

# Shutdown Controller Design for SUMR Wind Turbine



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Renewable Energy

<https://youtu.be/5kAJMRGaWJQ>

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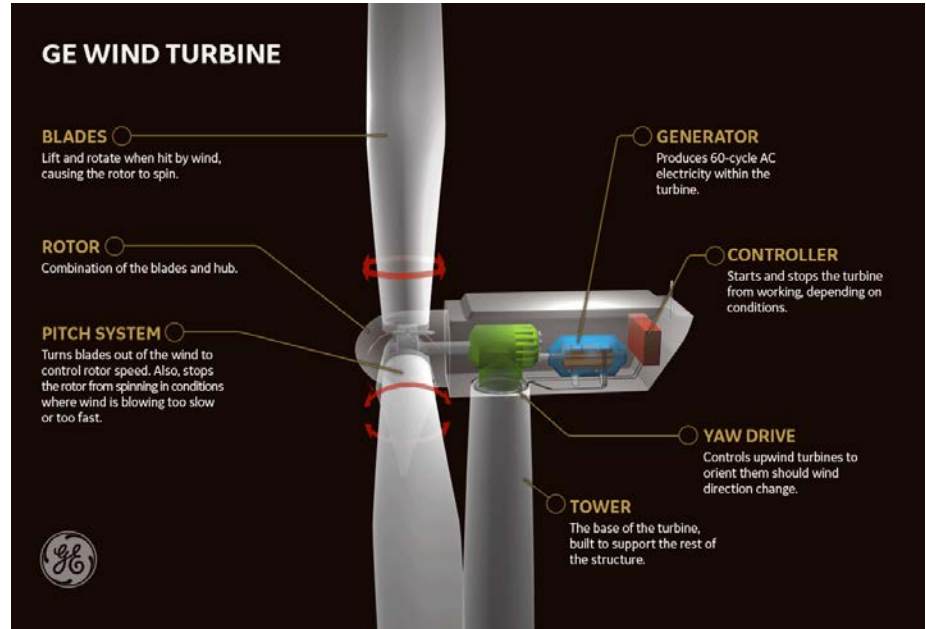
# Introduction

- ❖ For wind power to maintain and improve competitiveness building larger wind turbines with lower energy costs is needed
- ❖ Traditional upwind blades are too expensive and too heavy to avoid striking their towers
- ❖ SUMR team has designed huge and novel wind turbine



<https://gifer.com>

## Traditional wind turbine



<https://gifer.com/en/IuK>

# Introduction



<https://giphy.com/gifs/wind-weather-miami-HmTLatwLWpTQk>



[https://www.123rf.com/photo\\_73870464\\_damaged-broken-](https://www.123rf.com/photo_73870464_damaged-broken-)

- ❖ Wind turbines may break down during storm
- ❖ SUMR team has been inspired by palm trees
- ❖ Palm trees bent during the storm so they do not fall off like other trees.
- ❖ SUMR team has designed blades that can
- ❖ morph and sway with the wind can align with the blade path to decrease loads on blades during storm



Palm Trees Design

<https://www.energy.gov/articles/enormous-blades-offshore-energy>

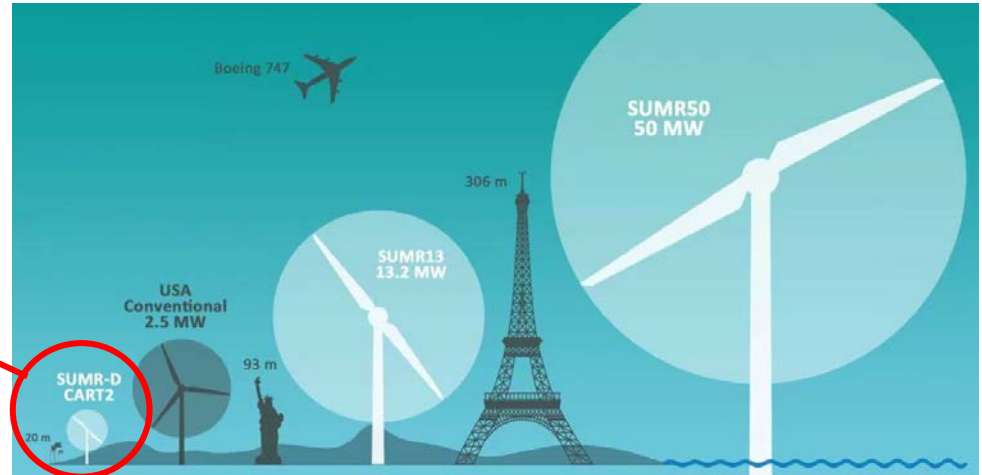


# Introduction

- SUMR turbine: Segmented Ultralight Morphing Rotor, downwind, 2-bladed



Video courtesy of NREL



Picture source: [<https://sumrwind.com/>]

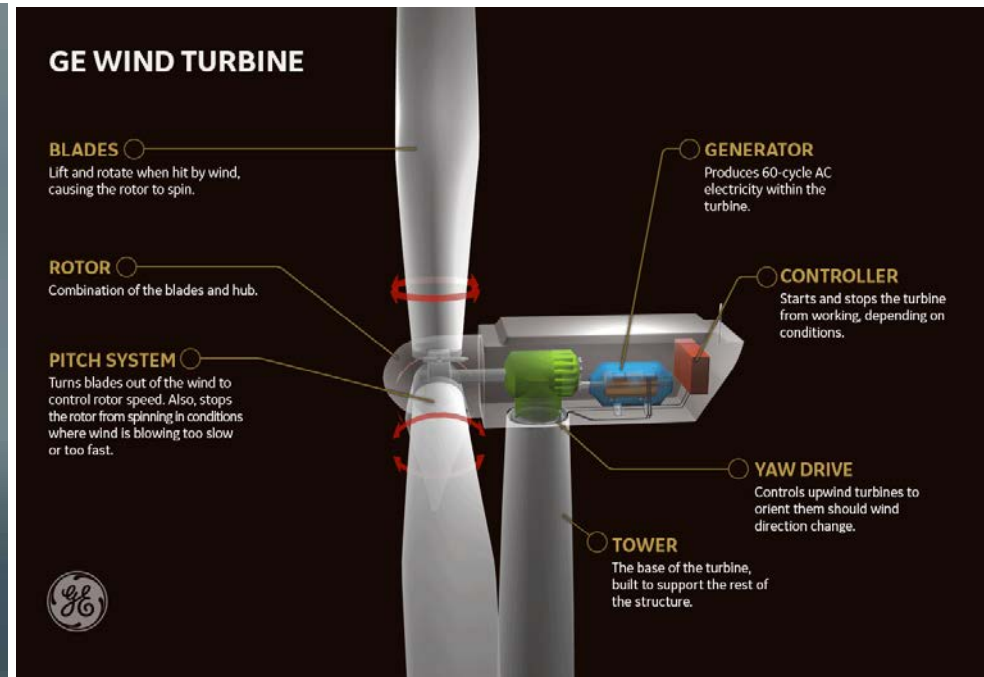
For the big project, we start with the small

# Motivation

- ❖ Shutdown in high-speed can be breakdown wind turbines
- ❖ New method of shutdown can decrease damages on wind turbines from shutdown procedure



Credit: [<https://www.youtube.com/watch?v=ZMNqjirbWoQ>]



<https://giphy.com/>

# Objective

- ❖ Producing maximum energy extraction
- ❖ To keep the wind turbine safe during shutdown procedure

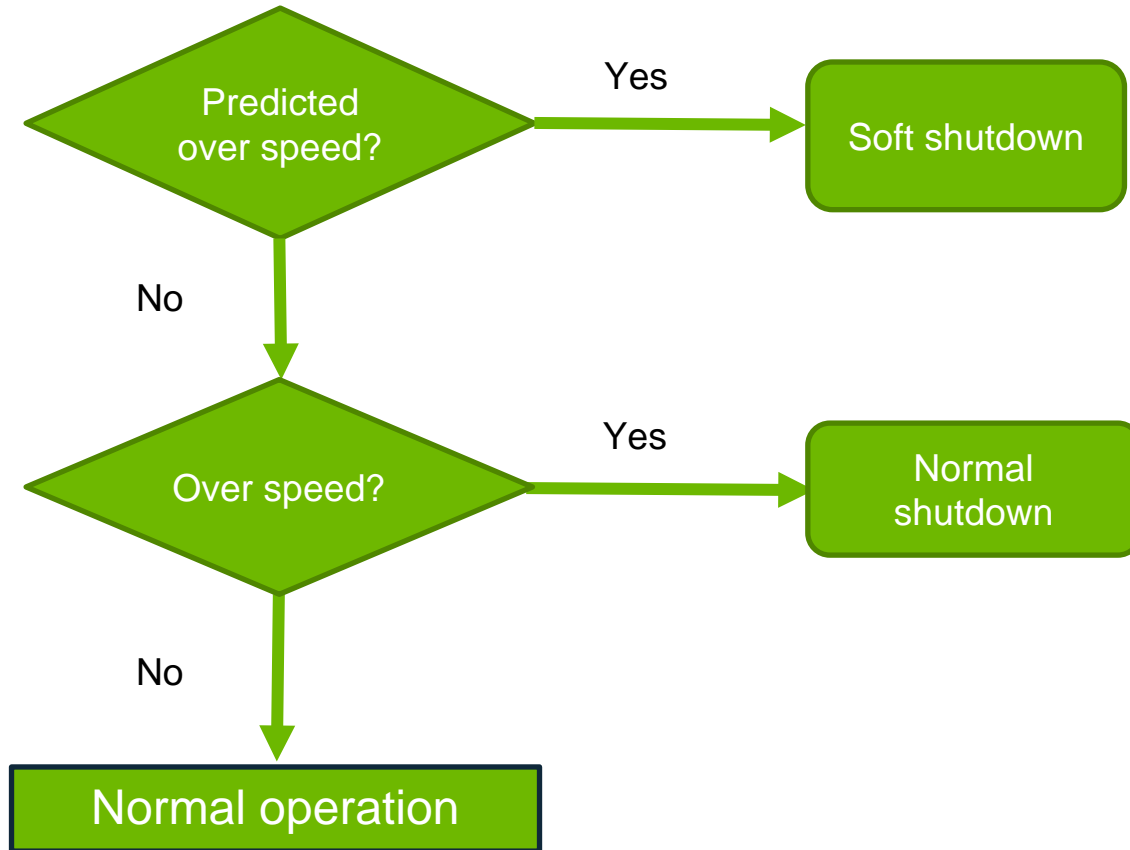


# Methods

- ❖ My method predicts rotor speed ahead of time
- ❖ If rotor speed exceeds the allowable speed limit, if it exceeds:
  - ❑ Then it triggers the soft shutdown controller 2.5 seconds earlier
  - ❑ More time is available to apply a “soft,” gradual shutdown

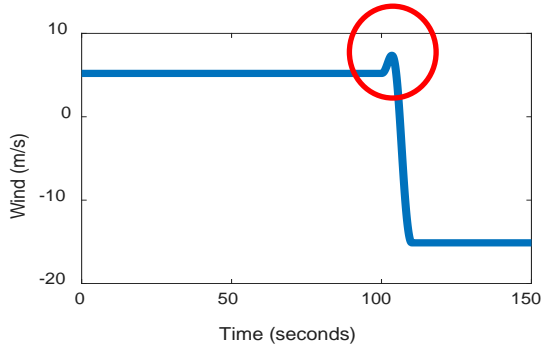


# Methods -Shutdown Decision Procedure

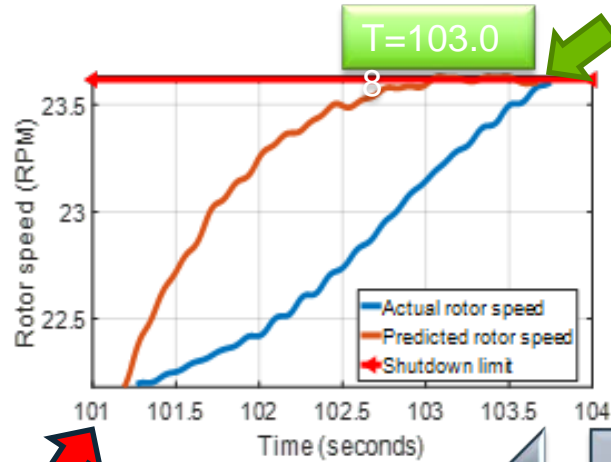




# Results

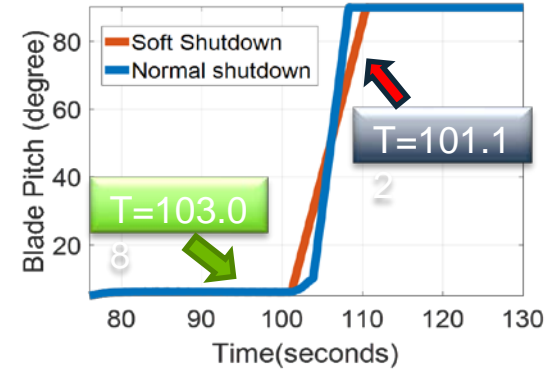


Sudden high wind speed



T=101.1

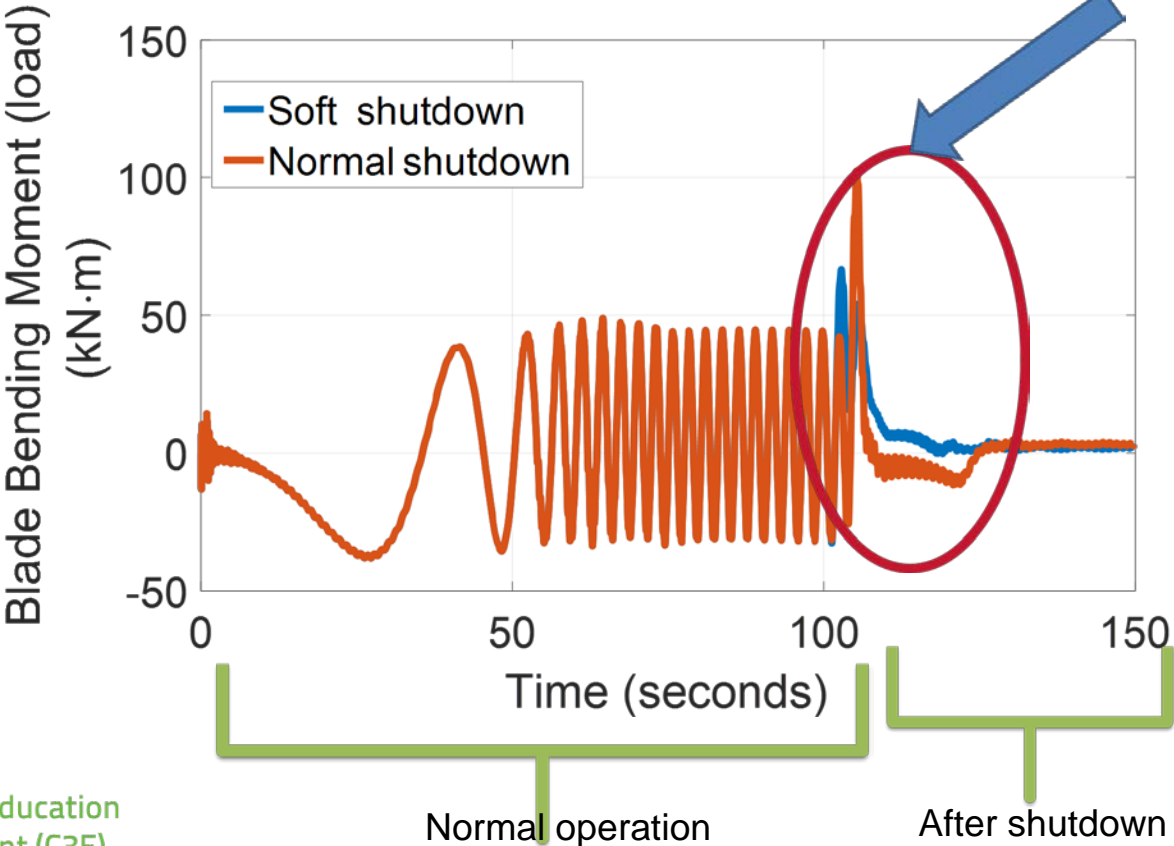
Predicted rotor speed is close to the actual rotor speed



Triggered earlier shutdown than normal one, so there is enough time for a soft shutdown

# Results

Peak load induced by shutdown procedure



# Conclusions

- ❖ The soft shutdown controller was developed to safely shutdown the wind turbine blades
- ❖ It generates less peak load on the blades compared to normal shutdown
- ❖ Soft shutdown helps to reduce the cost of maintenance of the wind turbines



# Future work

- ❖ Model predictive control is on going work that can reduce the number of the shutdown



Images courtesy of NREL

# Acknowledgments



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**ENERGY**

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# References

1. Kianbakht, S., & Johnson, K. (2019). Model based soft shutdown controller for SUMR wind turbine. In *AIAA Scitech 2019 Forum* (p. 1299).
2. Kianbakht, S., & Johnson, K. Shutdown Controller Design for a 13 MW Segmented Ultralight Morphing Rotor Wind Turbine.
3. <https://sumrwind.com/>

Thank you