlight hour of **7.92** hours



Incident Solar Radiation

Site receives average solar radiation load of **820** kWh/m2.

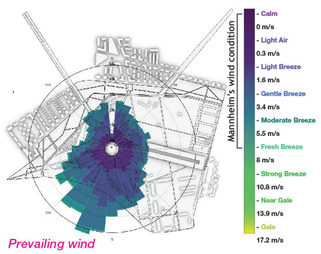


Energy Technologies:

Thin-film cadmium telluride (CdTe) photovoltaic solar cells, Crystalline silicon photovoltaic solar cells and Piezoelectricity.

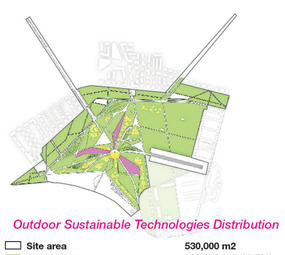
Annual Capacity:

Total estimate renewable energy capacity is **1,902** MWh.



Prevailing wind

Prevailing wind can be noticed from Southwest and Northeast during Winter, Spring and Falls. While Northwest wind occurs during summer.



Outdoor Sustainable Technologies Distribution

Site area	530,000 m2
Green area	338,000 m2 (63.7%)
Piezoelectricity	16,200 m2 (3%)
Photovoltaic umbrella roof	14,500 m2 (2.7%)
Photovoltaic pavilion roof	2,180 m2 (0.4%)

Environmental Performance and Optimization

Regarding material use, the approach was driven by the two factors of using less material and using low-impact material. For that reason, the decision for the PV panels fell to an organic solar thin-films. These solar thin-films use organic polymers to create energy from sunlight. Its light, flexible structure and use of organic material make it the best choice for the proposed concept regarding environmental impact. Moreover, with a conversion efficiency of up to 16%, it can outperform conventional PV over time due to the light situation.

Using as little material as possible led the design to pneumatic structures fabricated out of membrane material. Using air to stiffen rigid structure components is a highly efficient way of creating large spanning surfaces. Due to its minimal weight, tremendously larger spans can be reached compared to common structural materials. This saves the amount of support structure needed to carry the building’s dead weight. Nowadays, the implementation of such systems is still relatively less common due to a lack of technological knowledge and stagnating development in the building industry.

The air pressure maintanance inside inflatable structures needs to be performed only rarely. Furthermore, the air pressure adjustment consumes low energy, which decreases the energy output of the kinetic systems less significant compared to the gains achieved by tracking the sun’s position. An annual energy consumption of 21kWh was calculated, while a production capacity of 93MWh is achieved.