

# World's First Triple Turbine Ultra Low Wind Power Generation System

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## Abstract

The first wind power generation system, namely INVELOX™, with three turbines is presented in this paper. This breakthrough technology is often referenced as "The New Face of Wind Power." INVELOX solves three key challenges with the current wind turbines. First, the cut in wind speed can be as low as 1 meter per second, allowing wind power generation to take place nearly anywhere around the globe. Second, INVELOX has adjustable rated wind speed in the range of 4 to 7 meter per second. This is perhaps the most breakthrough feature of the technology. The adjustable low rated wind speed allows for capacity factors to reach 70 to 90%. Significantly reducing intermittent power generation that is often associated with wind power. Third, the rotor diameter is reduced by 80% allowing for greatly reduced production costs, much easier and less costly transportation & installation, not to mention safely housing turbine/generators near ground level results in much safer and cost-effective O&M.

In addition to the three breakthrough features, INVELOX has no radar interference and does not harm birds, wildlife,

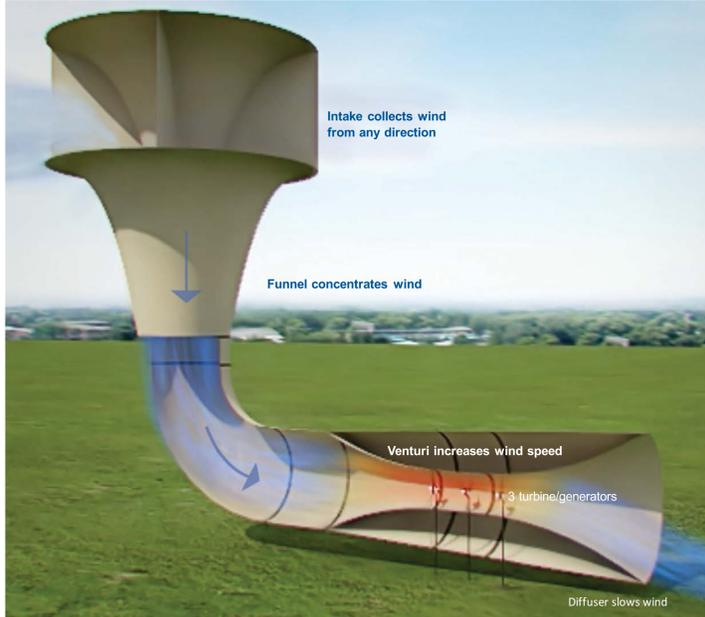
or people around it. For these reasons, this breakthrough product was purchased by the U.S. government and The Nature Conservancy along with The U.S. Fish & Wildlife Service in 2015. The U.S. Army National Guard has installed one unit near Battle Creek in Michigan in early 2016, and two units will be installed near Camp Grayling in Michigan by September 2016. The Nature Conservancy's installation is on Palmyra Atoll, located 1000 miles away from Hawaii, and is a scientific research station and a national wildlife refuge.

The INVELOX system funnels wind through to increase its speed and deliver to three turbines in series housed in the Venturi section of the funnel. Multiple turbines allow for nearly zero downtime and the ability to upgrade should the power demand of the customer change. The U.S. government will consider INVELOX installation for facilities across the USA after successful demonstration of the above-mentioned systems. The Nature Conservancy is using a combination of solar and INVELOX wind power generation systems to make its wildlife refuge free of fossil

fuel. Details of the system and its performance will be presented. Installing INVELOX the only wind power generation system that increases wind speeds for high power generation is the only viable option for many government facilities, wildlife refuges, commercial processing plants, manufacturing plants, and cities that are seeking to be sustainable. INVELOX can easily be installed on existing buildings or be integrated into new construction. Its widespread application has been changing how wind power is perceived through the lens of this innovative, elegantly simple product.

The first installation is near Battle Creek, Michigan. Based on the collected data in late 2015 and early 2016, wind speeds were increased speed by 7-12 times, with maximum wind speeds reaching 75 meters per second inside the Venturi. This means the power capacity of the 3-meter rotor may reach 100kW from a free wind speed of 3 to 5 meter per second. The system can have up to three wind turbine generator systems with the total output power reaching over 200kW at wind speed less than 5 meters per second.

## How it works



**INVELOX uses the ducted turbine concept in a new way.** By separating the turbines from the duct, we eliminate the large structural addition to the turbines.

- Historically ducted turbines have shown positive results:**
1. Speed increase
  2. Power increase
  3. At small scale outperform traditional windmills
  4. Lower cut-in speed
  5. 2x speed increase potentially results in 8x more power same rotor size

- Challenges of traditional ducted turbines:**
1. Duct & WTG installed on top of tower
  2. Blade pitch control required
  3. Yaw control required
  4. O&M increase
  5. Manufacturing limitations/cost
  6. Not scalable to utility size
  7. Little environmental improvement
  8. No land reduction
  9. CAPEX increase
  10. Limited applications/size/capacity
  11. Difficult business case

INVELOX successfully eliminates the above challenges and solves the wide range of issues that plague the current renewable industry. Including cost, CAPEX, capacity factor, and potential harm to flying creatures and humans.

## Renewable energy for low wind & no radar impact

### U.S. Army National Guard-Michigan

2-intake system designed for low wind conditions

Power Capacity: 200kW  
Upgradable to 1MW



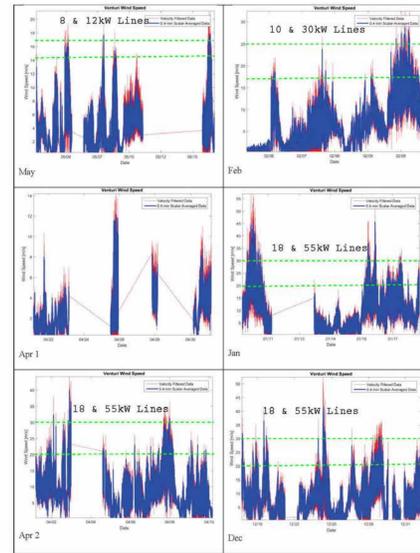
### Safely housed triple turbines

Funnel increases wind speed  
3 turbines

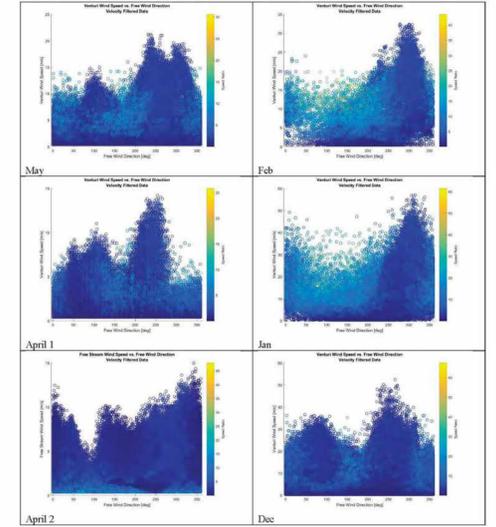
No radar interference/low frequency noise

Simplified system/no yaw or pitch  
Safer, simplified O&M

## Results

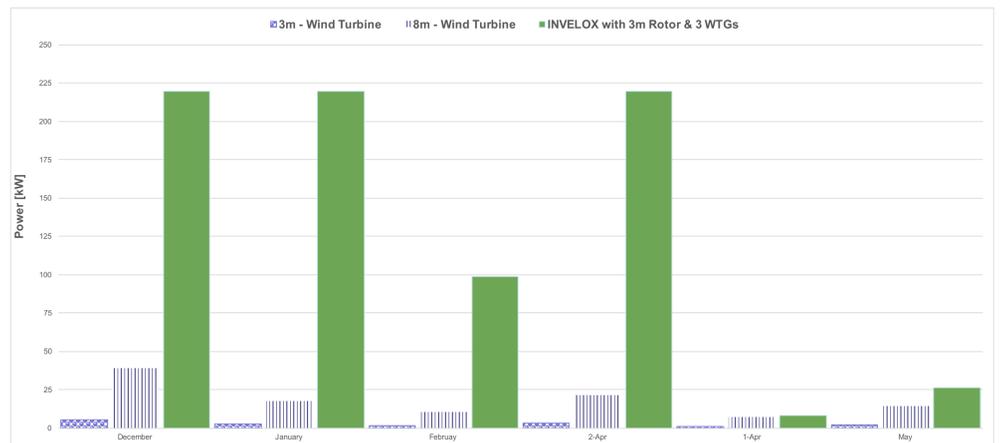


- Observation:
- 1) Maximum Venturi wind speed ranges from 15 to 60 m/s.
  - 2) Venturi wind speeds reaches 30 m/s in all data set except in late April when free wind speeds are low.
  - 3) The maximum of the 24-sec averaged VWS ranges from 6 to 45 m/s.



- Observation:
- 1) Maximum Venturi wind speed ranges from 15 to 60 m/s.
  - 2) Venturi wind speeds reaches 30 m/s in all data set except in late April when free wind speeds are low.
  - 3) Most of the 3K values range from 1 to 10.

### Maximum Power



## Conclusions

### Data INVELOX Army National Guard-Michigan

Wind speeds reached as high as 75 meters per second in INVELOX

Free stream wind speeds vs INVELOX wind speeds

1. INVELOX system increased wind speed by 7 to 12 times
2. System performed in a broad range of wind directions

INVELOX system is expected to generate its rated power with:

- 1 WTG @ 100kW
- 2 WTGs at 170kW
- 3 WTGs @ 200kW.

- Demonstrated 200 KW power generation from a 3 meter rotor
- Capacity factor increases to more than 70%

## References

1. INVELOX with multiple wind turbine generator systems, [Energy Volume 93, Part 1](#), 15 December 2015
2. INVELOX: Description of a new concept in wind power and its performance evaluation, [Energy Volume 69](#), 1 May 2014
3. INVELOX: A NEW CONCEPT IN WIND ENERGY HARVESTING, ASME 2013 7th International Conference on Energy Sustainability & 11th, Fuel Cell Science, Engineering and Technology Conference

## Methods

Wind speeds are based on actual raw data measured in the field. The estimated power is based on the designed power curve of the rotor.

