**First Rays of Spring**

Executive Summary

Technology Used

Hybrid of piezoelectric-photovoltaic material – Generates annual capacity of 125 MWh

Photovoltaic Cells with a dyed face glass – Generates annual capacity of 2000 MWh

**Total annual capacity of 2125MWh**.

Public activities and Social co-benefits

* Children play area with sand pit and use of filtered rainwater.
* Sheltered seating
* Art walk from the old train track
* Outdoor stage for multiuse
* Green-Blue infrastructure for environmental and social benefit

UN Sustainability Goals Advanced

**Goal 3** - Ensure healthy lives and promote well-being for all at all ages

**Goal 7** - Ensure access to affordable, reliable, sustainable and modern energy for all

**Goal 11** - Make cities and human settlements inclusive, safe, resilient and sustainable

**Goal 12** - Ensure sustainable consumption and production patterns

**Goal 15** - Protect, restore and promote sustainable use of terrestrial ecosystems,

sustainably manage forests, combat desertification, and halt and reverse land

degradation and halt biodiversity loss

Environmental Impact Summary

Piezoelectric materials commonly have negative environmental impacts for its emissions and toxic chemical usages. The piezoelectric material in this design is the organic polymer, polyvinylidene fluoride (PVDF). It has beneficial properties such as being biodegradable and non-toxic. This polymer is also suited for the outdoor environment, being durable and has a high dielectric strength ensuring longevity and efficiency. It’s processing and biocompatibility makes it a suitable option as a piezoelectric material. In addition, semiconducting polymers can be used as an organic photovoltaic material meaning it is fully degradable. (Vatansever, et al., 2012)

Photovoltaic productions also involve hazardous contaminants which pollute air and water supply. There are further emissions for the energy required for production. Despite this, it is much less damaging than common fossil fuels. Nevertheless, this design mitigates environmental impacts through the ability of supporting larger vegetation cover and thereby biodiversity, which is long-term beneficial to the natural ecosystem. Other benefits include the recycling and reuse of water. The park is self-sufficient in energy while also providing for local communities.

Construction emissions for the assembling of the design include machinery usage and other construction materials for the foundation and support. However this initial impact will support a design with expected low maintenance and longevity. This design uses locally sourced materials and products to mitigate transportation emissions. Germany has a well-developed solar panel manufacturing industry. The instalment of blue and green infrastructure such as swale are further long-term benefits of the design to mitigate initial environmental impact which also provide social benefits. There will be emissions and waste produced to replace solar panels every 30 years. However, energy production and benefit to the environment outweighs this.

Narrative of First Rays of Spring

The use of a biophilic design is to embrace the natural form and beauty. This allows fluid connections between urban realms and natural landscapes. Studies have shown that biophilic urbanism leads to societal benefits such as stress reduction, depression and anxiety. It further enhances productivity, healing and physiological immunity (Russo, Alessio; Cirella, Giuseppe T, 2017). A biophilic design therefore contributes to goal 3 of the UN, “Ensuring good health and promoting wellbeing” and should be further explored with renewable energy designs. With increasing significance to transition away from fossil fuel, this philosophy will allow integration of renewable infrastructure into the public realm, particularly in urban landscapes through organic designs, embracing the natural structure in the form of an artistic piece. The main inspiration behind this design is the floral form and structure to demonstrate the fluidity and interconnection of nature. From the petals which capture the sun, to the drift of the leaves in the wind, it is a multifunctional artistic model. The aim was a designing which embraced urban climates, often intensified weather, and to integrate the design into the landscape. The historical significance of Mannheim is a hotspot for German art and culture. A sculptural artwork to represent the balance of design and science within the city’s park is a very fitting, in relation to the city’s historical scientific achievement.

The central piece is a sculptured flower head. It’s petals are photovoltaic cells. It uses face glass on the solar panels (Ferry & Monoian, 2019), dyed to resemble the floral aesthetic. It’s capable of generating an annually capacity of 2000 MWh, at an efficiency of 20%. The use of solar energy is common in urban areas and its static nature makes it the most appropriate. The spread of the petal in this design provides other benefits such as offering shade and a comfortable seating experience. In addition, it’s large cover collects water during rainfall or flows into the blue roof. Multifunctional designs are significant as it improves urban resilience, inspired by farmers using panels to shade vegetation as crops or for grazing. This design combines functionality and art inspired by natural forms. This contributes to goal 7 of the UN, “Ensuring access to affordable and clean energy”; and goal 11, “Making sustainable cities and communities”. The size of this design is small compared to conventional renewable infrastructure, meaning this design is adaptable in scale and function, such as providing a roof for the theatre space within the park. Music and performance are a major part of the city’s culture. It provides a different experience and perspective for the public from conventional renewable energy. Energy is stored underground and used to power electric appliances in the park and the surrounding residential areas.

Piezoelectric fibres generate electricity through kinetic motion from wind or rain by converting mechanical energy into electricity, with a maximum efficiency rate of 15%. This design uses a hybrid of piezoelectric-photovoltaic materials woven with electrical conducting fibres. Semiconducting polymer can be used as an organic photovoltaic material. It is 14% efficient, less than other solar energy generating materials such as silicon, but it is fully degradable which makes it more sustainable and therefore necessary. It generates an annual capacity of 125MWh. The photovoltaic fibre is coated in interconnected nanoparticles, dyed, soaked in electrolytes, and slathered with transparent electrodes (Vatansever, et al., 2012). Electricity generation works better when wet because it improves electrical contact between each fibre. Making it more suited for the environmental conditions to generate electricity. Through weather conditions, this design strives for interactivity with the renewable infrastructure to increase public engagement with the park and sculpture through the use of motion. The diversity in electricity generation is advantageous when the main source of energy is dependent on the weather, increasingly unpredictable and inconsistence. The ability to generate electricity through most weather conditions, which is typically intensified in the urban realm, makes this technology a necessary part of future renewable designs and makes it a more reliable source of energy production. Making renewable infrastructure multifunctional further adds value benefiting goal 12 of the UN, “Responsible production and conception of energy”. The fabric is attached to linear poles which transfers generated electricity underground to be stored. It also allows for movement, attached to a pivot at the base creating a sway motion. Within this design, it connects the proposed green corridors of the park with the renewable energy sculpture. There is minimal impact on the wide area of the instalment due to its smaller scale. This makes it suitable and easily applicable, allowing for diversity in how this can be implemented into any landscape. This could be a form of microgeneration production, where investments can mitigate energy demand.

This design integrated SuDs with the renewable energy infrastructure to add value and function. The green roof shelter is organic in shape and designed to dam rainwater, inspired by the green roof on the Victoria and Albert museum, London. The implementation of SuDs is recognised to be necessary by most governmental bodies for its ability to drain water sustainably and provide growth of vegetation. It supports biodiversity, UN goal 15, but it also demonstrates how renewable infrastructure can coexist and increase biodiversity in the urban realm which is an issue in most conventional designs. Especially when renewable energy requires a vast land area and often risks harm to flora and fauna. There is a water collection system which collects and stores rainwater runoff from the solar panels underground allowing it to be reused. Due to urban impact on the water cycle, there is generally increased cloud cover and precipitation over urban areas with lower humidity due to the rapid surface runoff. There is further implementation of SuDs with the addition of swales within the site to collect rainwater when overflowed from the shelter as well as run-off from surrounding impermeable surfaces to create a water feature from rain. It further aids in ecosystem services, supporting the European Landscape Convention, 3.9, enhancing proposed green infrastructure such as the green corridor. These also contribute to the extension of habitat for wetland fauna in the designated wetland being restored. The water can be put to other uses such as water for the children’s play area. Mannheim is in the centre of mainland Europe. Therefore, the children’s play area has a large sand pit with water fountains using filtered rainwater to bring the beach experience into the inland city.

This design priorities functionality within the public realm, minimising damage and enhancing the ecosystem. Multifunctional spaces are desirable due to limited land availability, this applies particularly to renewable infrastructure, which requires a lot of space and sources around 25% of global energy supply. It is important for this design to generate renewable energy while allowing for the presence of increased urban greenery, shown by providing habitat space for flora and fauna. It is also beneficial to people as it provides an outdoor shelter for community use. When there is more diversity in use, there is greater economic incentive and therefore it increases value and benefit for the people. Multifunctional landscapes are promoted in the European Landscape Convention Part 2, 2.28. Its organic nature ensures transition to other areas of the park. As one of Europe’s largest inland ports, the city has old train tracks. It is turned into a public art walk in this design to relate to Mannheim’s cultural and historic background while adding functionality. Public art also allows for individual expression, beneficial for the local community.

This renewable energy design is scalable and adaptable. Through the use of microgeneration, it slots well into a private garden as a sculpture piece. This provides flexibility and maintains function. Multi-benefits are required in all urban developments such as energy production and rainwater collection. Microgeneration helps evolve the urban system or residential areas to achieve net zero landscapes or reduce reliance on natural energy sources. The idea of microgeneration of renewable energy production can be installed or implemented throughout the urban realm, achieving UN goal 12. Small scale generation of energy within households or communities where there is increased efficiency and no distribution of costs (Gallizzi, 2021) would be greatly beneficial, environmentally and economically.

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