“**Once Upon a Blade**” is our regenerative, low-carbon solution that repurposes end-of-life (EOL) decommissioned wind turbine blades made of glass fiber reinforced plastic (GFRP) and epoxy resin. We believe EOL blades – like discarded tires – are indigenous to our material culture and therefore propose constructive uses for entire root/mid+tip/tip sections and X-sections of EOL blades as building-elements in our innovative architectural design for **FlyRanch**, consequently eliminating the need to:

* dump EOL blades in a landfill
* shred EOL blades - using a lot of energy - for conversion into supposedly usable material
* incinerate EOL blades - ostensibly for deriving energy.

The *piece-de-resistance* of our architectural design is the **Blade Monument**, a structure **inspired by the Paiute teepee**. Instead of wooden poles it uses ~30m-long blade (mid & tip) sections as all-weather, external “poles”. The resulting exo-skeleton is a conical structure that obviates the need for a roof. And, buffalo skin is being replaced by hemp-canvas that won’t be wrapped around, but stretched blade-to-blade on the inside.

The Blade Monument is symbolic of a “**shelter**”. It could serve as a visitor-center/healing- hut/maker-space. More importantly, irrespective of how it’s used, it is meant to pay tribute to the Paiute tribe, their Elders (past, present & future), their ancestors’ simple way of life in ca. 18th century, and the land - revered by them - on which the structure will be located **/\**

By introducing building-integrated photovoltaics (**BIPV**) via CIGS thin film solar pv strips on the south facing portion of the monument, we’ve created an off-grid, zero net energy (**ZNE**) shelter. Furthermore, when the rainwater collector at the top is connected to a rainwater harvesting (RwH) system, it renders the shelter “zero net water” (**ZNW**).

In designing the ~24m-high structure with ~330m2 of canvas paneling, we’ve deliberately violated human scale for monumental effect. However, everything else in our architectural design is human scale, demonstrating a strong connection of the structures - and the people using them - to the earth, air/wind, sun and water.

We’ve visualized the metamorphosis of the Blade Monument into other useful forms of **blade-based shelters & ancillary structures that echo the spirit of “leave no trace” in the context of a post-carbon FlyRanch of tomorrow** **/\**

Superficially, the blade might appear like a bone in all our creations. In a deeper sense, though, the blade is symbolic of the fact - and hence will serve as a constant, humbling reminder to occupants of - and visitors to - FlyRanch - that industrial hardware created by humans often outlive the humans that created them.

Our innovative renewable energy (RE) solution features **reciprocating** **steam engines** (yes, that 200y-old technology is still so relevant!) as prime movers, and **airborne wind energy** (kitepower) systems (as a “leave no trace” version of wind turbines).

**SHELTERS**

1. **Blade Huts** (human-scale variants of the Blade Monument)

~6mφx6m-high & ~12mφx12m-high, conical (therefore roofless), **multi-purpose shelters**:

* 1. year-round dwellings for short-duration overnight stay
  2. spaces for collaborating & learning
  3. spaces for introspection: digital detox, yoga, meditation & healing
  4. art studios
  5. shells for development of creative, sustainable interiors by placemakers
* Default spec: compressed stabilized earth blocks (CSEB) for the walls, recycled-wood flooring, hemp-canvas paneling, BIPV, LED lights, wind-driven turbine-ventilator (passive cooling), RwH.
* Optional spec:
  + Stilted for flood-prone zones
  + 2-story (internal spiral staircase)
  + Pit-house (Walipini-inspired) for low water-table zones
  + **Octaform**® **FormWork**™ wall
  + Paneling: glass, **R+Heatshield™+Hexacomb™**, **ETFE**, sustainable plywood
  + Active heating/cooling: ground-source heat-pump (**GSHP**), energy-efficient fans/coolers, radiator-based heating using hot-spring water for huts close to geothermal zone (GZ)

1. **Blade Bowl**

~86mφx12m-high marquee juxtaposed with an amphitheater:

* discarded tires (as rammed-earth bricks) for the base & CSEB for the walls; optional Octaform FormWork.
* blade root sections as inner columns; root+mid sections as outer columns; mid+tip sections as joists/rafters – and also seats!
* ETFE (+BIPV) lightweight roof mimicking birds’ wings, symbolic of flight & motion.

1. **Blade Pods** (utilizing cylindrical, hollow blade root-sections):
   1. Personal cocoons (privacy/tranquility pods)
   2. Enclosures for bio-filtration toilets
   3. Hot tubs

**ENERGY**

For providing reliable, off-grid, RE to FlyRanch & Black-Rock Station (BRS), we’re proposing a hybrid system that guarantees year-round flexibility & reliability:

1. **Geothermal**
   1. ~**150kW Steam Piston Engine** and a “green”, low-cost, hot-water thermal energy storage (**TES**) system deployed near the **GZ**. Advantages:

* efficient part-load operation
* extended out-of-service not detrimental
* fast start-up
* low/modest
  + steam temperature & pressure
  + water consumption
  + noise
  + maintenance

Hot-spring water is piped (\*) to a heat exchanger (HE) to heat non-spring water, which is then converted to steam using

* concentrating solar power (**CSP**), parabolic trough collector (**PTC**) direct steam generation (**DSG**)
* biomass (sustainable, locally-grown) boiler.
  1. **Organic Rankine Cycle (ORC)**, low-temperature, modular (~150kWe) geothermal power plant (**GPP**) deployed near the GZ. Hot-spring water is piped (\*) to ORC-GPP’s HE.

1. **CSP-Biomass Thermal PP (TPP)**. Steam Engine + TES can also be deployed anywhere on the ranch, using steam only from CSP-system and/or biomass boiler.
2. **Solar: Ballasted** (foundation-less), ground-mount pv arrays, with battery-storage, in micro-grid format, to supplement CIGS thin-film (on huts/marquee/yurts).
3. **Wind: Airborne wind energy (AWE) – aka kitepower - systems**: as demonstrator projects.

ORC-GPP(s) and/or TPP(s) operate as base-load PPs when Fly Ranch/BRS is fully occupied. During low-occupancy months, PP(s) can be run on part-load, or switched off. Street lighting via solar-LEDs (independent of GPP/TPP).

(\*) via pipes running inside blades installed underground as (naturally) insulated conduits.

To summarize, our regenerative, ZNE+ZNW-campus, low-carbon, architectural and captive, off-grid, RE solution is:

1. An infrastructure template for a self-sufficient & efficient low-carbon community of tomorrow using present-day technology, repurposed and commercial-off-the-shelf materials…it is not futuristic!
2. A living laboratory in which the place-makers at FlyRanch provide the inspiration and intellectual freedom to explore - creatively and collaboratively - the technological, environmental, economic and societal aspects of sustainability, and the scope to design & engineer locally relevant solutions.Occupants and visitorsshould be encouraged to advance sustainability scholarship & stewardship inside and outside FlyRanch.
3. “Scale-elastic”: it’s designed for ~400 occupants but it can be scaled down/up to cater to 40/4,000 occupants, without losing functionality or reliability.
4. “Compatible”: it can be seamlessly co-deployed with solutions from other teams focused not only on food, water & zero-waste but also shelter & energy (our focus areas).
5. Viable in the year-round climatic conditions of FlyRanch.
6. Not detrimental to the geo-/bio-diversity of FlyRanch.
7. Like a time capsule: in 2050, visitors would look at it and marvel at how 18th century teepees are still so relevant as shelters in mid-21st century, once they’ve been tweaked with present-day sustainable materials and electricity.

Technology used in our design

Various sections of EOL blades will be used as the structural element in all our architectural solutions.

For RE:

1. Steam engine(s)
2. ORC-GPP
3. CSP-PTC-DSG
4. Biomass boilers
5. CIGS thin-film & conventional solar pv panels
6. AWEs

List of activities our design would support

1. Overnight residence
2. Workshops
3. Corporate getaways
4. Destination resort
5. Thermal spa
6. Digital detox, yoga, meditation & healing
7. Displays of large-scale outdoor art/sculpture (including M.Mannhard’s BladeYARD!)
8. Development of inspirational prototypes of new cleantech & sustainable habitat solutions; scope for collaboration with DRI
9. Performances at amphitheaters
10. Open-air/sky planetarium for star-gazing and/or 3D-AR experience
11. Geothermal powergen using steam-engine/ORC
12. Power-kite flying (AWEs demonstrators)
13. Biomass-plantations: energy grasses & fast-growing trees
14. Agri-voltaics: alleys of solar pv arrays and food crops
15. RwH & flood water control (canals & flexible bladders)
16. Soil protection (using blade X-sections as geo-cells)
17. Greenhouse-farming

List of system inputs

Inputs would depend on the scale of deployment, but in general, maintenance is expected to be simple and low-cost.

List of system outputs

* Outputs would depend on the scale of deployment, e.g. ~100kW each from solar & wind, 150kW from each ORC-GPP/TPP
* No discharge from bio-filtration toilets
* Eco-incineration of non-plastic solid-waste in the TPP.

List of the primary materials used in our design and major dimensions

EOL blades (each ~30m-long, ~8 tonnes), hemp-canvas, CIGS thin-film & solar pv panels, local soil, sand, gravel, cement, R+Heatshield™+Hexacomb™, ETFE, glass, wood, HDPE sheets, discarded tires, galvanized steel guy wire, hemp ropes, PVC pipes.

Order-of-magnitude conceptual cost estimate

Cost would depend on the scale of deployment. If shortlisted, we’ll come up with estimates.

A short summary of our strategy for on-site prototype development in the event that we are chosen for an honorarium grant

We’re hoping to source EOL blades free-of-cost from a wind energy company, but we may have to bear the cost of transport from Casper, Wy (~1,000mi), or Palm Springs, Ca (~600mi). We’d require cranes, back-hoes, blade-cutting equipment, gensets and labor.

We also plan to collaborate with OEMs of:

* Steam engines
* ORC-GPPs
* CSP-PTC-DSGs
* Biomass boilers
* AWE systems

as our RE solution provides them an opportunity to demonstrate their technologies. We have identified such OEMs, but we’re not sure if they’d agree to advertisement-free sponsorship.

Environmental Impact Summary

Caveat: This is not meant to be an expert EIA report; it’s just a self-assessment document.

We believe the (negative) environmental impact of our solution would be minimal.

Most of our architectural solutions use repurposed EOL wind turbine blades as key structural elements, so apart from the carbon footprint associated with transporting the blades to the site (no different than transporting any other material to site) there’s no additional environmental impact. In fact, there’s zero carbon footprint for the blades (as building materials) *per se* since they have not been specifically manufactured for our solutions!

The dwellings are conical structures obviating the need for a roof. The dwellings are also feature passive as well as low energy use heating and cooling systems.

Foundations are going to be fairly shallow requiring very little concrete.

No grid connection is required. The ranch would use on-site natural energy sources – solar, wind, biomass and geothermal – in a sustainable fashion to produce heat & electricity as required. Solar pv panels are going to be ballasted ground-mount systems so no need for foundations. Biomass (a carbon-neutral fuel) would be cultivated on site in a sustainable manner. Since our energy solutions are all renewable and therefore “green” in nature, no CO2 footprint.

The toilet pods house bio-filtration toilets so no impact on the air or ground water resources, even in high water table zones.

The entire blade is used! The blade cross section **geo-cells** would help prevent top soil erosion.

As the blades are naturally insulated (by virtue of being made from GFRP), the blade-based conduits would enable transport of hot water and steam with minimal heat losses even in winter.

If the project is abandoned in the future, the structures can be dis-assembled, transported and redeployed elsewhere. Alternatively, if the structures are stripped down, the blades can be used as fences for the property. Or, the blade structures (minus the canvas) can even be left behind *in situ* as mute monuments ‼

The ORC-GPP, steam engine based TPP and the solar & wind energy systems can be deployed as-is elsewhere!