

# On the Effects of Directional Bin Size when Simulating Large Offshore Wind Farms with CFD

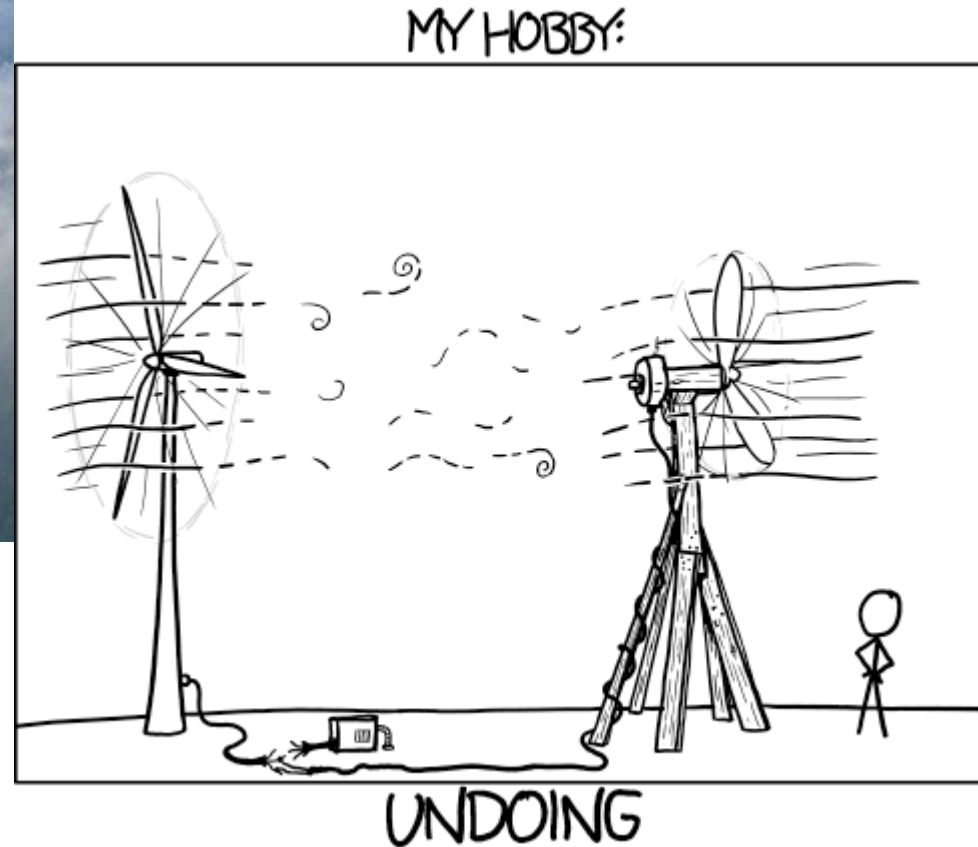
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# Reason for study



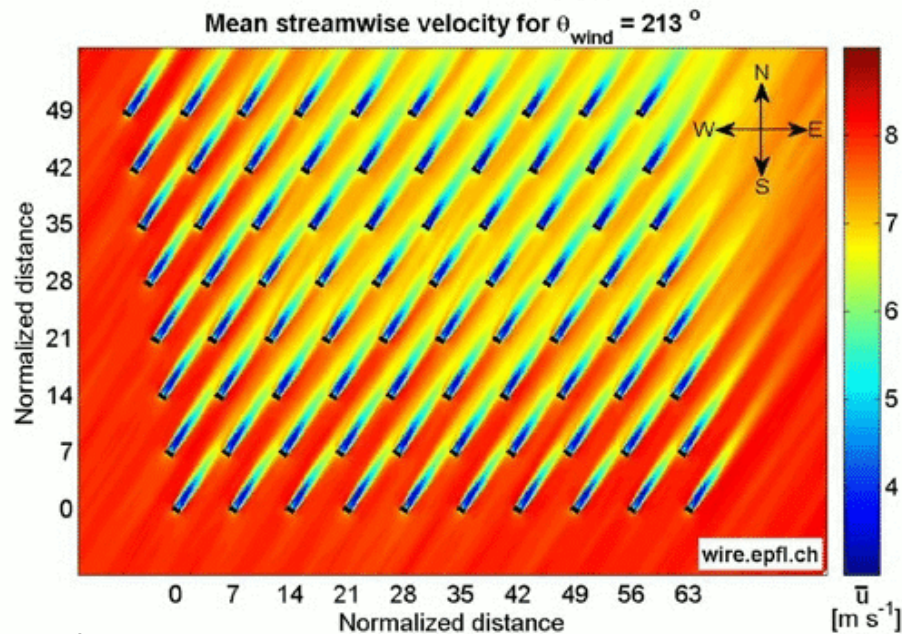
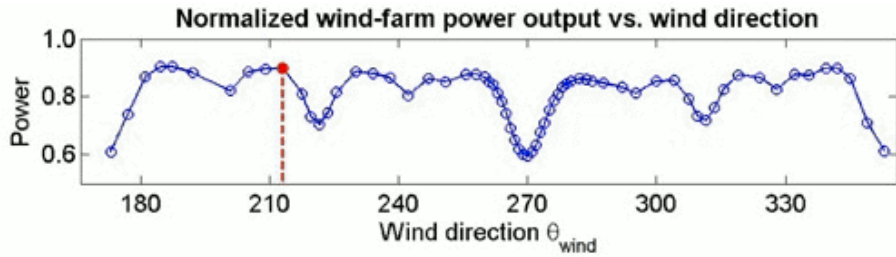
Many people have ideas about how to reduce the observed turbine wakes:

Solutions are often developed based on CFD results, but how do we ensure simulations actually represent reality?

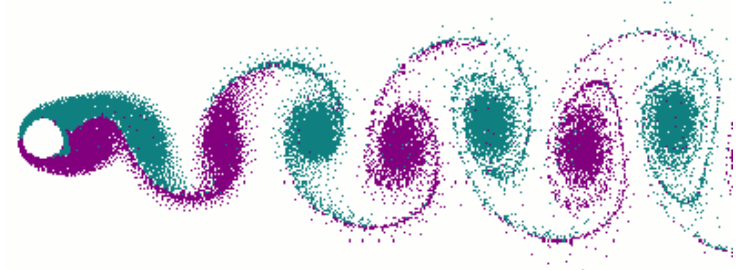


Permanent link to this comic: <http://xkcd.com/1119/>

# Why Does Bin Size Matter?



Wake Meandering / Vortex shedding

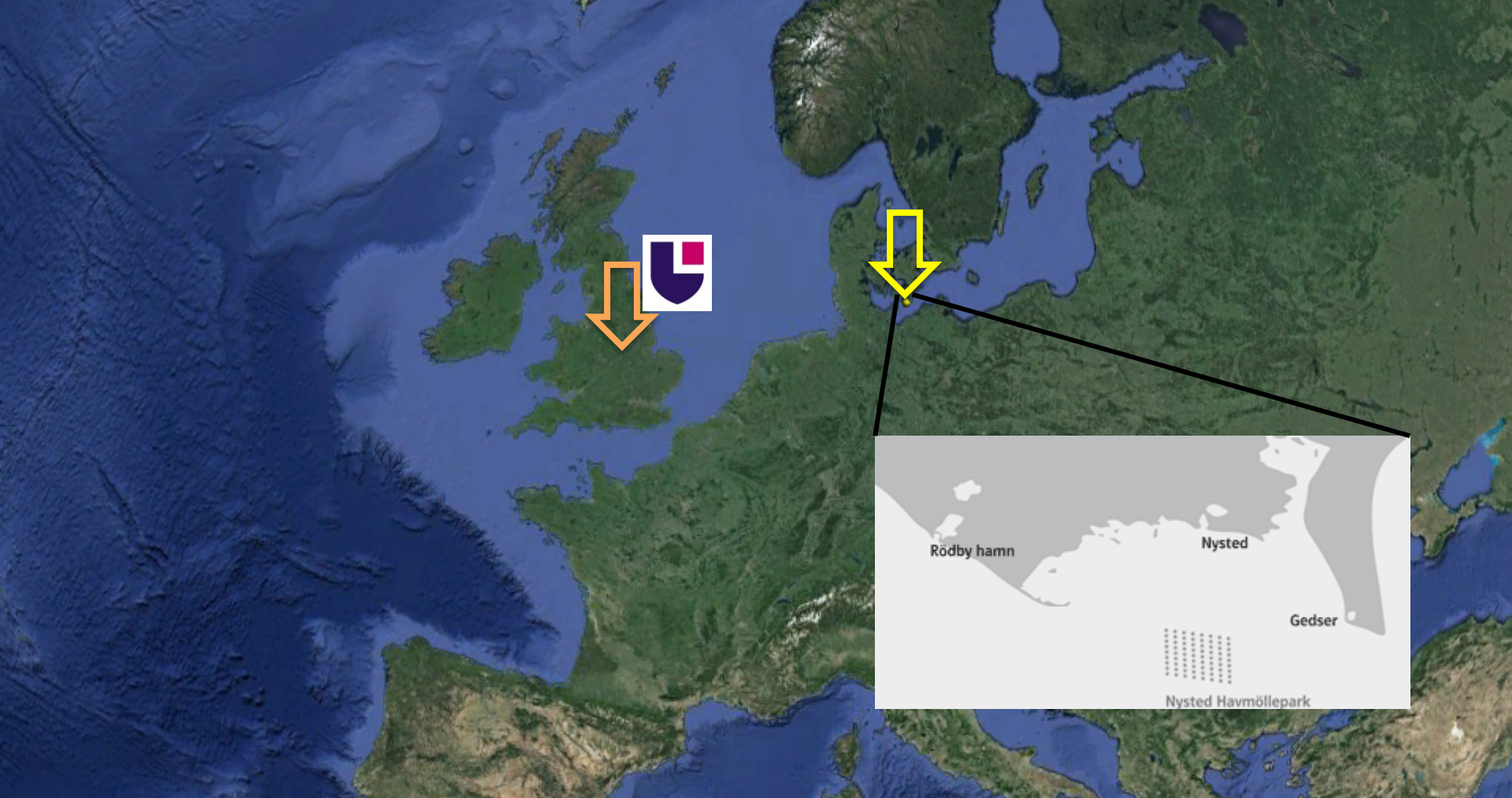


## Wake Losses:

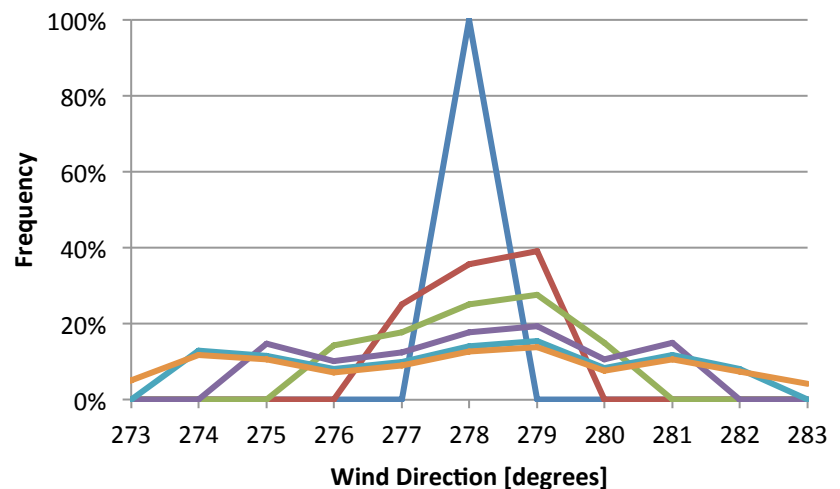
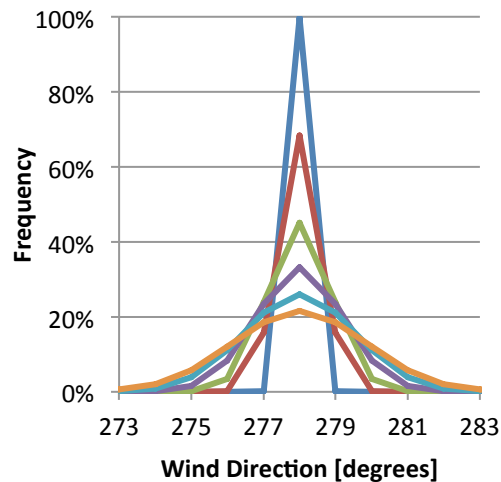
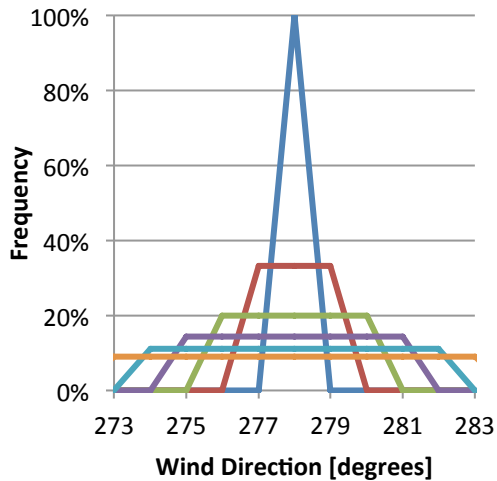
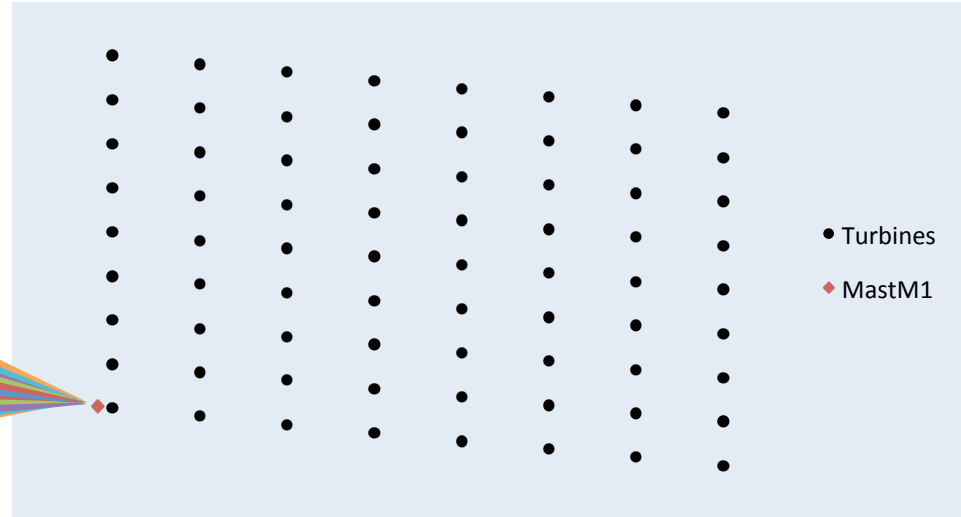
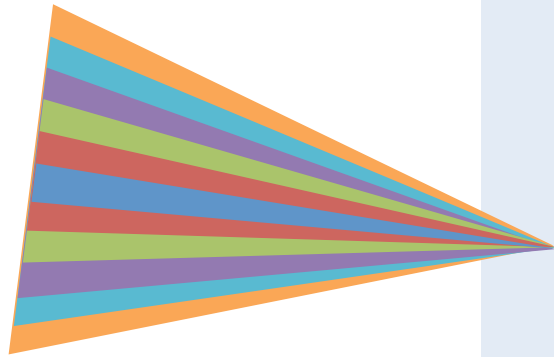
Porté-Agel, F.; Wu, Y.-T.; Chen, C.-H. A Numerical Study of the Effects of Wind Direction on Turbine Wakes and Power Losses in a Large Wind Farm. *Energies* **2013**, *6*, 5297-5313.



# Case Study

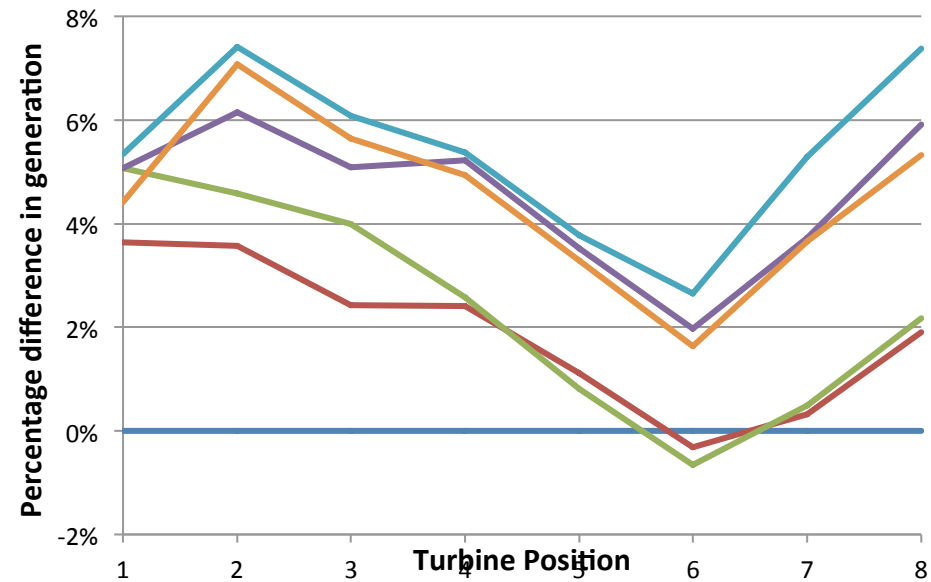
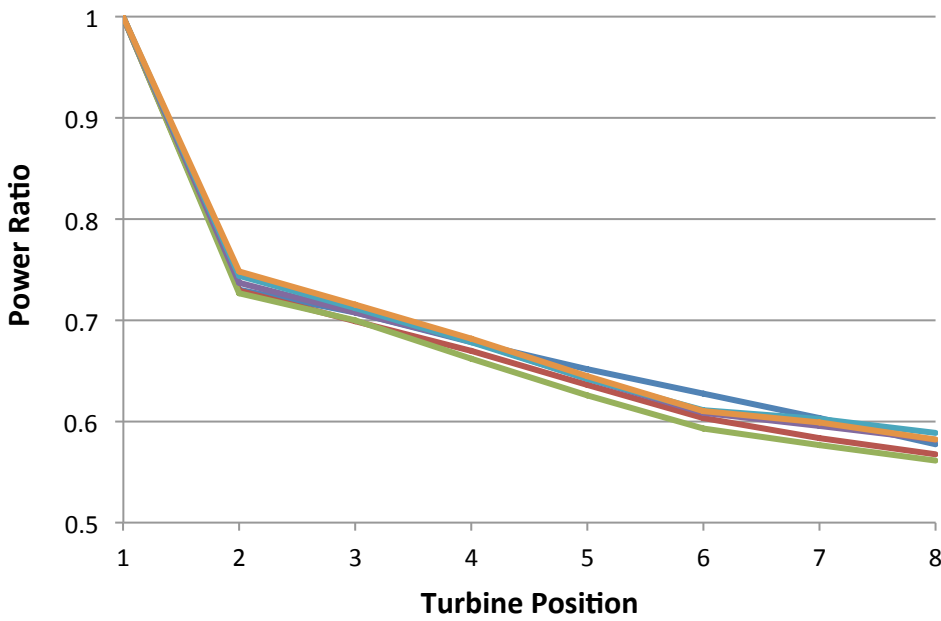


# Bin Size/Shape Considerations

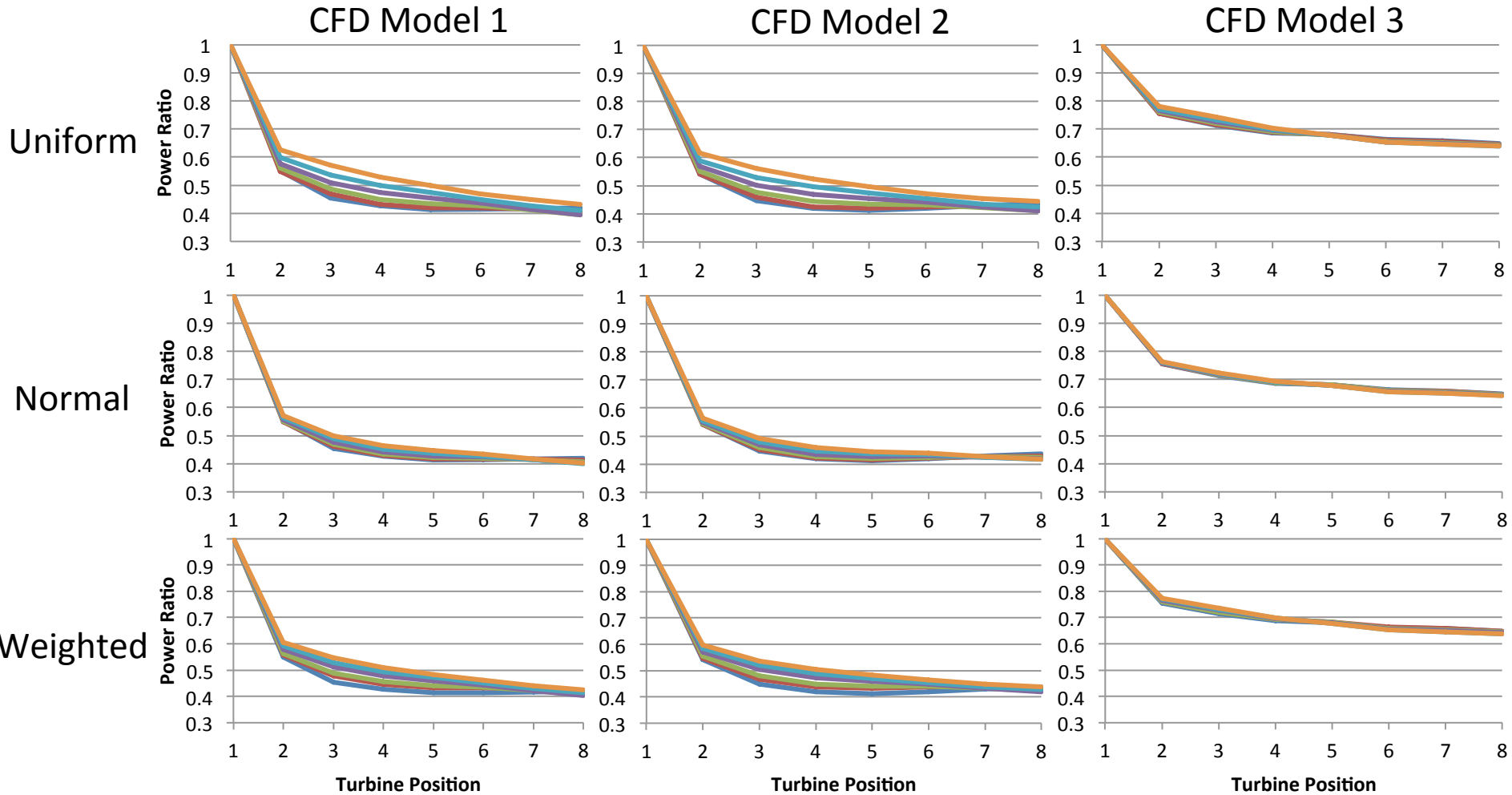


# Bin Size Effects on Measurements

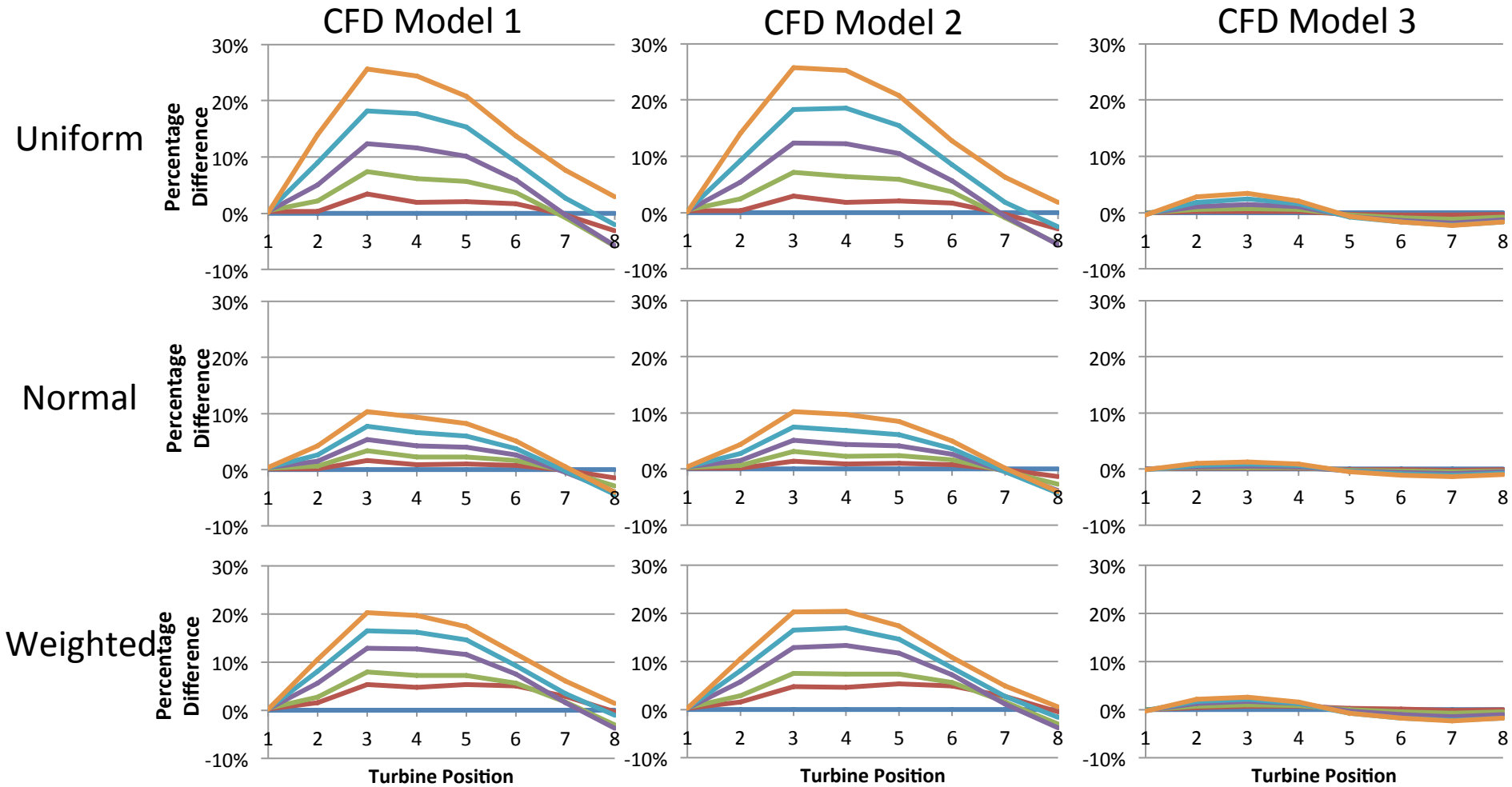
Case Name	Directions Included	Bin Size	Events	Wind Speed	Colour
Case A	$278 \pm 0.5^\circ$	$1^\circ$	173	$7.53 \text{ms}^{-1}$	Blue
Case B	$278 \pm 1.5^\circ$	$3^\circ$	485	$7.60 \text{ms}^{-1}$	Red
Case C	$278 \pm 2.5^\circ$	$5^\circ$	687	$7.64 \text{ms}^{-1}$	Green
Case D	$278 \pm 3.5^\circ$	$7^\circ$	977	$7.67 \text{ms}^{-1}$	Purple
Case E	$278 \pm 4.5^\circ$	$9^\circ$	1238	$7.68 \text{ms}^{-1}$	Cyan
Case F	$278 \pm 5.5^\circ$	$11^\circ$	1368	$7.68 \text{ms}^{-1}$	Orange



# Simulation Results (Power Ratio)

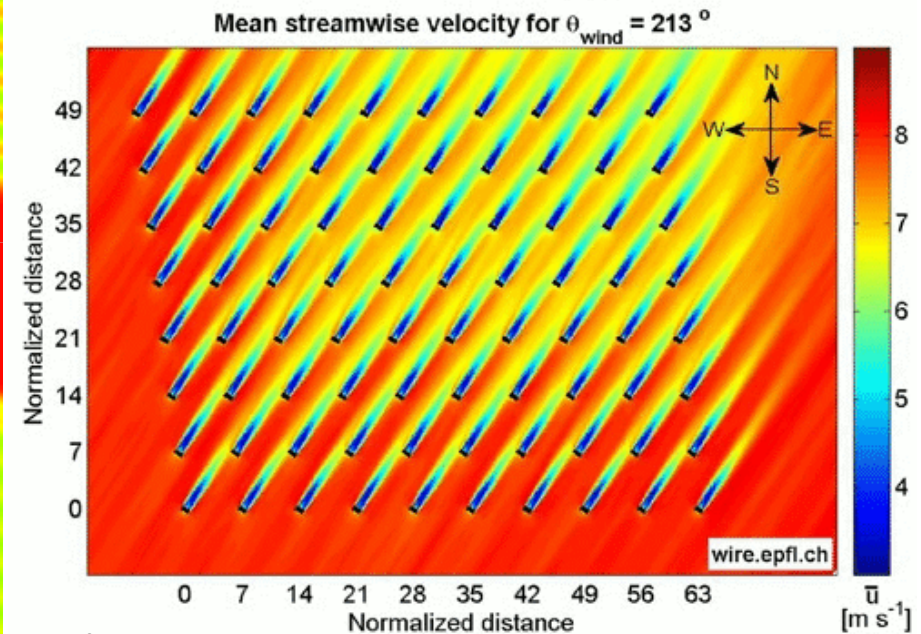
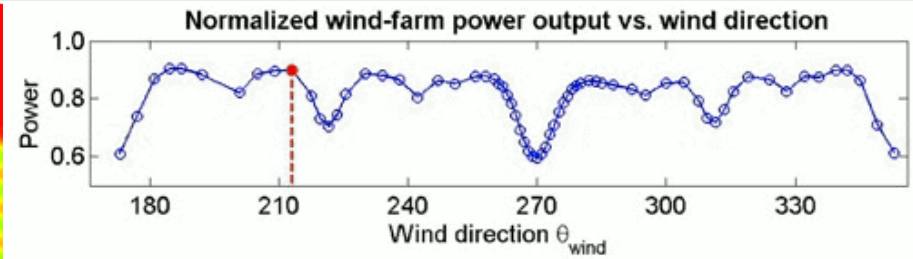
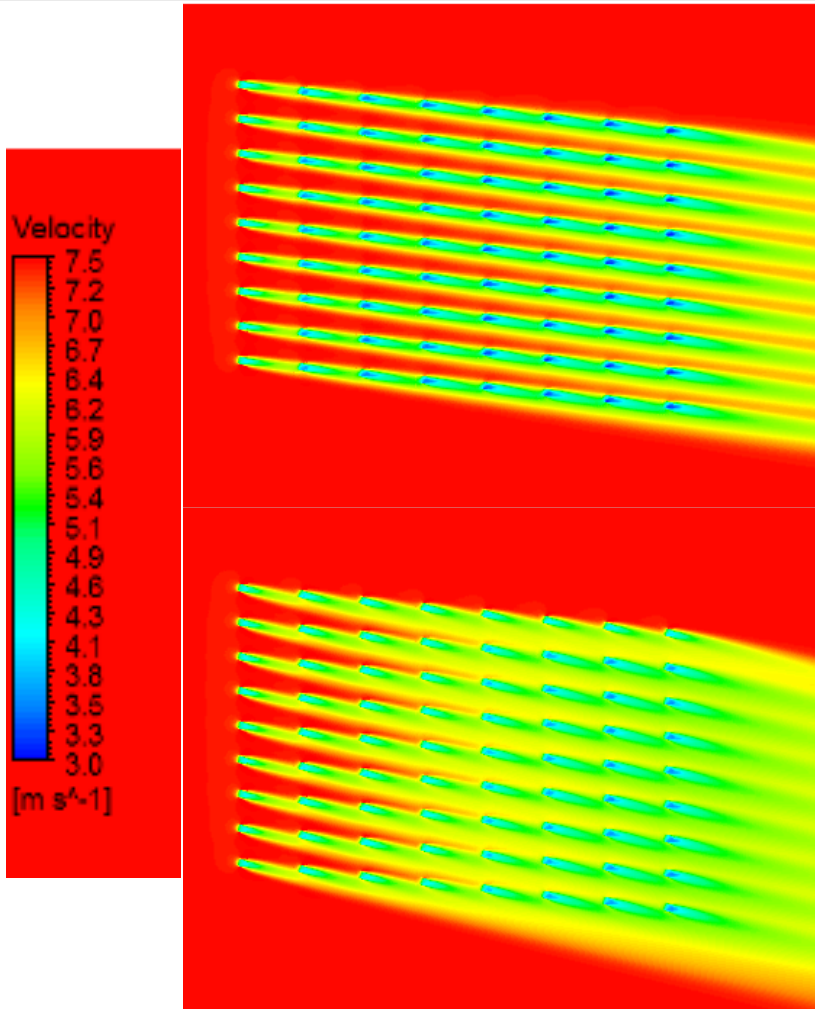


# Simulation Results (Percentage Difference)





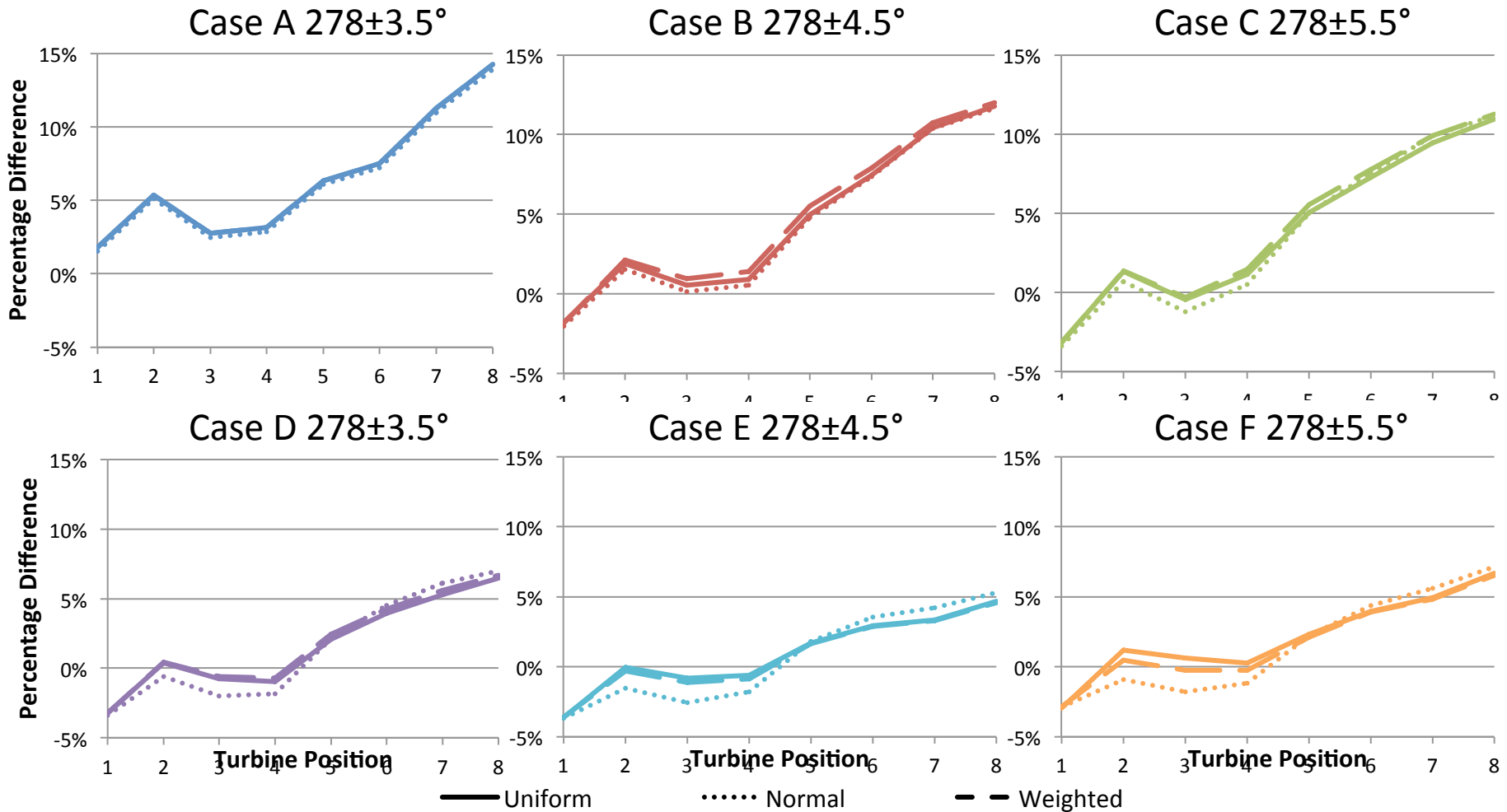
# Peak Difference at Turbine 3



## Wake Losses:

Porté-Agel, F.; Wu, Y.-T.; Chen, C.-H. A Numerical Study of the Effects of Wind Direction on Turbine Wakes and Power Losses in a Large Wind Farm. *Energies* **2013**, *6*, 5297-5313.

# Model 3 Differences from Measured Values



# Conclusions

## Nothing Unexpected:

- Wider bin sizes show lower wake losses
- The significance of directional bin size is dependent on:
  - The turbulence model
  - The method used to weight simulations by direction
    - Uniform distributions suggest lower wake losses
    - Normal distributions suggest higher wake losses
- Differences in results are most significant at turbine position 3
  - Wake expansion reduces significance further into the farm

## Not Considered:

- Atmospheric stability
- CFD model technique – RANS models were used here for speed
- Variable free-stream wind speed
- Turbine separation

# Questions

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E.ON for sponsoring this research through an EPSRC CASE award  
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