Energiebaum functioning as TPV collectors during the day

Energiebaum functioning as Wind turbines during low light

In a residential square

The Challenge
Renewable energy has always been the ethos of clean energy. Climate change has created not just a crisis of energy but also of clean water. Most water (more than 70%) is sourced from groundwater.

For Mannheim, already on the route to using the sustainable energy sources, the next step is creating beautiful energy generating art that not just to generate energy but also to recharge groundwater.

The Design
The design of **Energiebaum** relies on two processes.
1) Thermophotovoltiac (TPV)converts heat energy directly into electricity via photons. TPV employs photovoltaic technology but does not necessarily rely on the sun as the emitter of the photon energy. TPV converts residual heat energy that is otherwise wasted to electricity.

2) Vertical axis wind turbines VAWTs have lower cut-in speeds (the wind speed at which they begin to produce electricity). They can also be placed closer to the ground and in closer proximity to each other. Dense configurations can actually increase efficiency of the overall installation with turbines picking up wake energy from the rotations of adjacent turbines. The TPV system which works through an emitter concentrates heat energy and converts it to photons during daylight hours when atmospheric heat is high.

The TPV system which works through an emitter concentrates heat energy and converts it to photons during daylight hours when atmospheric heat is high. Water passes through the leaf-like membrane and recharges the groundwater. The leaf-like membrane closes in low heat environments and changes to a vertical axis wind turbine. Power generated is proportionate to the area of the membranes and cubic to the wind speed across them.

One **Energiebaum** generates an average of *1.052 mWh* annually at an average wind speed of 15.61kmph for fourteen hours a day.
Using TPV technology and sensors to orient the leaf blades at the optimal tilt angle the **Energiebaum** can generate an average of *5.01kwH/m2/day*.

Considering the average surface area for energy generation of one **Energiebaum**, the annual electricity generation using MTPV technology is *1.442 mWh*. This gives us a combined potential of *2.495 mWh* per Energiebaum.

Collectively 450 **Energiebaum** have the potential to generate *1,123 mWh* annually in 45 Hectares of area (at approximately 10 nos per hectare). As a visual reference during night and low light levels, the rings beneath the Energiebaum beat to the rhythm of the amount of energy generated making the setting even more dynamic. Each **Energiebaum** has a catchment of *24sq.m*. and recharges a total of *18,277 liters* of water. Collectively 450 **Energiebaum** recharge *82,24,677 liters* of water annually.

It is well established that arts boost local economies in five key ways: attracting visitors; creating jobs and developing skills; attracting and retaining businesses revitalizing places; and developing talent.

The embodied energy of a typical Energiebaum is *130GJ* or *36,111.1 kWh* for the TPV component (with no electricity storage. The energy is used or fed to the grid). The embodied energy for the vertical axis wind turbine component is approximately *3.5GJ* per *500 kWh* or approximately *7GJ* or *1000kW* per Energiebaum. Thus, total embodied energy is *37,111.1 kWh* for a lifecycle of 25 years. The total energy produced is *2,495.54 kWh* (annual energy produced by one Energiebaum x 25 years) *62,388.5 kWh*.