Wind Energy: A New Approach for Capturing an Untapped Energy Source

IEEE-CNSV Meeting – July 9, 2024
SEMI – Milpitas, CA

IEEE-CNSV
Consultants' Network of Silicon Valley

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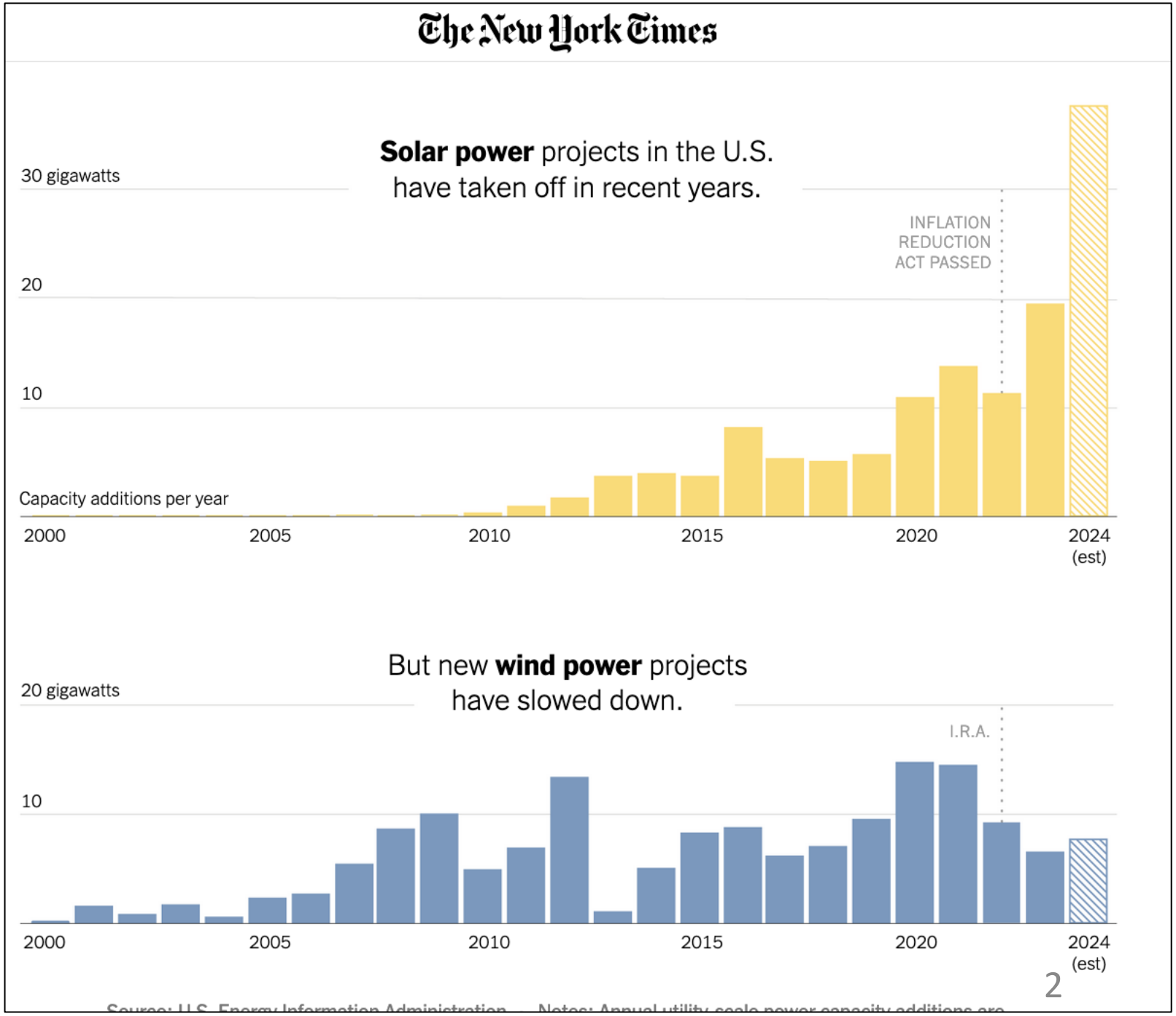
NYT, 6/3/2024:

As Solar Power Surges, U.S. Wind is in Trouble

Why are there fewer wind farms being installed in the U.S. and around the world?



PROBLEM:

Wind Power Faces Barriers to Expansion

- Most on-shore areas with good wind resources already **built out**
- Greenfield and offshore projects are **costly** and **time-consuming**
- Tall turbines **can't be installed** in many locations
- Offshore development faces **opposition**
- Concerns over impacts to **wildlife**
- Rooftop wind offers **limited capacity**

Problem:

Traditional Turbines Create a Long and Wide Wake

FIGURE 2. Horns Rev Offshore Wind Farm, North Sea. Turbulent wakes visible in fog behind front row of turbines. Photo Credit: Christian Steiness.

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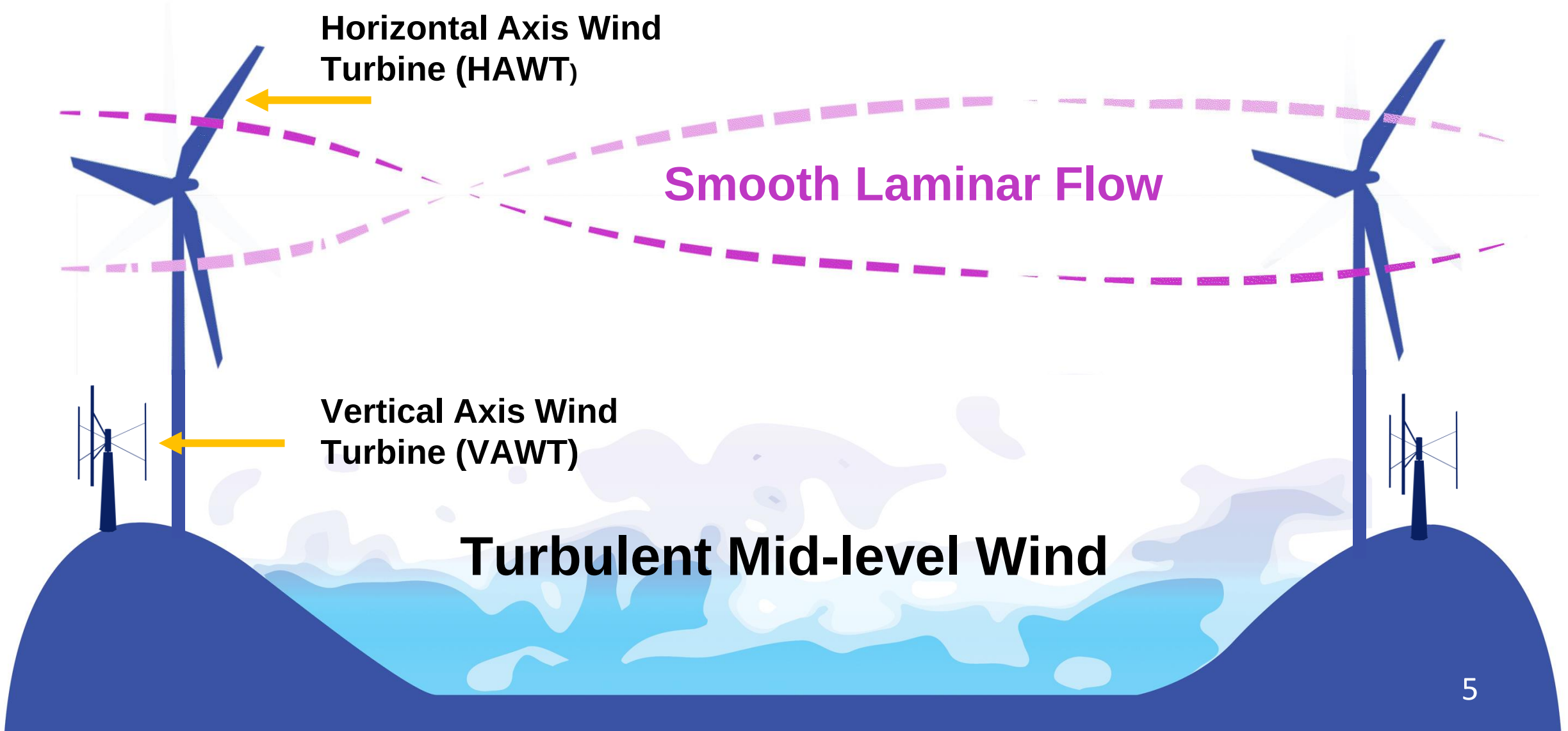
Traditional Turbines Can't Handle Turbulent Wind

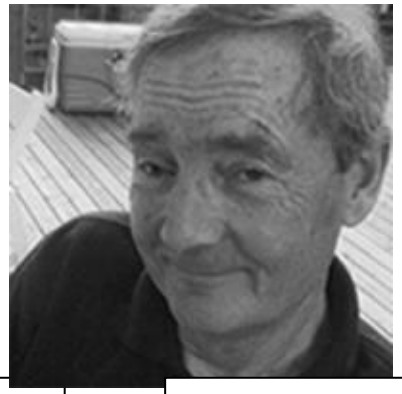


SOLUTION: Our Engineering Team

Wind Harvest

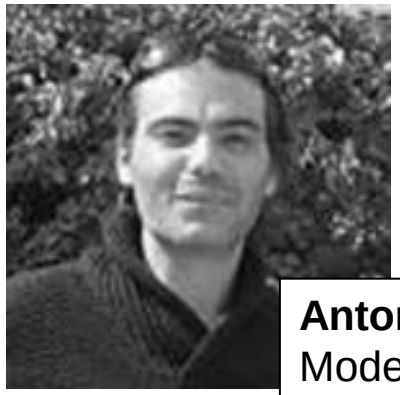
Bob Thomas (1933-2019), Founding Engineer

Dr. Olamide Ajala-Inyang
Principal Engineer



Dr. David Malcolm
Senior Engineer
Aeroelastic Modeling

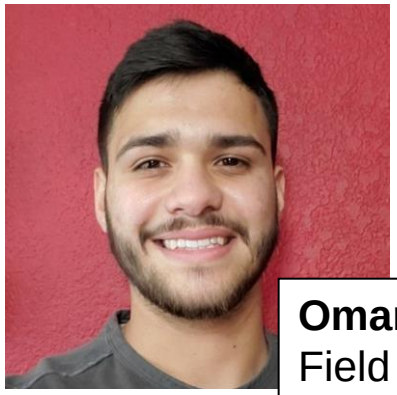
Mark Chang
Lead Electrical Engineer



Antonio Ojeda
Model 4.0
Chief Engineer

Ionut Munteanu
Consulting Engineer

Jeff Willis
Production Manager



Omar Garcia
Field & Mechanical Engineer

SOLUTION: *Wind Harvesters* ®

Wind Harvest

- **First-to-Market** with a *compact* turbine that operates in **turbulent wind**
- **Ready for Certification** and *Technology Readiness Level* 8 (of 9)
- **Easy to Make, Assemble, & Install:** 50-80% can be made locally
- 99% recyclable. **Wildlife friendly.** Less raw land converted to wind farms**.**

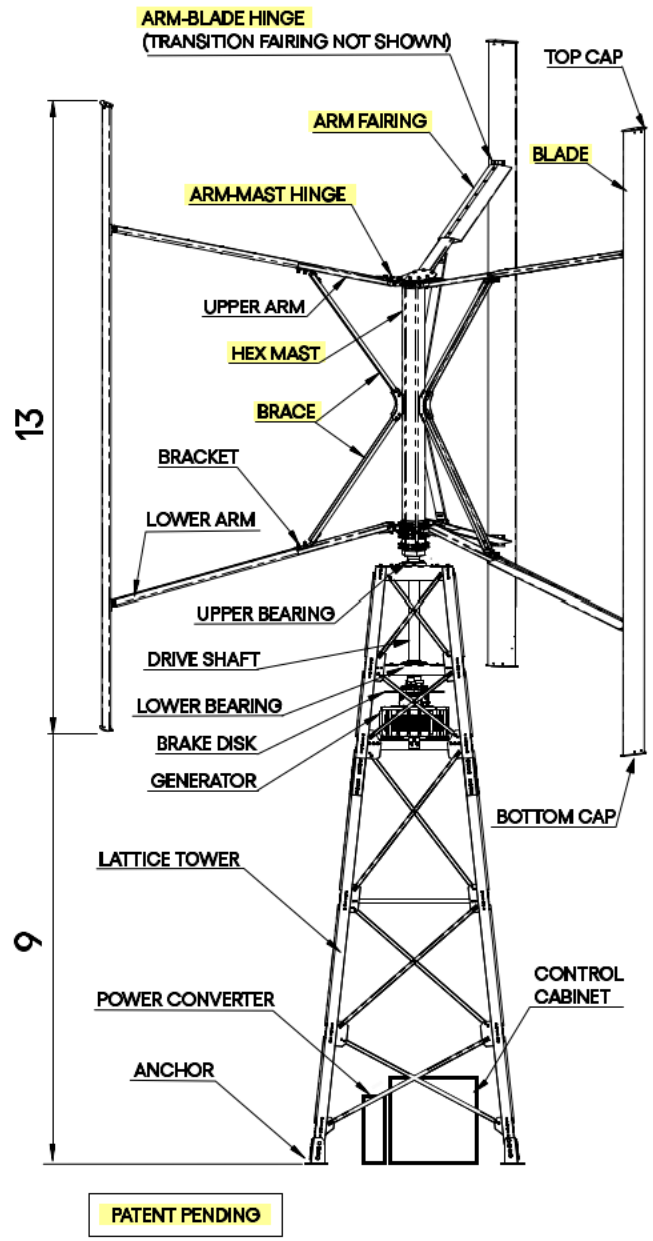
Model 2.0, Finland

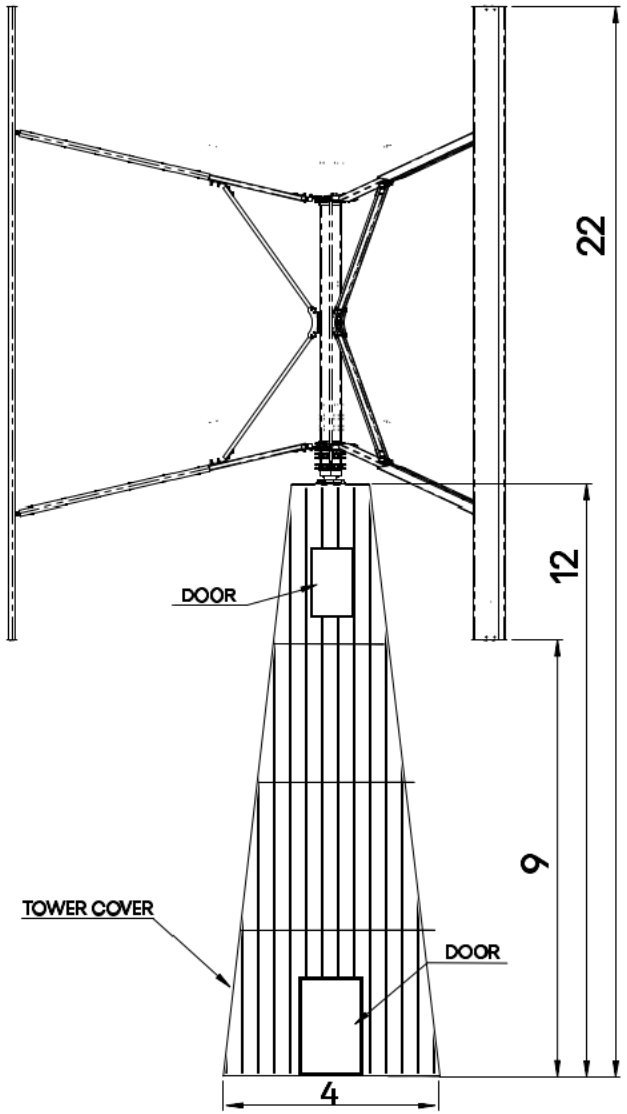
Model 3.0, Denmark

Model 3.1, Texas

Model 4.0, Texas

Wind Harvester™ 4.0





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UNITS: METERS	SCALE 1:100

Some parts of these drawings have been slightly changed from what will be installed.

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VAWT with Variable Thickness Blade:

Patent Pending

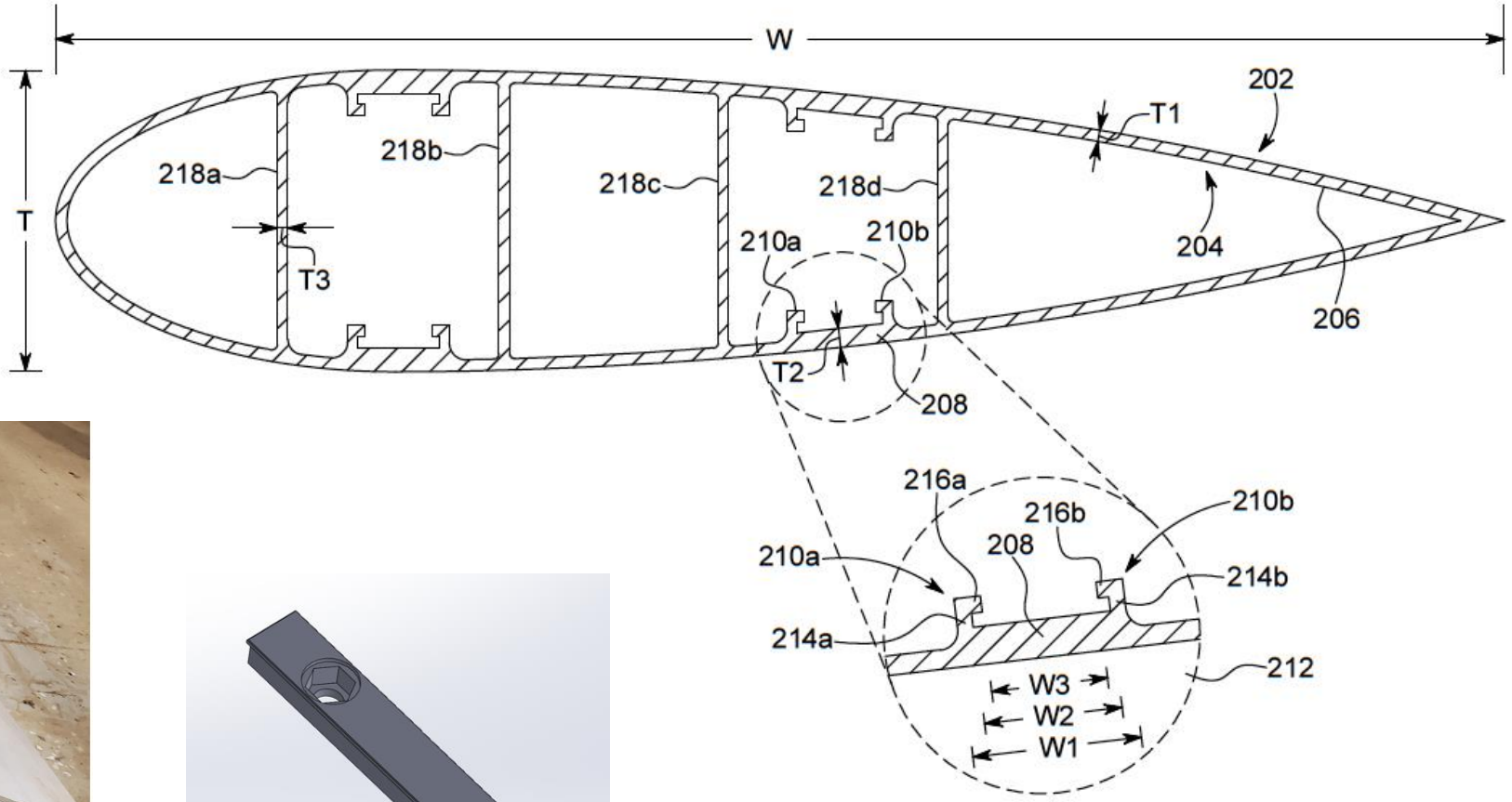


FIG. 2

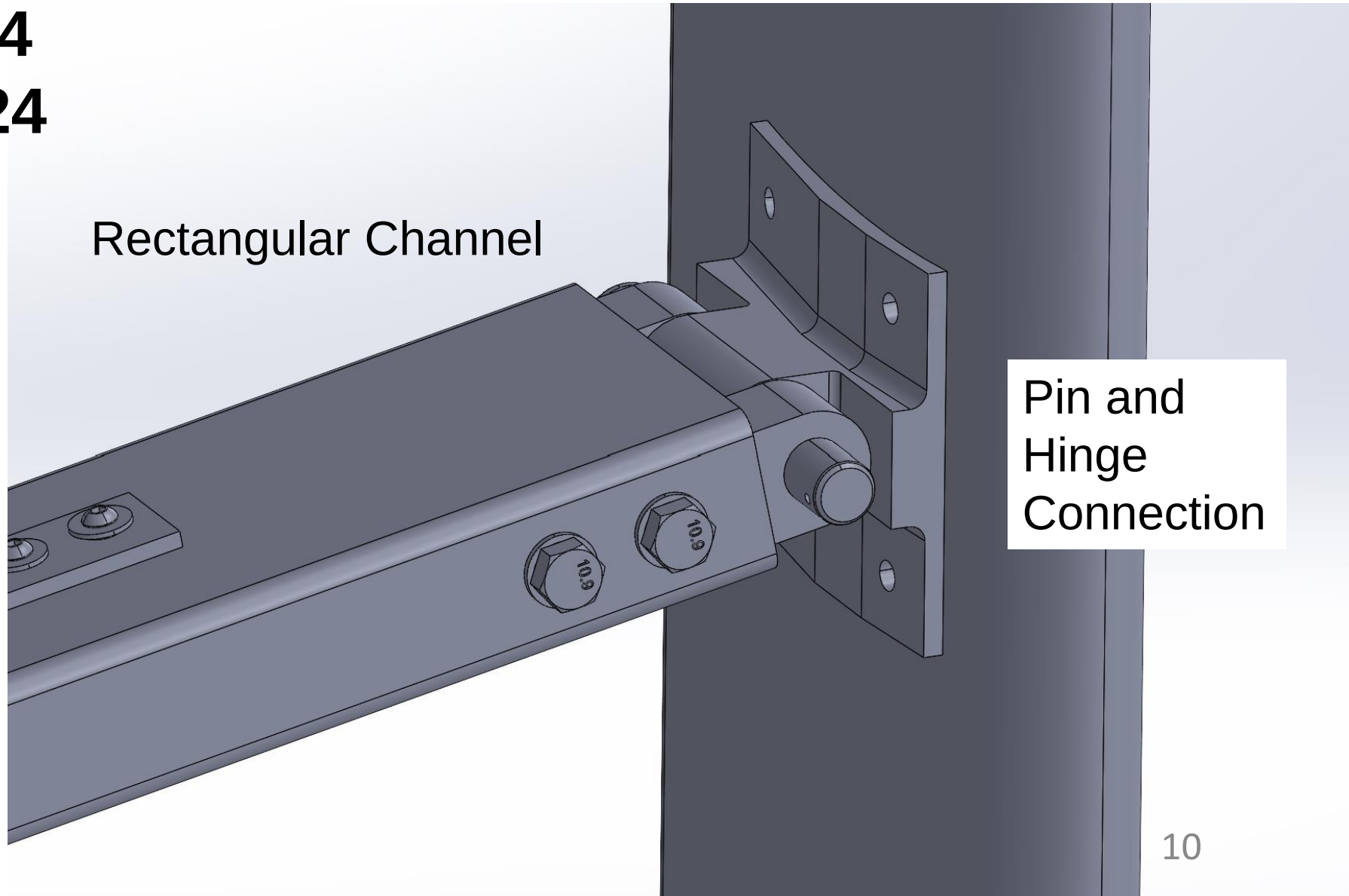
3d printed plastic nutbar

Blade-Arm Connection Member:

Patent #11927174
Granted 3/12/2024

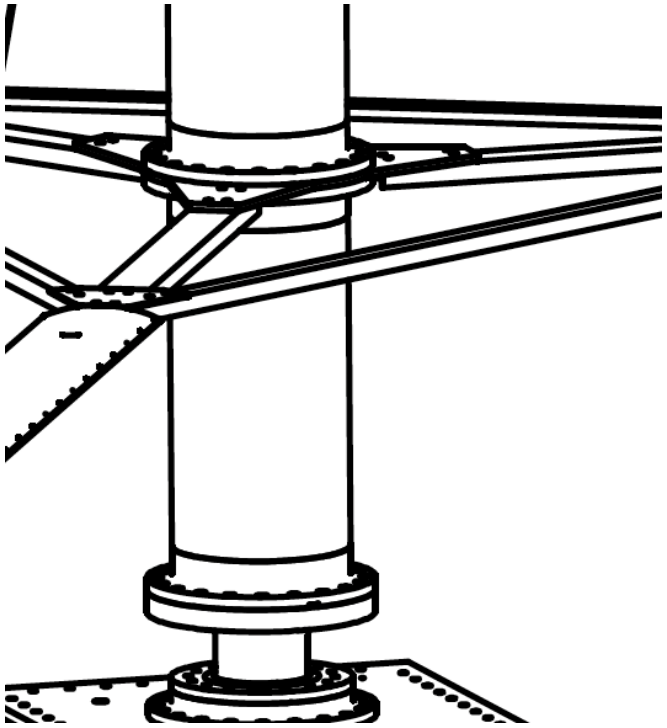
15M rotations per year

May be impossible for potential competitors to make a VAWT for turbulence without licensing the hinge patents

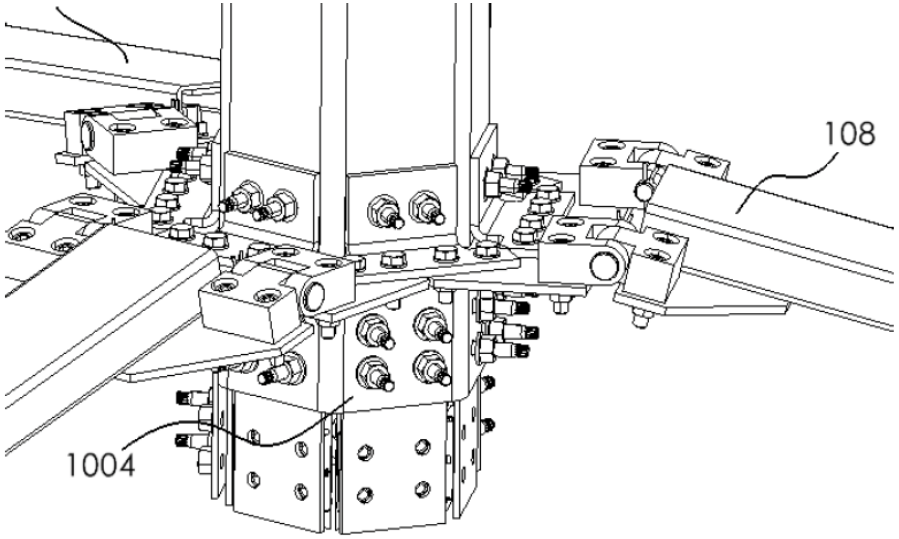


Hex Mast and Mast-Arm Hinge Patent

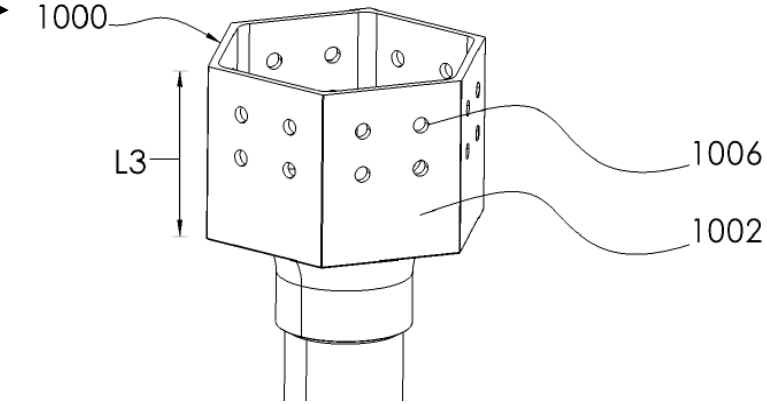
Patents Pending



~$24,000 Model 3.1 with full penetration welds on five flanges and three pieces of pipe.

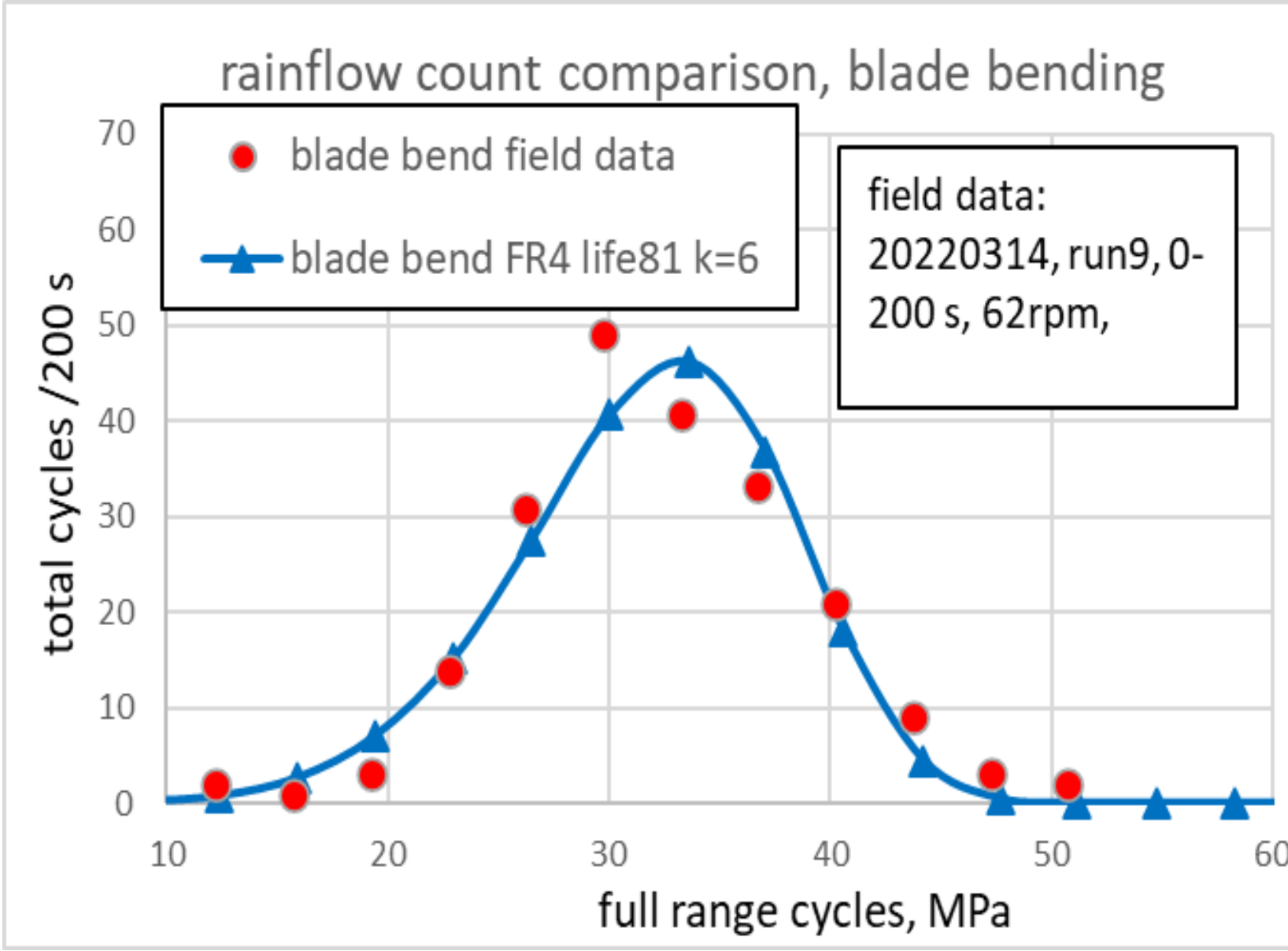


~$6000 - Model 4.0 hexagonal mast with two vertical welds using Northstar Wind's nutbar patent. Note the patent-pending **hinge** between the arm and mast.

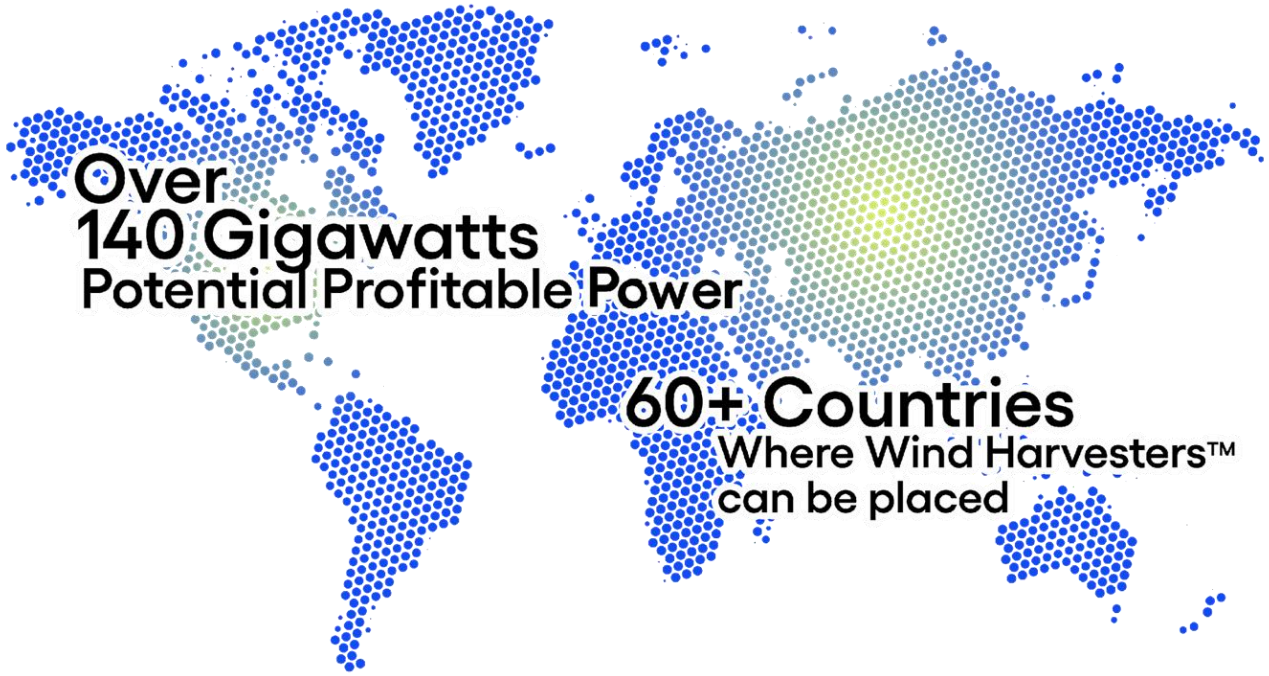


Fatigue Analysis Field vs. Model

- Field data are rainflow counted to identify fatigue cycles.
- Material SN data used to calculate fatigue life.
- The predicted cyclic loads from FR4 code used to predict histogram of fatigue cycles.
- Model based on Sandia National Lab's LIFE code for VAWTs.



Market Opportunity:



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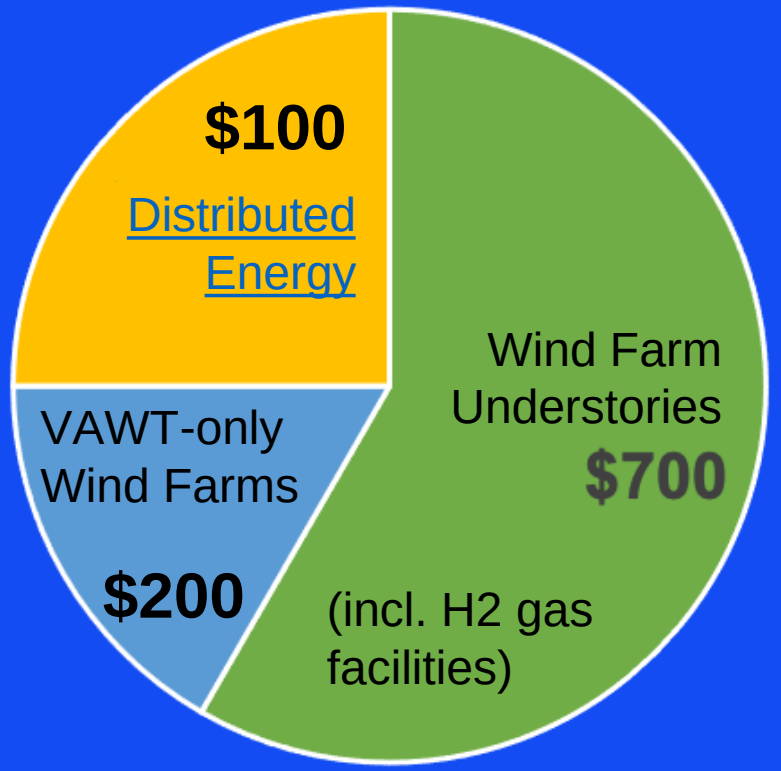
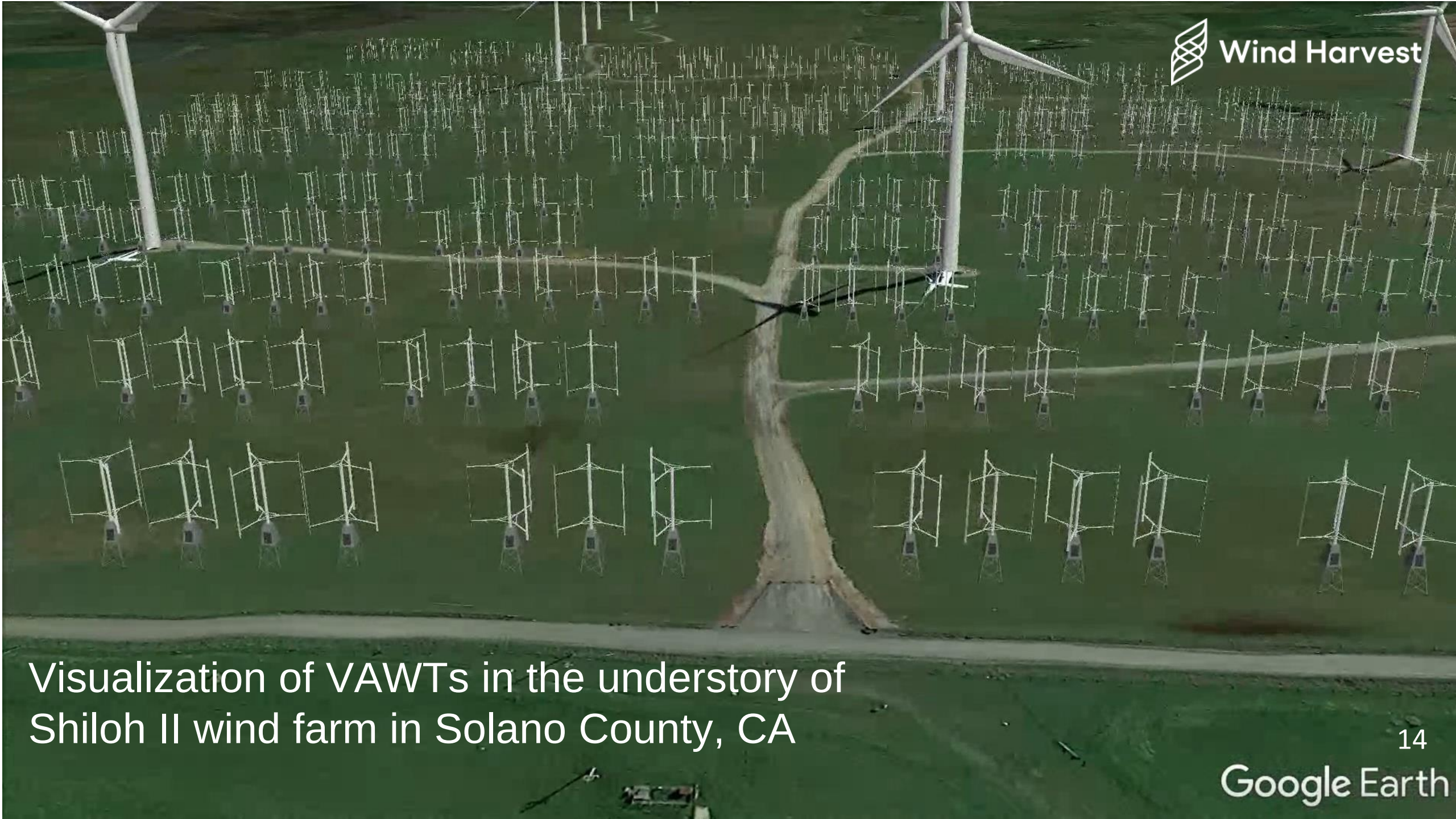
2030 Markets in Billions



Mid-level wind wasted in existing wind farms is worth **$400 billion**. This market should double in 10 years.

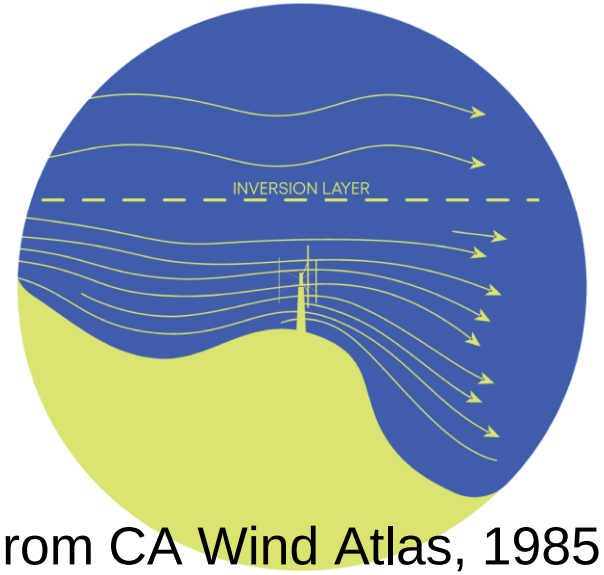


Visualization of VAWTs in the understory of Shiloh II wind farm in Solano County, CA

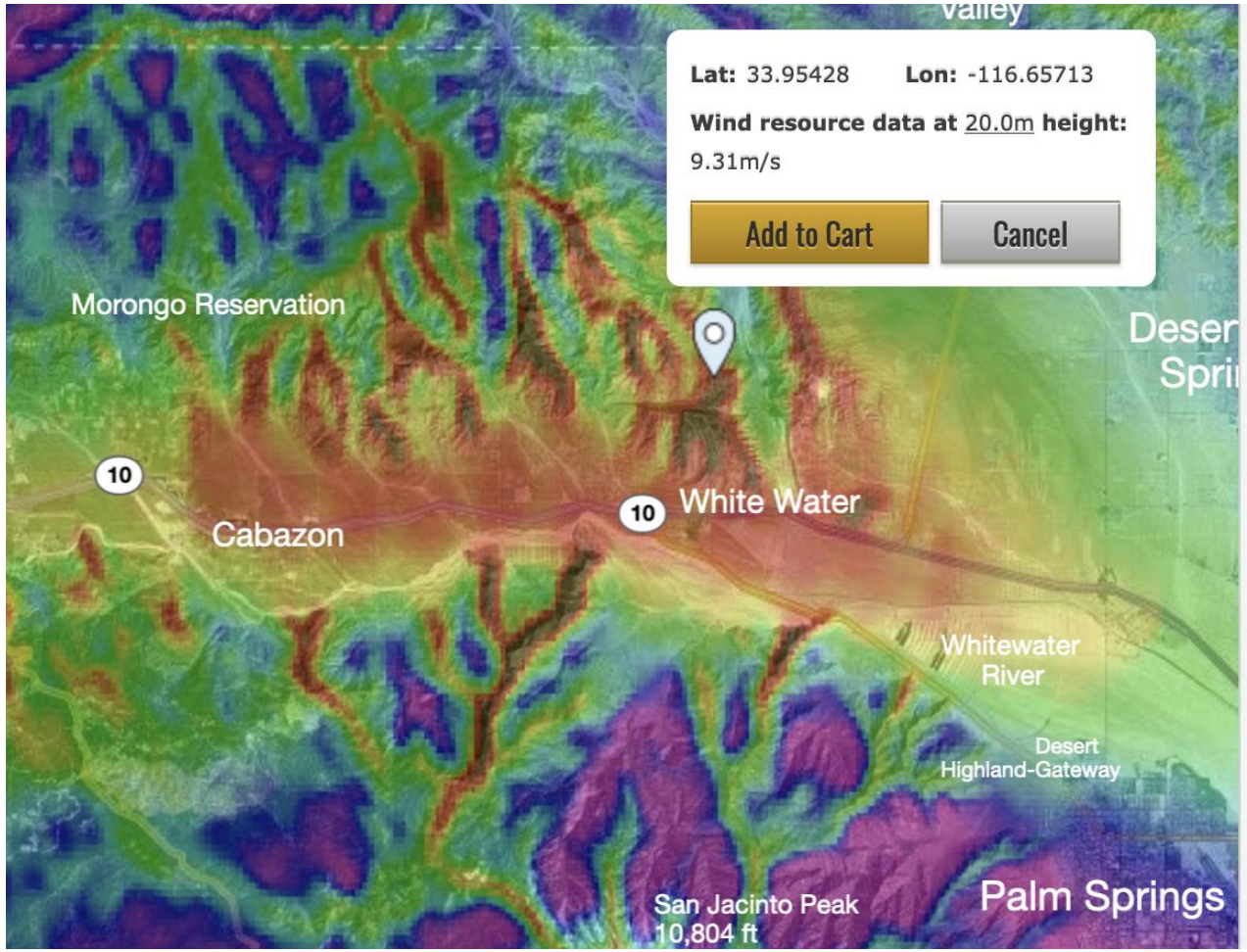
California's Mid-Level Wind Resources Rediscovered

15 GWs, 45,000 GWh, $40B of Potential for Short VAWTs

Wind Funnels and Speeds Up in Passes and over Hills and Ridgelines



From CA Wind Atlas, 1985



UL Windnavigator

Latitude: **33.95428** Longitude: **-116.65713**

Elevation: **789.5m** Roughness: **0.05 m**

Wind resource data at 20.0m height:

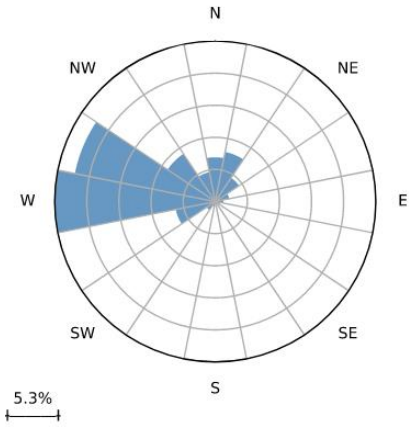
Air Density: **1.148 kg/m^3**

Mean Wind Speed: **9.31 ± 0.35 m/s**

Mean Wind Power Density: **878 W/m^2**

Weibull A: **10.51 m/s** Weibull k: **2.373**

Wind Rose Monthly Speeds



USE CASE: Capacity Factor Enhancement

Example: An Existing 100 MW Wind Farm

25 MWs (~350 *Wind Harvesters* = $60M)

125 MWs combined. Uses only the existing 100 MW substation and transmission line

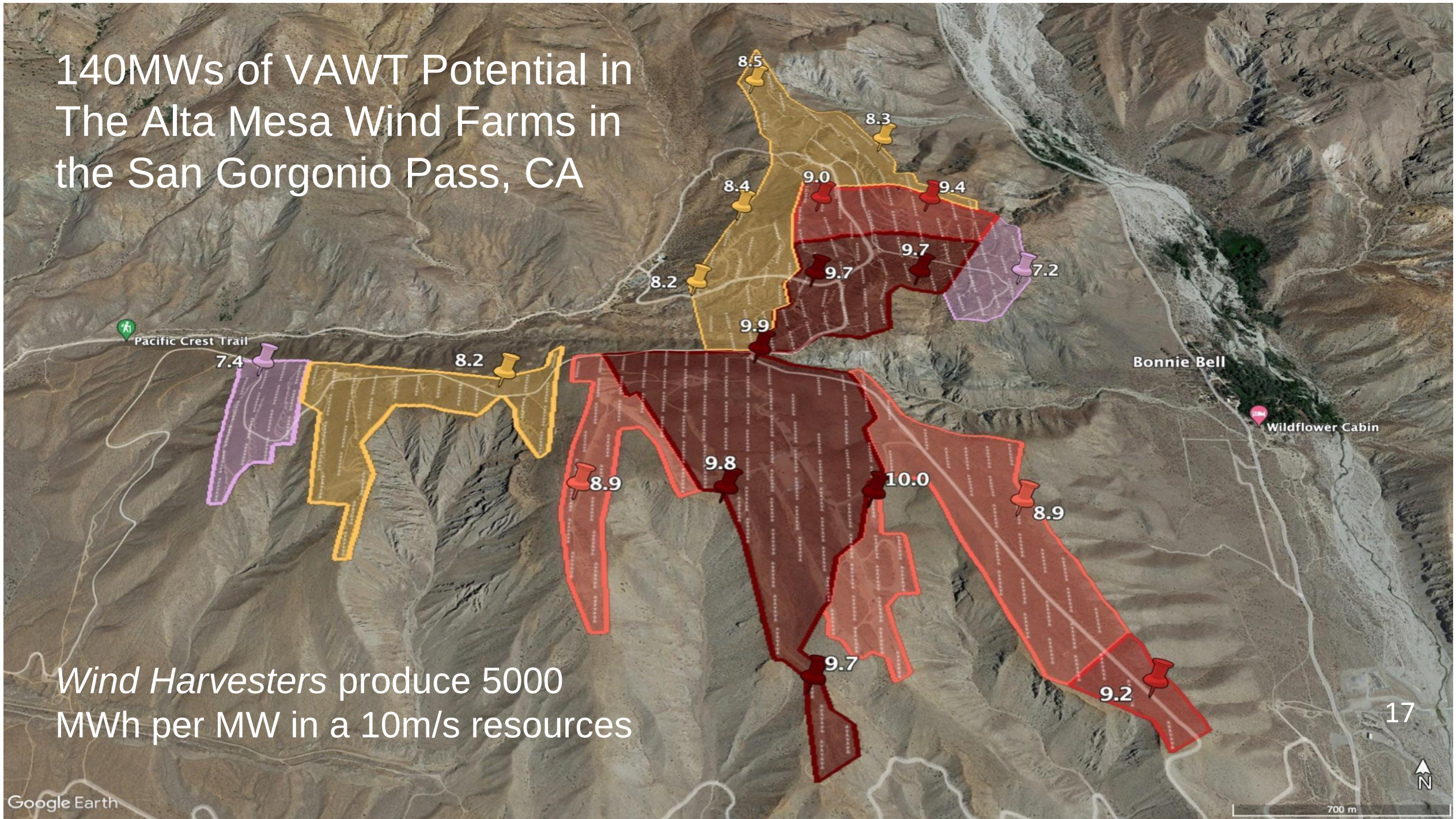
20-25% ↑ project Capacity Factor

~5% ↑ Energy Output for HAWTs

10-year HAWT life extension because they can pitch blades earlier in high wind events

No new land, main roads, or fencing

8-15+% Project IRRs


140MWs of VAWT Potential in The Alta Mesa Wind Farms in the San Gorgonio Pass, CA
Wind Harvesters produce 5000 MWh per MW in a 10m/s resources
8.5
8.3
8.4
9.0
9.4
9.7
9.7
7.2
8.2
9.9
Pacific Crest Trail
7.4
8.2
Bonnie Bell
Wildflower Cabin
9.8
8.9
10.0
8.9
9.7
9.2
17
N
Google Earth
700 m

A Problem leads to a Solution

Windstar 1066, 50 kW (1992
San Gorgonio Pass, CA)

Wind Harvest

Five Stators on the Points of Star

Coupled Vortex Effect

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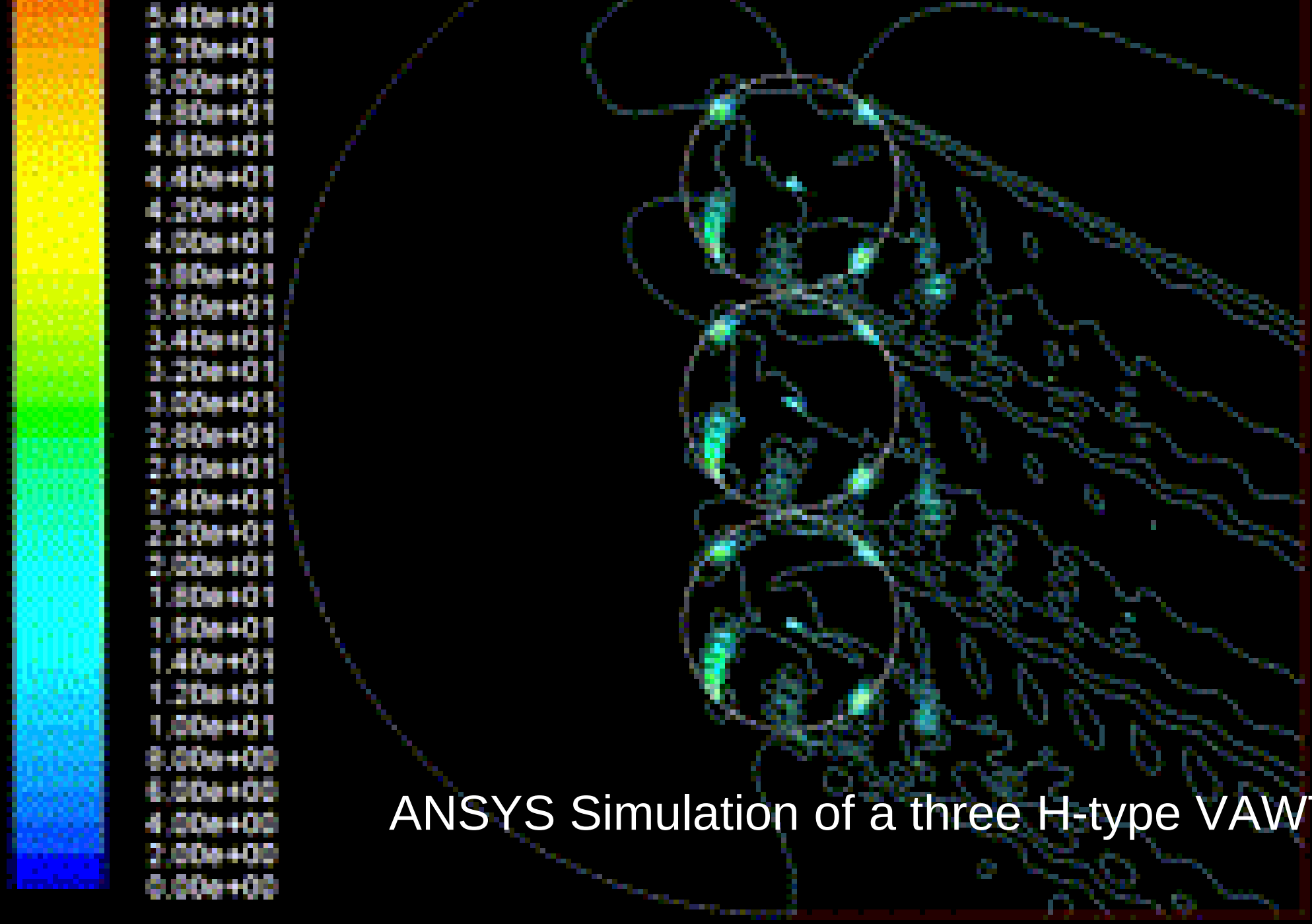
Bob Thomas with turbine array in Palm Springs

Kevin Wolf assisting with turbine installation



ANSYS Simulation of a three H-type VAWT array

Wind Farm Synergy:

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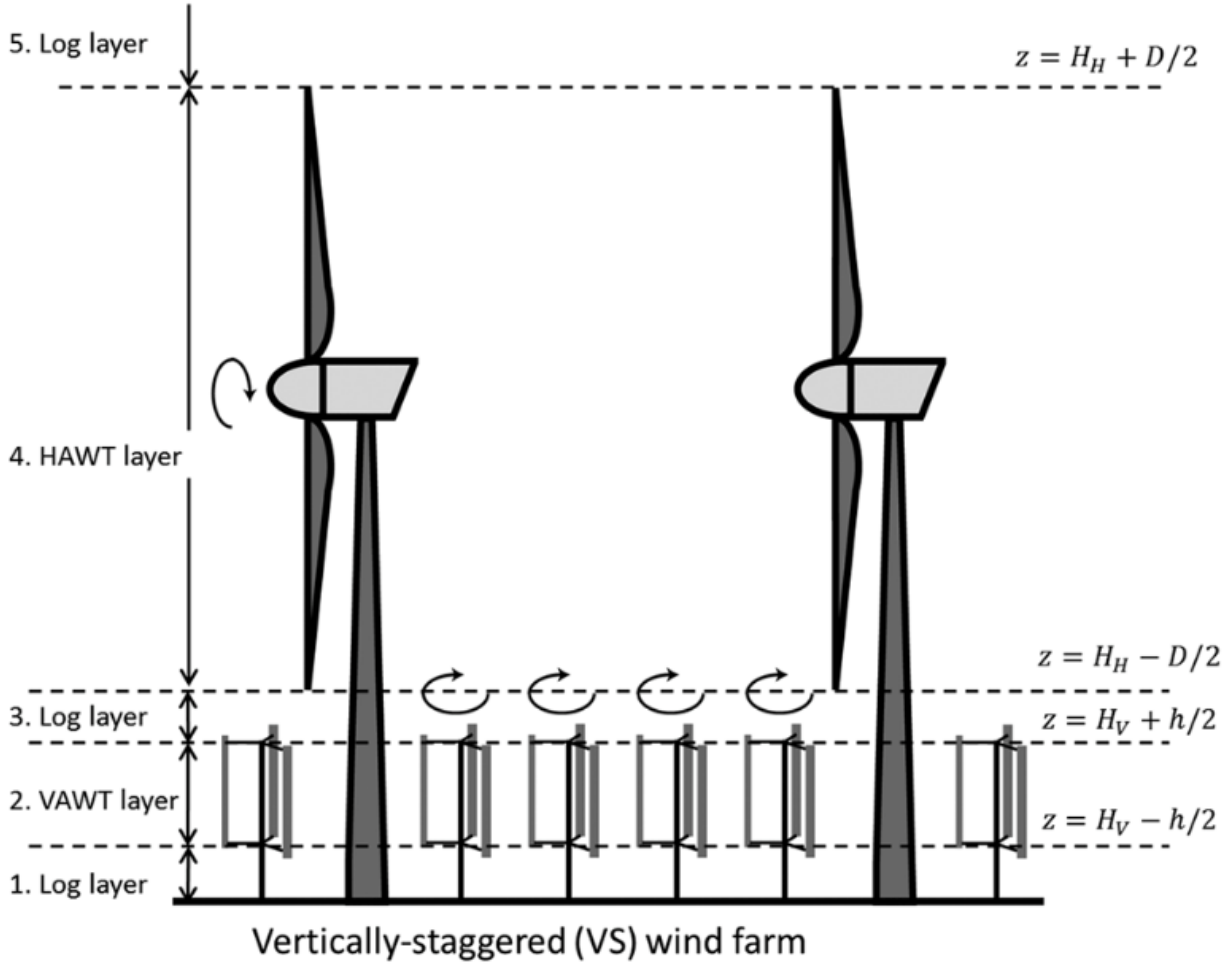
VAWTs help HAWTs

VAWTs can create a **10% increase in output** of HAWTs

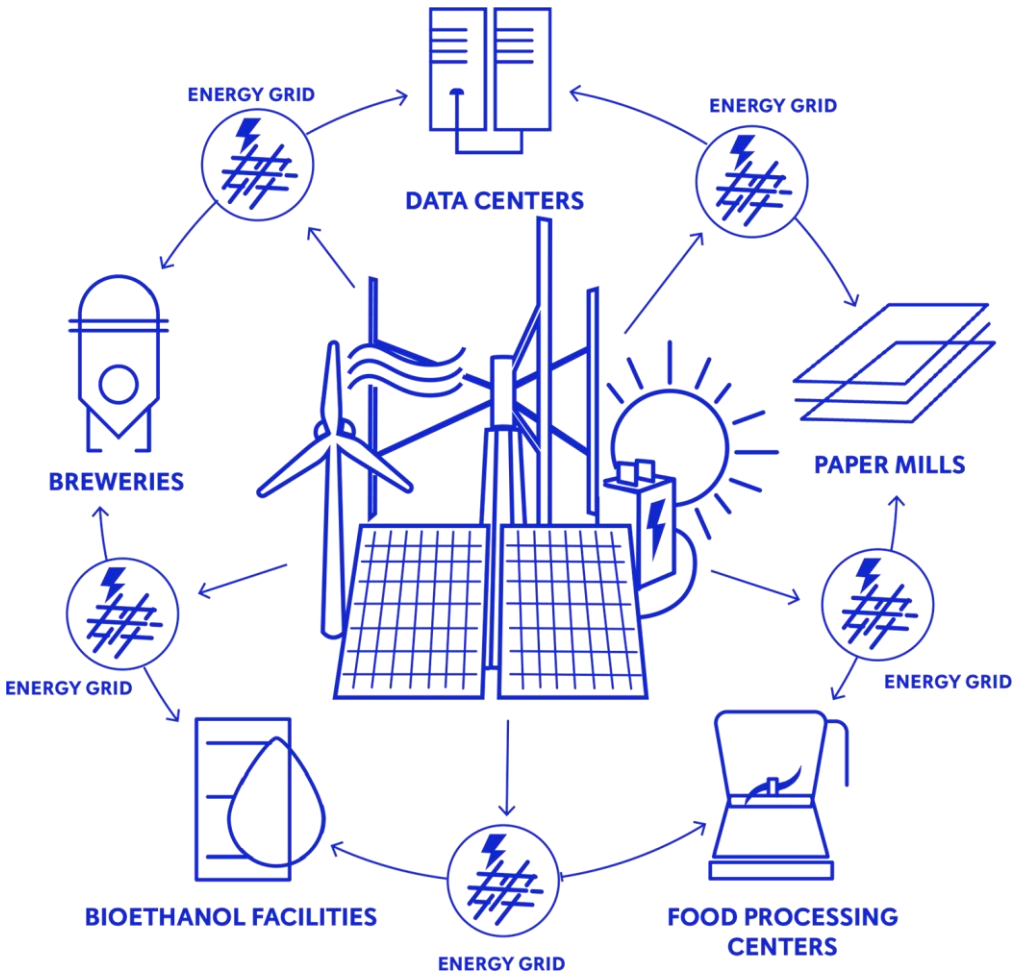
VAWTs shed vortices that draw down **faster moving wind** into HAWT blades

Extend HAWT fatigue life by 10 years



Vertically-staggered (VS) wind farm

Figure in Shengbail Xie, Cristina Archer et al., 2016



Other Uses of Short *Wind Harvesters*

- 5-10 MW projects that supply the local distribution grid with power
- Properties with tight setback easements
- Airports and Air Force Bases with radar issues
- Islands like Barbados where tourism and problematic roads make tall turbines unusable
- Telecom towers on windy ridgelines
- Places where visual impacts are important
- Bird and bat sensitive properties - VAWTs are safer for animals than HAWTs

USE CASE: Islands

Barbados Has Great Unused Mid-Level Trade Winds

The country is struggling to meet its renewable energy goals.

- HAWTs are **too large** for views, roads and setback easement
- Solar takes up **too much land**
- Feed In Tariff PPA at US**$ 0.17/kWh**
- **100s of MWs** of 6-7m/s (13-16 mph) mid-level winds are unused
- Windy government **land is available**
- **50% of each *Wind Harvester*** can be made and assembled on the island

USE CASE: High Energy Using Facilities

e.g. Data centers, distribution warehouses, large breweries

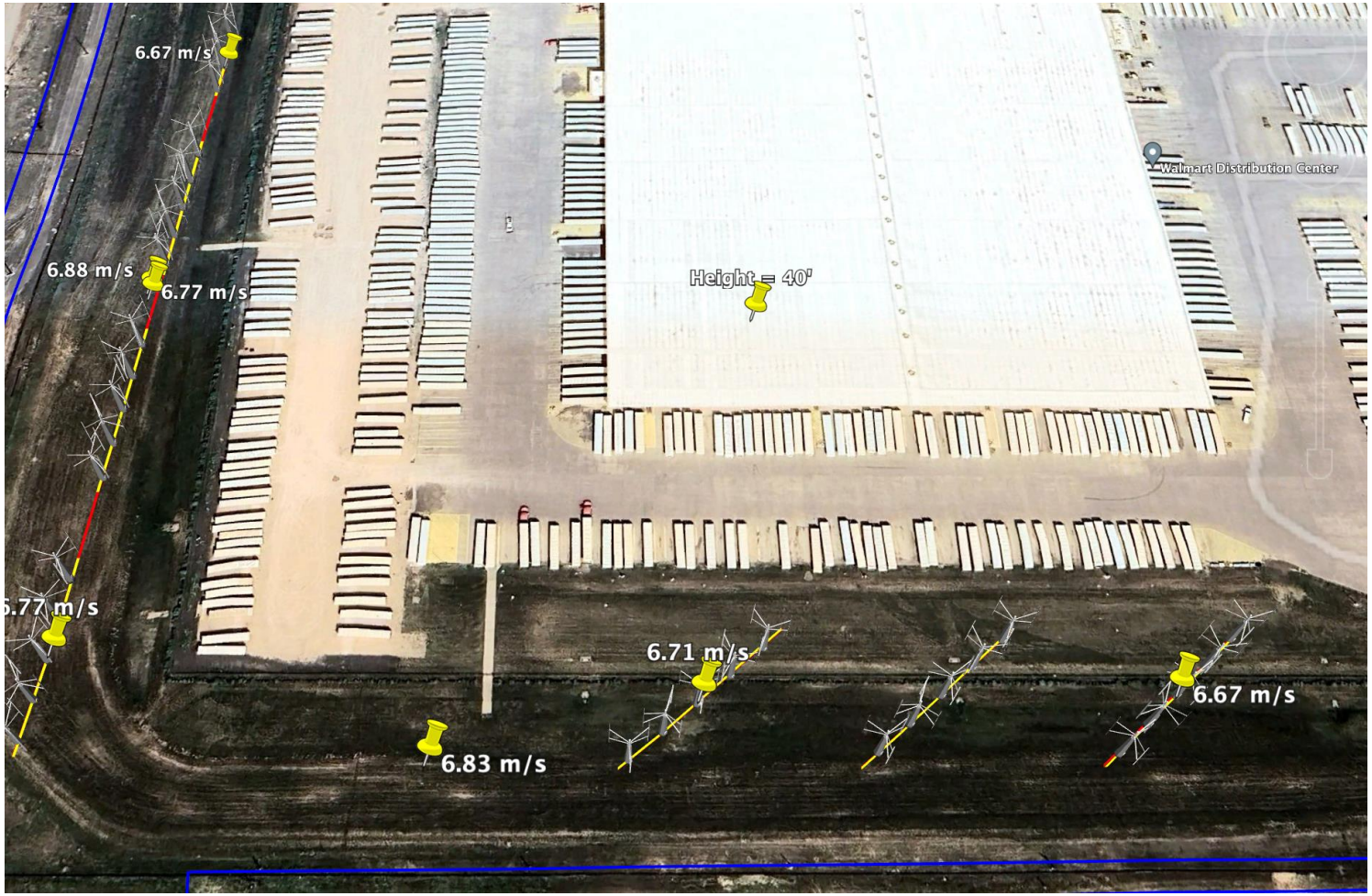
Wind Harvest

- Tall turbines don't fit on these properties
- EVs will increase energy demand
- High-value PPAs
- Complements solar *(wind blows at night)*
- 30-50% Investment Tax Credits
- Easy to permit, build and maintain

Use Case: ”Behind the Meter”

Walmart Distribution Center- Cheyenne WY

- **Possible buildout**: 8 MW
- **Ave Wind Speed** at 20m agl – 6.7m/s
- An**nual Production** per MW – 3200 MWh
- Project Total – 25,600 MWh/year
- **Gross Turbine Sale -** $32M
- **Margin** – 25% – $8M



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USE CASE: Ellsworth AFB, South Dakota

Pilot Project to Open Airports and Military Bases

- A two-turbine pilot project
- Research impacts on radar and flight patterns
- Potential for 5+ MWs on Base
  - 96 turbines
- Pilot project opens *Wind Harvester* for sales to Anderson AFB in Guam and Travis AFB in Solano County, California

A build out of Wind Harvesters envisioned for the north side of the AFB.

Possible Competition:

Wind Harvest

Offshore

SEATWIRL®

WorldWideWind

Not For Turbulence

XFLOW ENERGY

FAIRWIND
Votre énergie pour demain

Early in TRL

AIRLOOM ENERGY

Small & Inefficient

Flower Turbines

First-to-market advantages:

- 1st VAWTs made for turbulence
- Others will need Wind Harvest's patents

Waiting for the 1st Certified VAWT

Wind Harvest

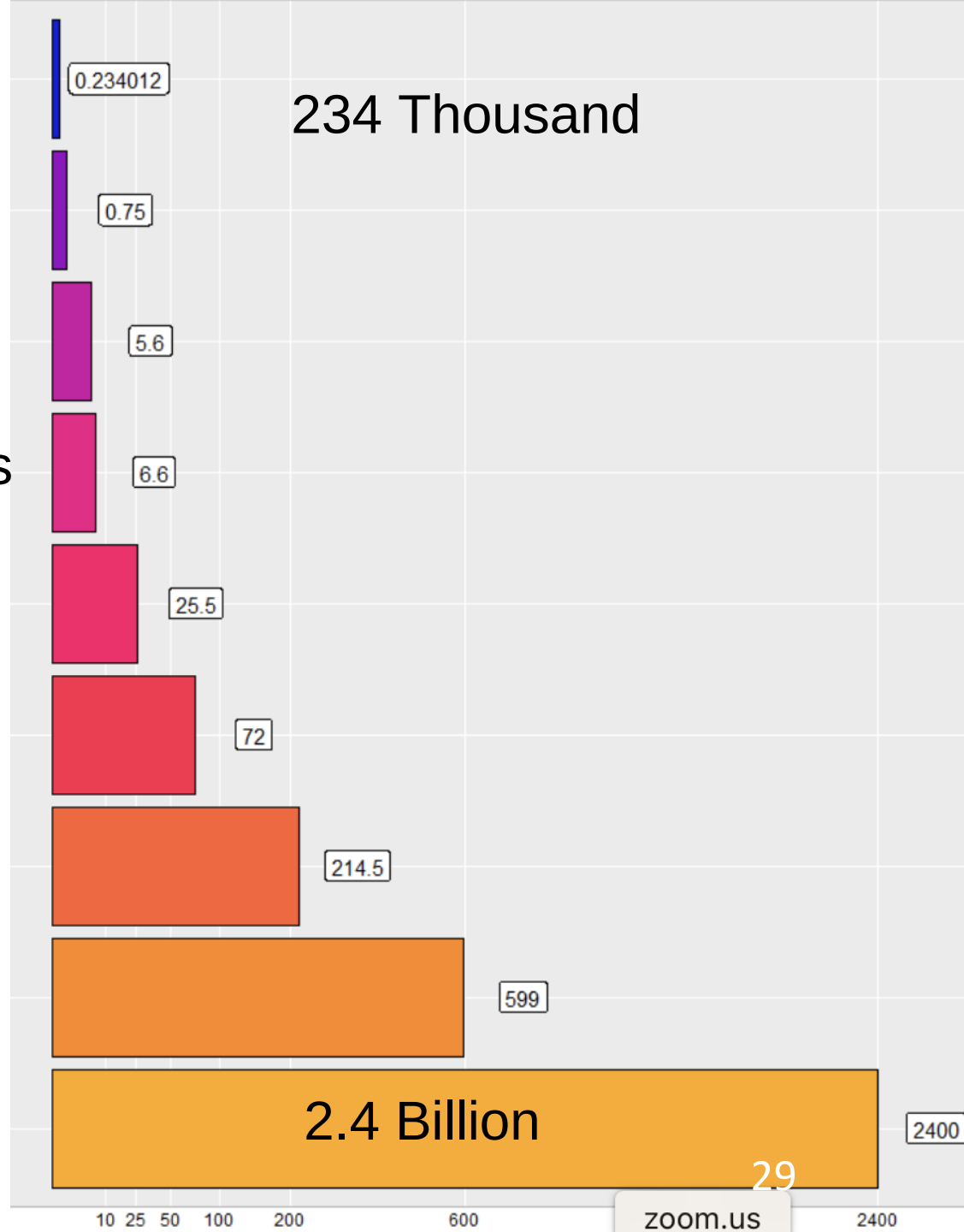
- No experience, engineers, or engineering models for VAWTs
- Know the turbulent wind resource is big
- Buy innovative companies to enter new markets

Perspective:

Wind Power is a Small Problem for Birds

1/10,000th of death from cats

Report from USFWS



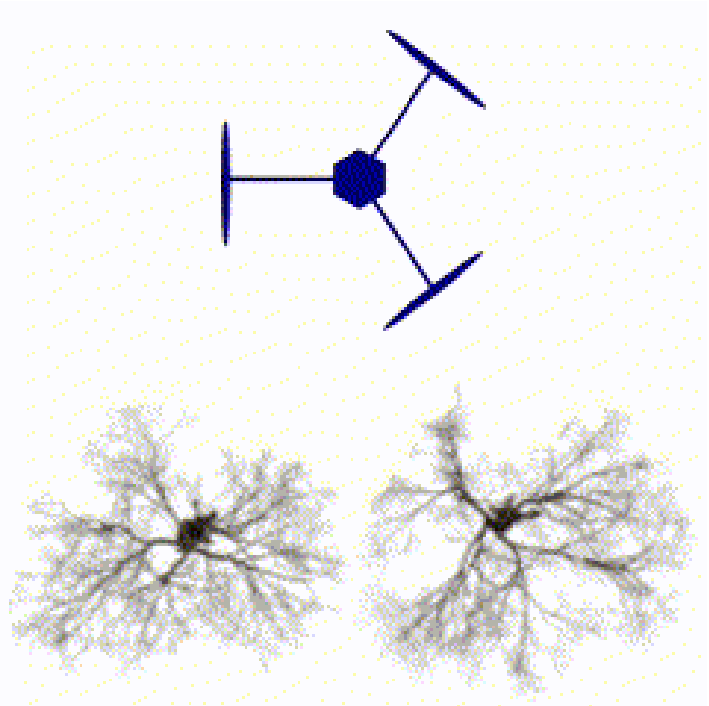
SOLUTION: *Wind Harvesters*

Wind Harvest

- **Short:** below the migratory paths and soaring altitudes of many species
- **Slower Speed of Blade Tips:** 40 to 80 mph
- **More Visible:** 3D vs. 2D
- **24/7 Motion Detection:** slow or stop turbines when necessary

Birds resting on Model 3.0, Denmark

3D Advantages for VAWTs



- Animals evolved in a 3D world
- Birds can see and avoid fast moving cars
- Blades move towards birds in the direction they are looking
- Every 1/3 second, a blade passes by

Motion Detection

- DT Bird dual cameras use changes in pixels
- Nvisionist cameras identify birds by photo recognition
- Both have deterence programs
- Both can shut down turbines
- DT Bird uses infrared to identify birds and bats at night

Less Habitat Lost

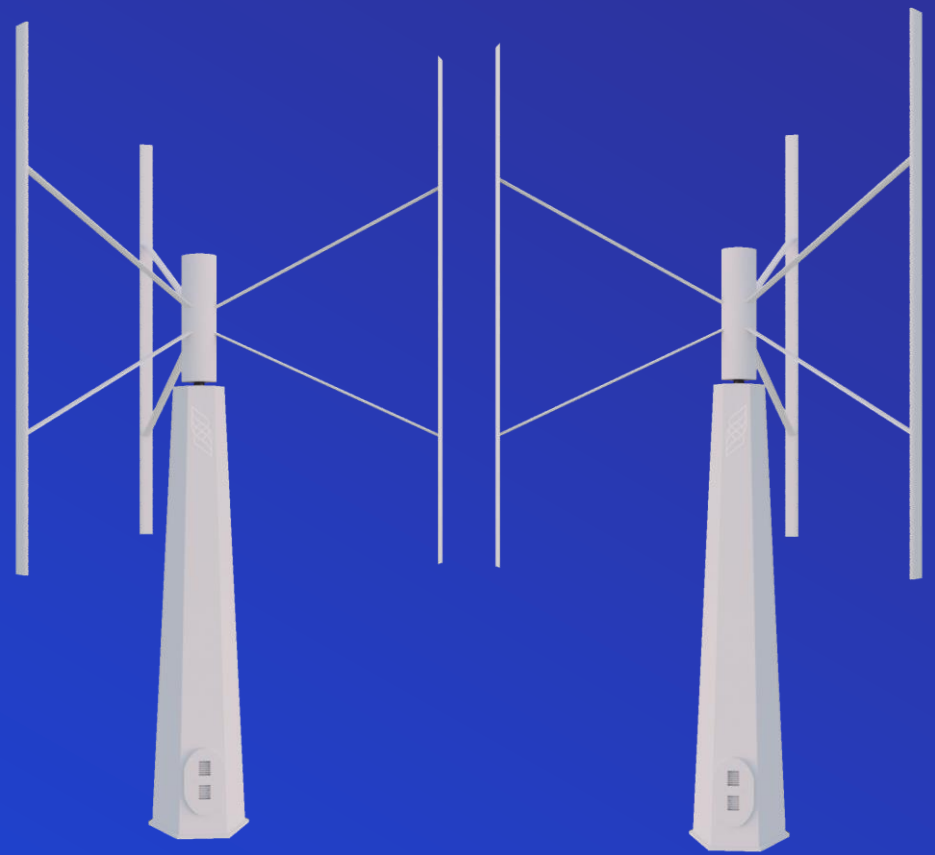
Wind Harvest

- Solar farms cover land and reduce habitat benefit
- New roads need to be built to access remote sites
- New transmission lines cut through wildlife areas

Wind Harvest

Creating New Markets for Wind Turbines

- First utility-scale turbines to operate in turbulent wind
- Difficult for potential competitors to make utility-scale VAWTs without licensing our patents
- $100+M in sales being developed for 2025- 2027
- Wind farm owners and developers want our turbines
- Near-limitless scalability. Many suppliers for the components.



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Wood Towers

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Vesta Wood Towers

Upsala 200kW VAWT Wood Towers

Ferrite “Pancake” Generators

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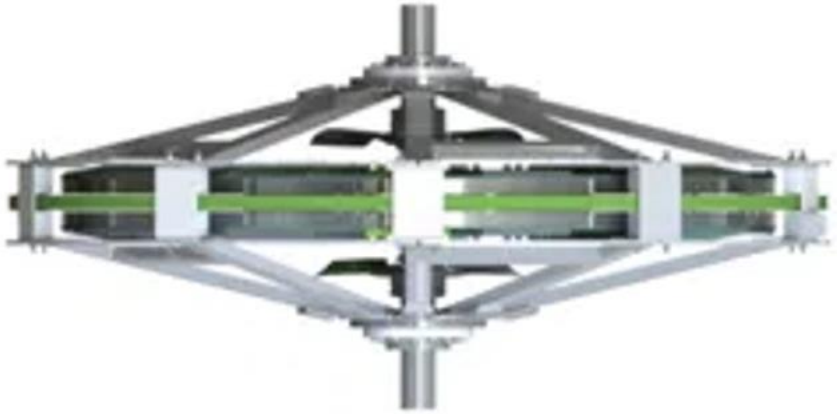
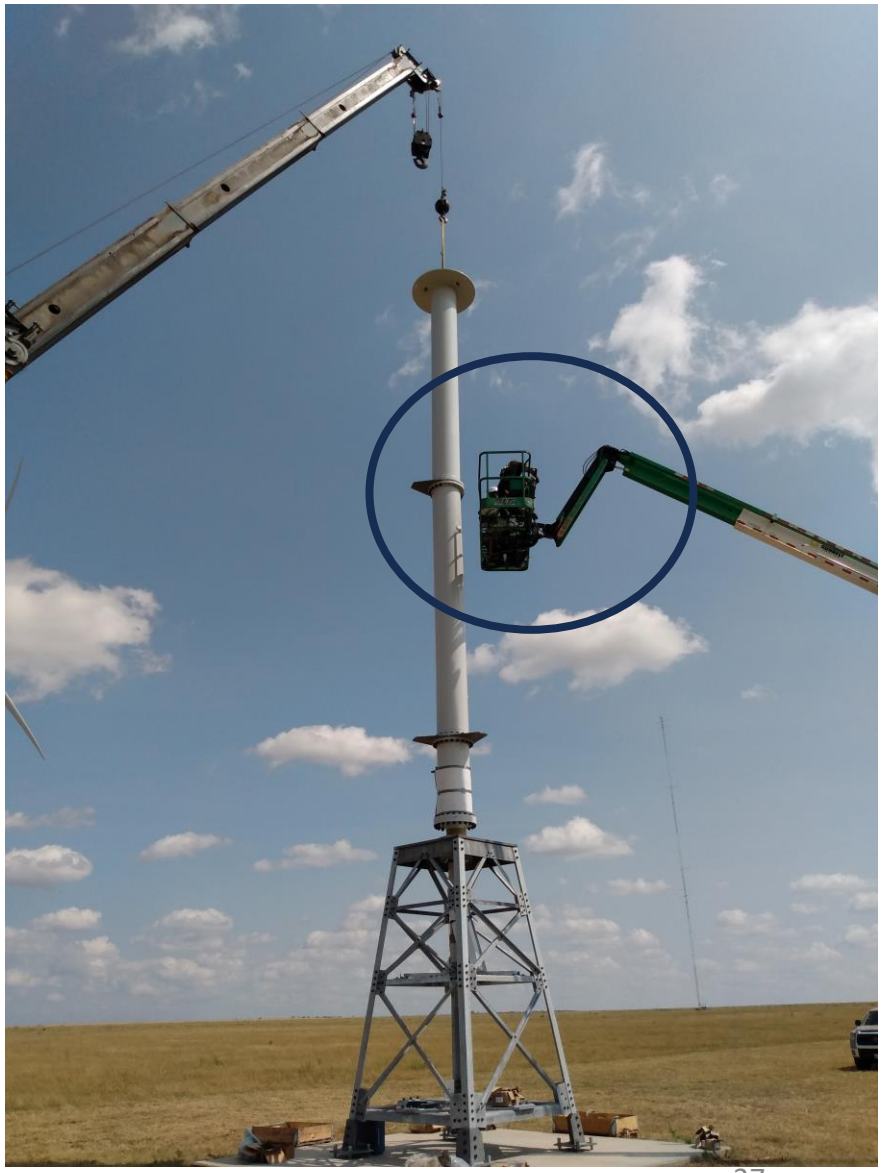


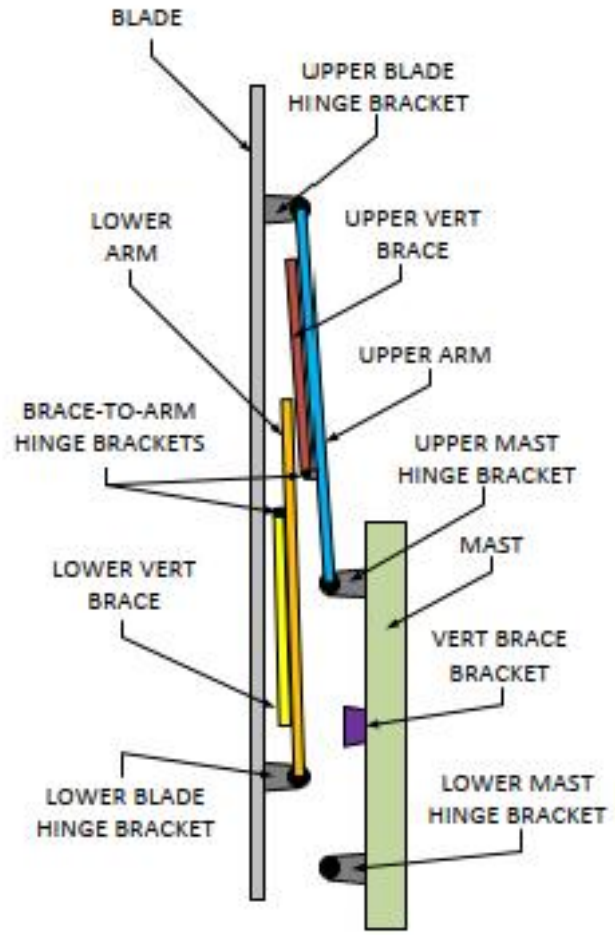
GreenSpur
RARE EARTH-FREE ENERGY
A Time To ACT plc business

Model 3.1:

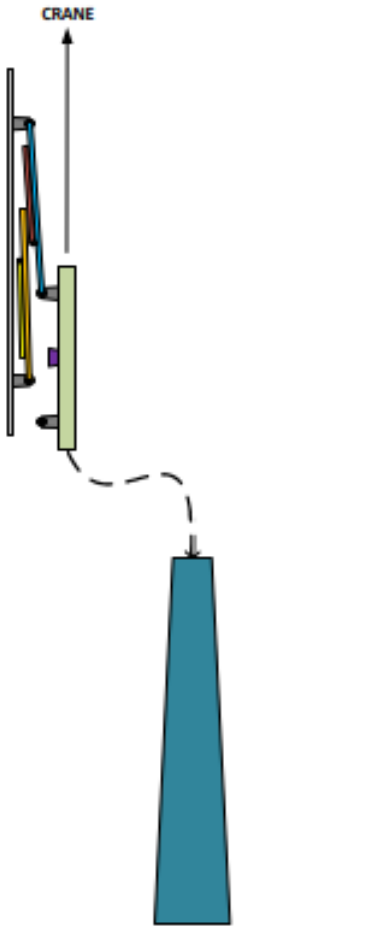
Mast Assembly



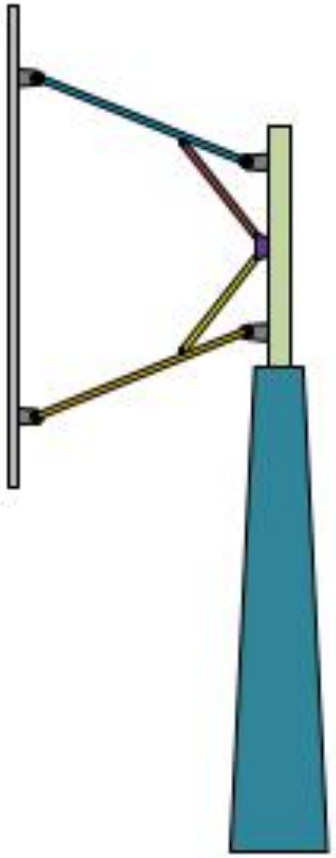
First Look: Collapsible Rotor



COLLAPSIBLE ROTOR ASSEMBLY

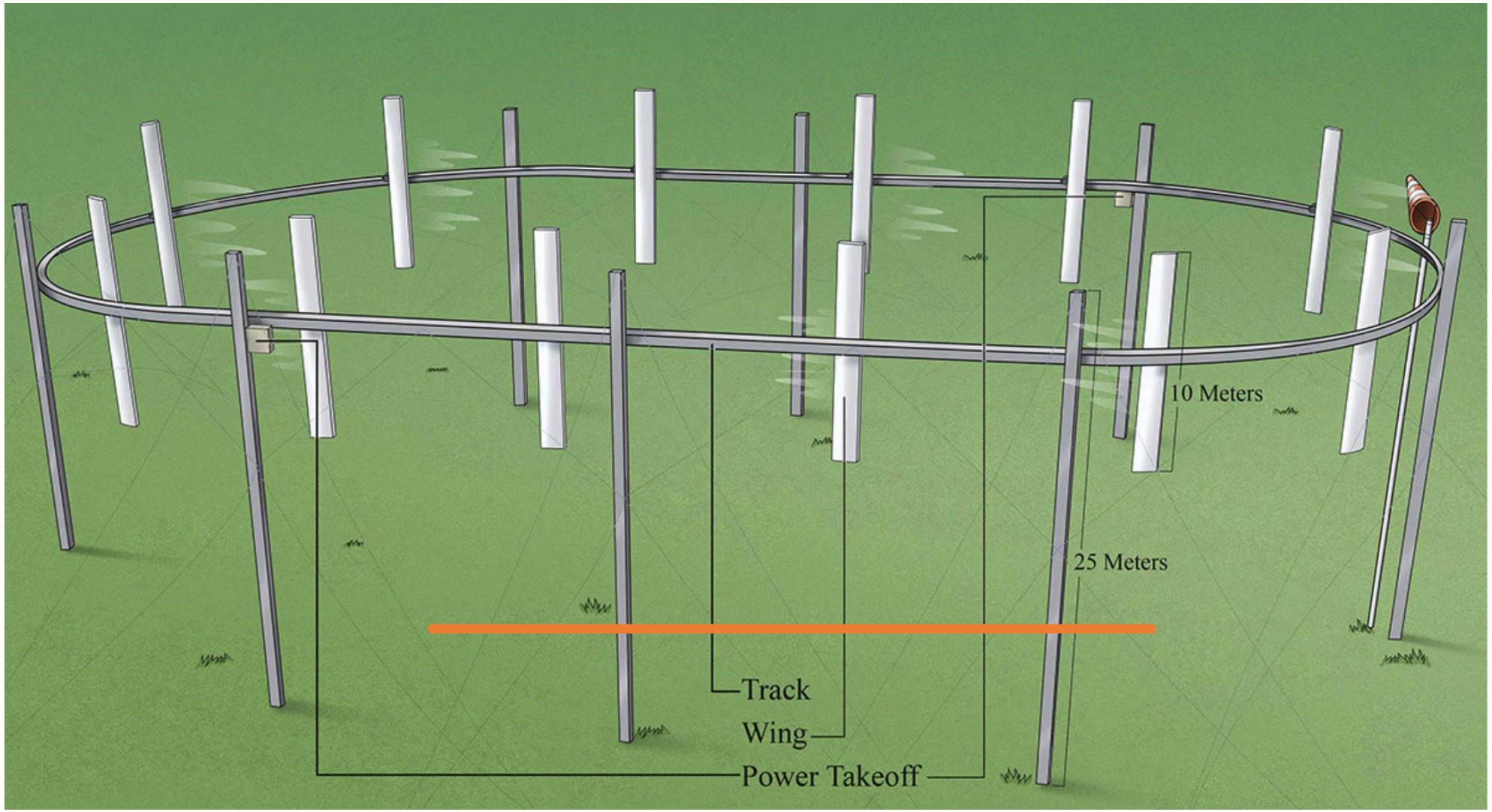


PLACE COLLAPSED ROTOR ASSEMBLY ONTO DRIVESHAFT / TOWER



BLADE/ARM ASSEMBLY FULLY SECURE AND IN FINAL POSITION

AirLoom Energy – a Wind Sail



Impacts of HAWTs on Bats:

- Blade tip speeds exceed 150 mph and can create “barotrauma” for bats
- 2d shape isn’t natural
- Blades are coming from above or below and not horizontally towards them.
- Height can impact migration

Bird and Bat Deterrence and Avoidance

- Sound – subsonic or audible
- Light – flashing
- Third blade painted black
- Slow rotor speed or shut turbines down
- Birds and bats don’t fly when it is very windy. Shut turbines down in low wind speeds.