**Energiebaum** (energy tree)

Why is a natural form or setting beautiful? There is something both artistic and powerful in natures design. Powerful shapes and powerful landscapes both evoke strong emotional ties and can motivate participants to take action.

Trees can rarely be separated from lush green landscapes. They are unwaveringly engraved in the collective imagination. They bring beauty and grace to every setting.

Their different shapes, sizes, positions and orientations elevate any environment whether it be a street, a park a humble residence or even an informal settlement. In this role, **Energiebaum** redefines this well-known form as infrastructure which harvests the suns and immediate environments heat and utilizes the wind to power its operations. The graceful and dynamic patterns of **Energiebaum** encapsulate an attractive and recognizable form that can blend in and stand out with a tree or a group as required by the setting.

More than ever, the realities of a warming world and the need for society to take quick and substantial action should challenge the perception of energy generating structures and how they impact their surroundings. **Energiebaum** demonstrates how combining the natural environment with the advantages of sustainable energy infrastructure may have significant and positive effects on how we perceive these locations through an artistic and technological reimagining of our natural forms.

**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 generate energy but also 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. 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 **1,052.66kWh** 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 **1,442.88 kWh**. This gives us a combined potential of **2,495.54 kWh per Energiebaum.** Collectively 450 Energiebaum have the potential to generate **11,22,993 kWh** 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.** andrecharges a total of **18,277 liters** of water. Collectively 450 Energiebaum recharge **82,24,677 liters** of water annually.

**Co-benefits of the design and fulfillment of UN sustainable development goals**

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 Energiebaum acts as a point of attraction for people with its human scale and vibrant and dynamic form. It has the potential to be a new tourist attraction thus creating a reason to visit Mannheim, the city of Energiebaum’s. These structures will require maintenance to function efficiently thereby **creating local employment** and developing the skills necessary to do so by **educating the required personnel**. Due to the influx of people, **new businesses** will be created and existing ones will improve. A cluster of Energiebaum’s beautifies existing open spaces creating new pause points (meeting spaces) for local citizens. Additionally, by providing charging points with clean energy within a cluster will encourage people to use these outdoor spaces.

The **clean energy generated** by the Energiebaum’s can be a hybrid system of on and off grid thereby reducing infrastructural needs and supplying local areas as well as offloading excess energy to the grid. In health and wellbeing, a number of studies have reported findings of applied arts and cultural interventions and measured their **positive impact on specific health conditions** which include dementia, depression and Parkinson’s disease. The use of art, when delivered effectively, has the power to facilitate social interaction as well as enabling those in receipt of social care to pursue creative interests. Additionally, due to the tree-like shape of the Energiebaum they create **gender neutral** spaces and **promote inclusivity**. Additionally, raising the groundwater table by recharging it will ensure **improved water availability** for generations to come.

These Energiebaum’s can also directly charge electric vehicles enabling free clean energy for public transportation as well as private vehicles. **Access to public transport** can be improved by recharging public vehicles anywhere using clean energy. Recharging wherever required rather than refueling in yards. The new clean energy will offset numerous carbon emissions that would otherwise be required to produce energy. This will control carbon emissions and help regulate rising temperatures.

**Environmental impact summary**

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.**

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