**The Energy+Art Garden** (TEAG) immerses visitors in a futurist world of dramatic energy producing and reactive sculpture and lighting, lush plantings, pathways, and gathering points for public engagement within the Spinelli climate park project. During the day, night, and all seasons, the beauty and multi-sensory experience of TEAG sparks visitors’ imagination and desire for a world powered by clean energy. “Before change can happen it must be imagined.” - *LAGI*

TEAG augments the design forms central to social systems of early civilizations and throughout history, with 21st century technologies that unlock the energies of the earth and sun. These forms–mound, ziggurat, pyramid, arena, and circle–used for agriculture, community, ceremony, cosmology, cultural and spiritual meaning, and aligning with the symbiosis of humans and the cycles of nature, are integral to the design of TEAG.

TEAG is a self-sustaining oasis that provides energy to the grid using geothermal, solar and kinetic energy technologies. A portion of the Geothermal energy finances the employment of a staff to oversee TEAG’s integrated system including its maintenance, community programming, gardens and organic farm that grows vegetables such as butternut squash, spinach, and composting of organic waste.

The quality of the air and its flow through Mannheim is enhanced through the plantings of diverse native wildflowers such as blue cornflowers, white German chamomile, purple and yellow summer forget-me-nots, and other vegetation that is integrated into the TEAG design and supports eco-regeneration for rewilding the site.

**The Energy+Art Garden helps advance UNSDGs**Goal 3: Ensure healthy lives and promote well-being for all ages
Goal 7: Ensure access to affordable, reliable, sustainable, modern energy for all
Goal 9: Build resilient infrastructure, promote inclusive, sustainable industrialization and foster innovation

**1- Technologies

Geothermal energy** brings power to the Mannheim grid and the park. It will be installed under the Energy Mound sculpture using Climeon (climeon.com) Geothermal system or comparable company. Mannheim is located in the Upper Rhine Rift, one of Germany’s 3 regions with deep geothermal waters that are important for large-scale Geothermal use. Germany’s environmental protection agency says Germany’s heating sector with shallow and deep geothermal will cover about half its heat supply by 2050.

**Thin film photovoltaic panels manufactured by SoloPower Systems Inc. (solopower.com) and kinetic tiles from Pavegen Corporation (pavegen.com)** integrate lighting, irrigation, heating, maintenance, agriculture, charging stations, exercise, programs for entertainment and play.

**Multi-material 3D printing manufactured by Sundberg-Ferar (sundbergferar.com)**
**Sculpture #1 - Hanging Garden:** photovoltaic panels on 3D printed structure. Vertical hanging garden design of concentric circles for hydroponic gardening, seed collection, programs and performances. Stored solar energy illuminates its pattern at night creating a light sculpture.
**Sculpture #2 - Solar Pavilion:** Galvanized steel tubing and profiles for the structure with concrete footings. Anodized aluminum panel supports and framing for ETFE or similar panels with photovoltaic applied film for the greenhouse-like roofline. Steel aircraft cable tension lines. Pavegen Kinetic energy floor tiles.   **Sculpture #3 - Data Lightways: photovoltaic panels, kinetic floor tiles, 3D printed structure.** The archways are lit by the stored photovoltaic energy. The kinetic floor tiles generate energy from footsteps and dance events.

**Sculpture #4 - Energy Mound for park:** **3D printed structure** constructed over a Geothermal facility that delivers energy directly to the Mannheim grid. Internally lit and gracious in appearance, the intensity of *the* energy *is* also visualized in the adjacent Data Lightways. No plants or visitor entry.
**Energy Mound small version for a neighborhood:** powered by photovoltaic panels and used only for community gardening.

**See layout board #3 for Data Lightways other world class energy sculptures that demonstrate a total vision for a flagship park.**

**2- Activities TEAG supports**

1) Visitors experience light and artful imagery among the sculptures that reflect the intensity of energy generated by the technologies.

2) Kinetic tiles generate energy from visitors' footsteps and dance events that trigger ambient lighting, data and art on screens and display monitors. A mobile phone app displays energy produced by visitors, that generates credits for purchasing vegetables grown in the community garden, products, or cash. Energy also flows into a storage battery, mobile phone charging stations and speakers with sound works.

Visitors have a sense of shared ownership and satisfaction when seeing the results of their energy and healthful exercise generating clean electricity and financial credits for their personal use.

3) Hanging Garden provides a continuous production of seeds to be collected, that people can “seed bomb” using a shaker or basket to distribute them throughout Mannheim and rewild the park and city.

4) TEAG’s power system energizes charging stations along the pathways for cars, mobile phones, for filling personal storage batteries, weatherproof speakers that play natural sounds such as birds from around the world, and other uses.

5) Hanging Garden, Solar Pavilion, Data Lighways and other TEAG areas provide unique places for performances and programs, including community gardening, classes on the ecosystem and sustainability, local history and art. 6) The Geothermal energy system finances the employment of Mannheim’s community to oversee TEAG.

**3- System inputs required to operate annually, and required maintenance

1) New deep Geothermal** - water based closed loop system together with Climeon technology, produce high energy. Maintenance requires facilities and operators, funded by income from the power produced. If a well is not operating, a new one is dug nearby and the alloy steel tubes underground disintegrate over centuries.

**2) Thin film photovoltaic -** transparent protective film can be removed and replaced every 15 years.

 **3) 3D printed structures -** every decade,resurface either with future advanced 3D printing or high quality paints and coatings to further protect original surfaces.

**4) Pavegen kinetic floor tiles** - TEAG staff financed by Geothermal energy income, maintain the tile system with easy instructions from Pavegen.Maintenance: Guarantee 10 years outside, 12 inside. Debris resistant, pressure or mop cleaning. 1 year warranty. Pavegen trains onsite staff on rarely needed maintenance. In 2023 tiles will be solar collectors, generators and tiles from recycled material.

**4- System outputs (how many kilowatt-hours or cubic meters of water, waste materials generated and where they go)**

**Geothermal:** **Output** - generates minimum of 17,520 MwH power per yea. District heating to approx. 2000 houses with residual heat from the generators. **Waste** - possible excess water that would be sent to nearby river.

**Thin film photovoltaics: Output** - Area 1824 m2 = approx. 1800KW solar power at max. Solopower Solopanel SP-1 gives 197,100  KWh per year. **Waste** - panel replacement after 25 to 30 years.

**Compost plant and vegetable cuttings**: **Output** at ground location in the park or neighborhood. **Waste** - Improves sustainability of soil nutrients, moisture holding capacity, crop productivity.

**Kinetic floor tiles:** **Output** - 2-5 joules per step. MwH per year depends on foot traffic volume. **Waste** - rarely needed easily replaced step generator piece.
**5- Primary materials and major dimensions, order-of-magnitude conceptual cost estimate

General cost: $900 euro per sq meter.

Hanging Garden** - multi-material 3D printing and thin film photovoltaics.
For park - 2000 m2 (28 meters diameter). Estimate $1.8M euro.
For neighborhoods -  50 m2 (7m diameter). Estimate $250K euro.

**Solar Pavilion - Solar Pavilion -** 40 meters diameter solar pavilion 1257 m2 horizontal ring-like surfaces. Made of galvanized steel tubing and profiles for the structure with concrete footings. The rings are made of anodized aluminum sandwich panels or similar panels with photovoltaic applied film; steel aircraft cable tension lines, kinetic floor tiles.  Estimate $1M euro.

**Data Lightways** - Galvanized steel tubing and profiles for structure with concrete footings. Anodized aluminum panel supports and framing for ETFE or similar panels with photovoltaic applied film.

**Energy Mound -** 3D printed structure in an ovaloid shape. 1257 m2 in plan in 20 meters diameter, 12 meters high. Estimate 1M euro. For neighborhood plantings: 250 m2. Estimate 250K euro.

**Pavegen kinetic floor tiles** - recycled materials for mechanism and solar tiles. Dimensions approx 250 sq meters, cost estimate $5K euro per sq meter = $1.2M euro. 20% for shipping and installation. 12 weeks to construct from contract to ground. Placed in Data Lightways and Solar Pavilion.

**6- Summary of strategy for on-site prototype development if chosen for an honorarium grant**

- Initial advanced Building Information Modeling budget with real time price modifications established by the lead architect and his construction cost analyst.
- Initial coordination with landscape and botany experts; scientists and geological land use professionals.

- Site consultation with technology manufacturing companies.
- Evaluation of TEAG details with local government authorities in charge of city construction and community activity planning.

- Further development by architects, designers, structural engineers to refine plan.

- Establish schedule for materials delivery and assembly of local construction team for on-site prototypes.

- Multiple project presentations to local community groups for comments.

**Environmental impact summary**

The fabrication of all sculptures would follow LEED-like and Carbon Neutral processes mainly based on energy efficient and material saving techniques. The main production method being multi-material 3D printing, would ensure low energy consumption and almost no production material waste. The choice of material would favor new hyper-long lasting metal alloys such as bronze-titanium, zinc-titanium and high grade stainless steel, as temperature resistant surfaces. Where 3D printing would not be the best solution hyper-baked massive laminated wood structures (when possible) would be used, capped with hyper-long lasting metal alloy capping.

To produce the sculptures in an ecological way, their transportation to the site from the fabrication shops would favor transportation by river barge and transportation by train. Some parts would be transported by electric flatbed truck, and some by regular trucks.

At installation, local flora and fauna would be respected and scientifically moved nearby with the aim to minimize ecosystem trauma.

The foundation work would use new carbonegative [algae](https://www.constructiondive.com/news/new-algae-based-cement-garners-attention-from-aec-industry-microsoft/625140/) based concrete mixtures. None of the concrete foundations would stand out in terms of complexity. They would be designed and built to be reasonably repaired every 2 decades.