



University of Stuttgart
Stuttgart Wind Energy (SWE)
@ Institute of Aircraft Design



Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Assessment of Deep Learning Surrogate Load Model Using RAVE Data

To estimate loads without accurate wind
turbine model

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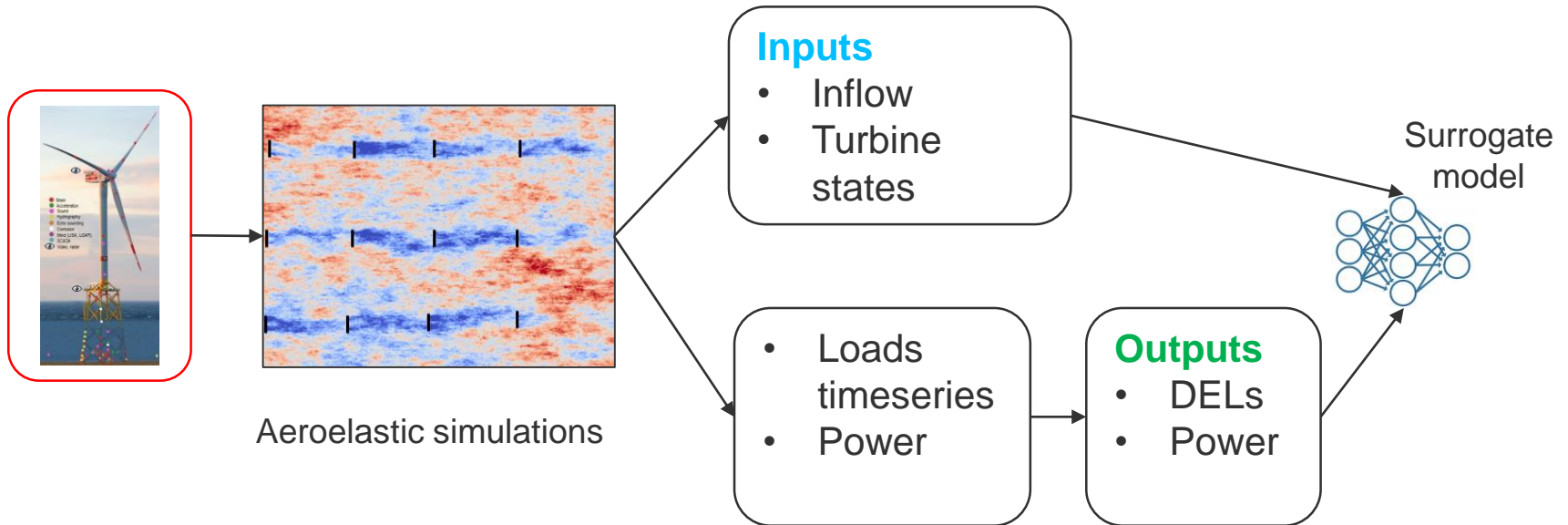
Outline

- **Motivation**
- **Methodology**
 - Transfer Learning
 - Databases
- **Results**
 - ANN model for NREL 5MW
 - TL model for Senvion 5MW
- **Take-away**

Motivation

Surrogate model for load predication

- **Turbine level: lack of the design information**
- **Farm level: limited usable dataset**

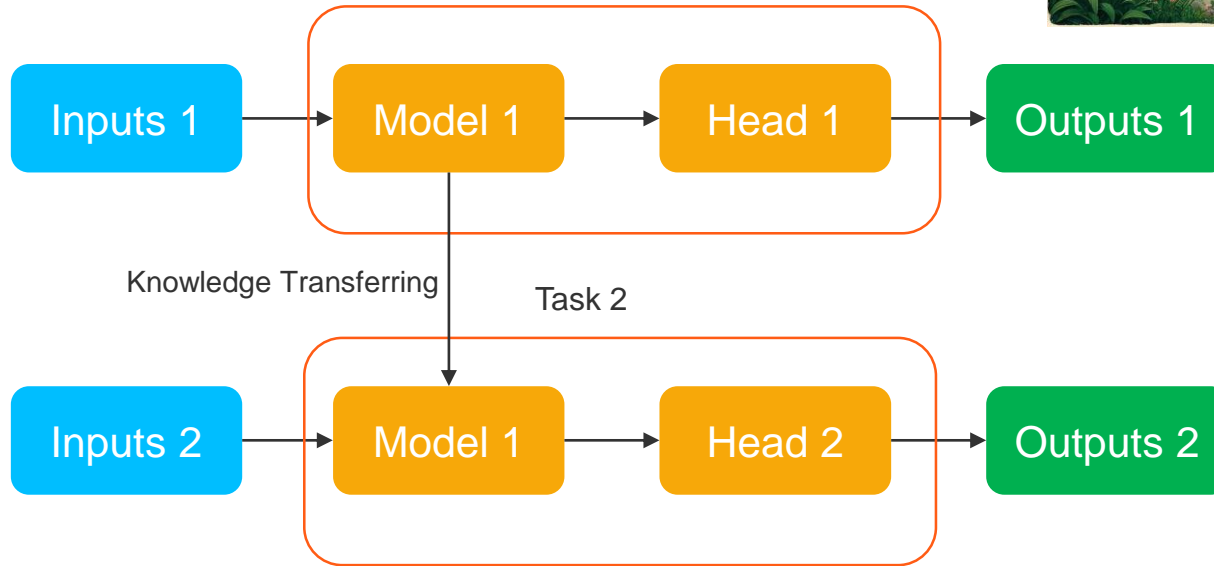


Methodology

Transfer Learning (TL)



Task 1



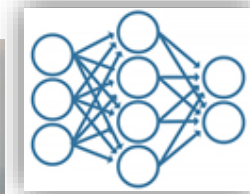
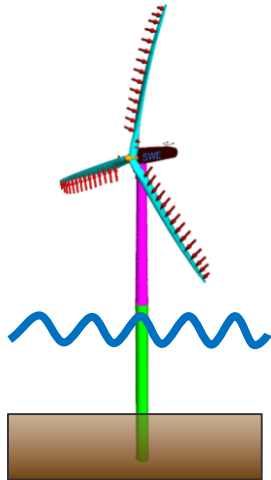
Methodology

Transfer Learning based on RAVE data

ANN load model of
NREL 5MW based on
OpenFAST simulation

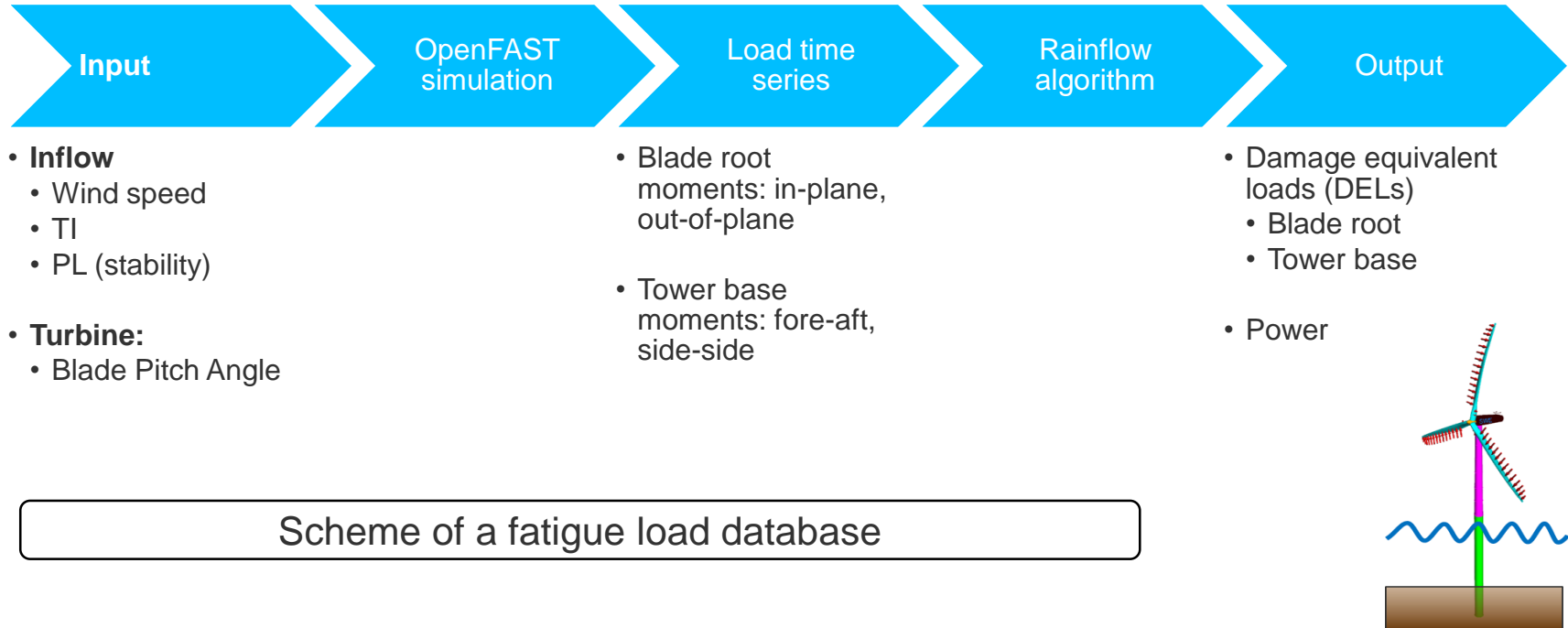
Transfer learning
based on
RAVE data

Load model of
Senvion 5MW (AV4)



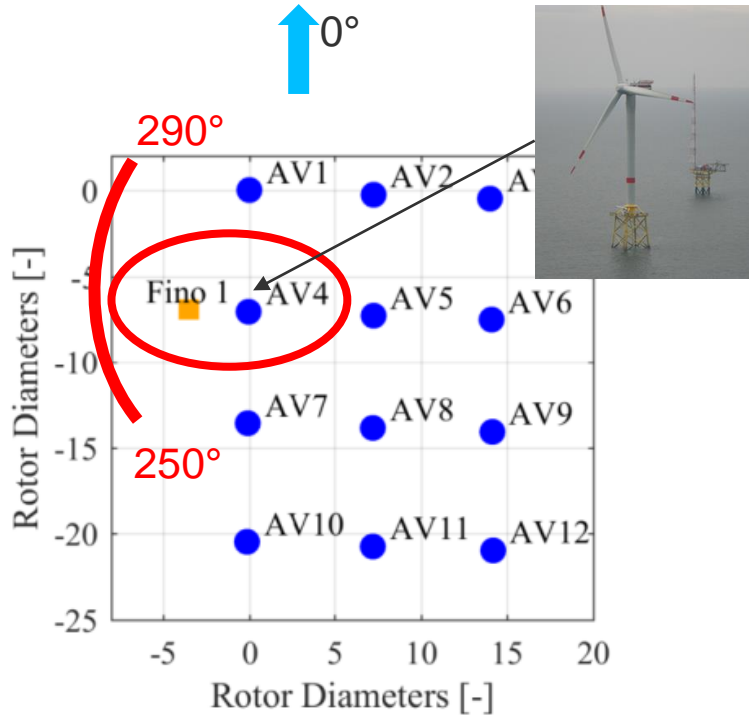
Methodology

Simulation database for NREL5MW (3240, 9)



Methodology

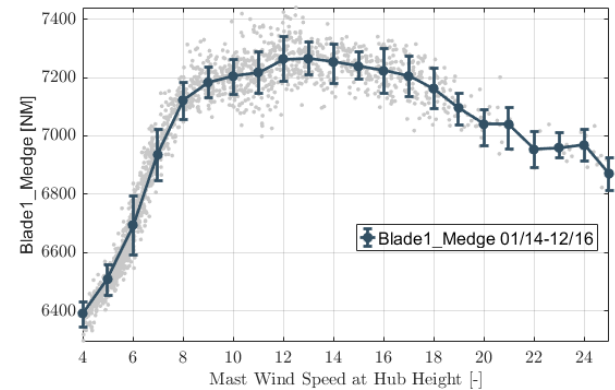
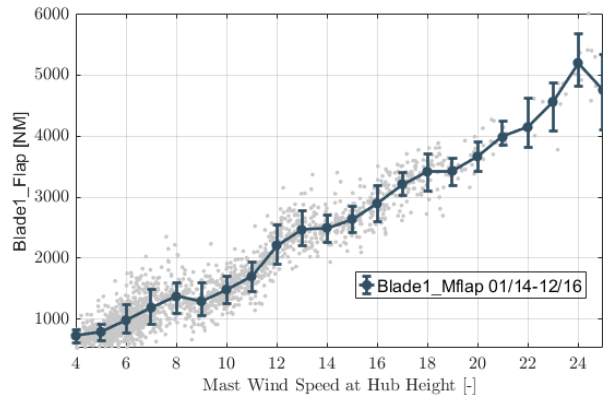
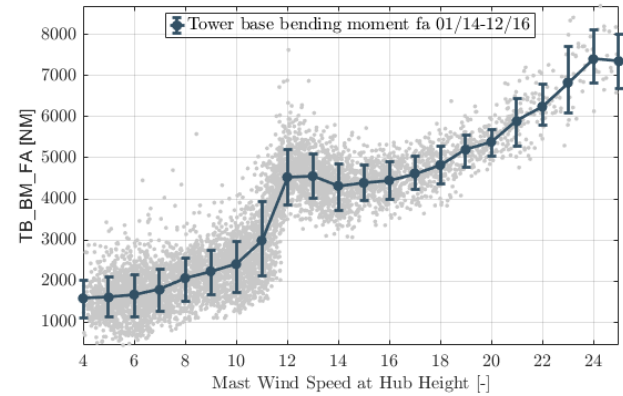
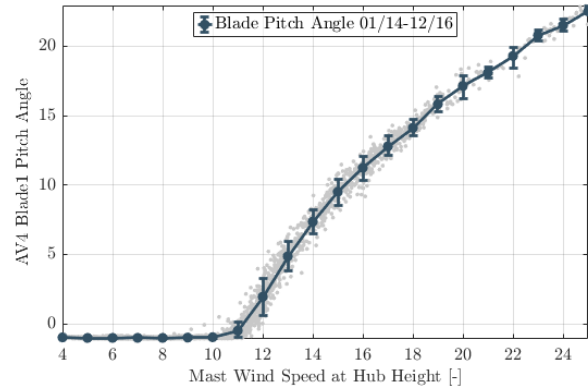
RAVE database for Senvion 5MW



- Meteorological data from FINO1
 - Wind speed
 - TI
 - PLExp (vertical sheer exponent)
- Senvion 5MW (AV4)
 - Blade pitch angle
 - Power
 - Blade1 root moment (edgewise)
 - Blade1 root moment (flapwise)
 - Tower base moment (side-side)
 - Tower base moment (fore-aft)

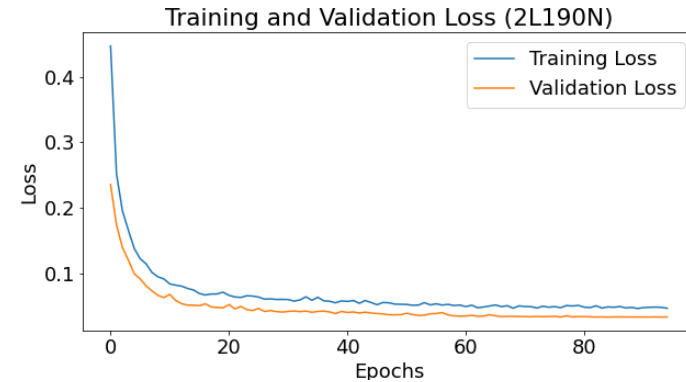
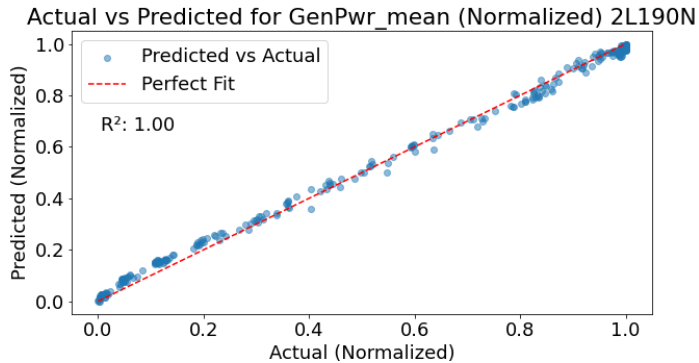
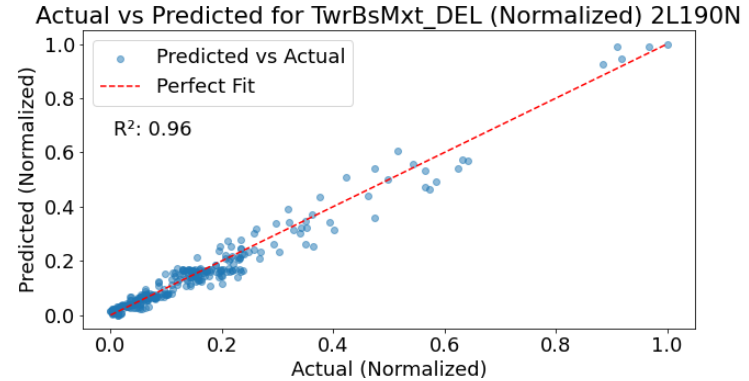
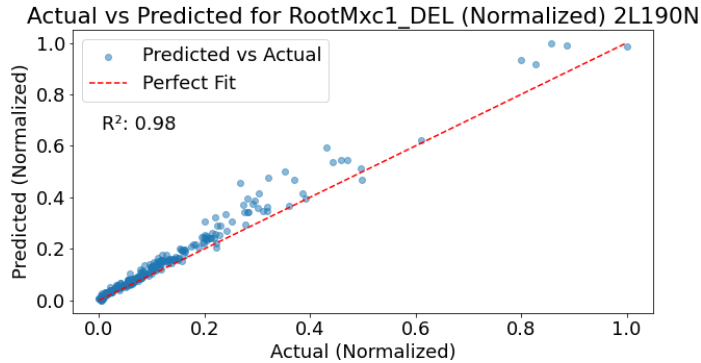
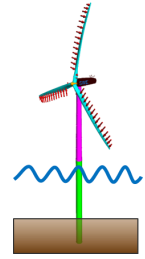
Results

Filtered database for Senvion 5MW (1728, 9)



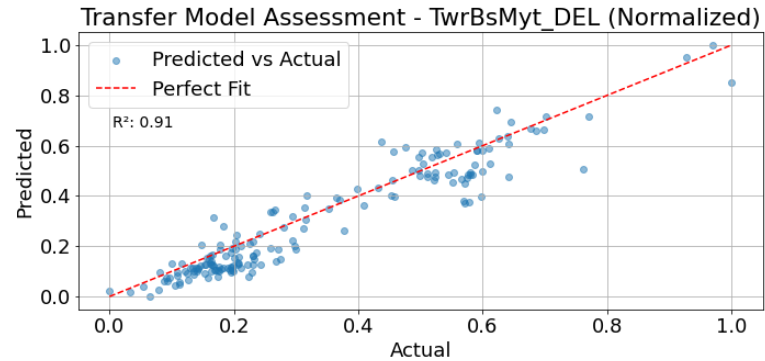
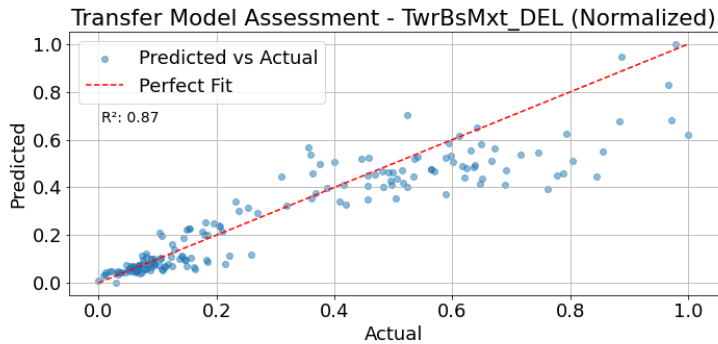
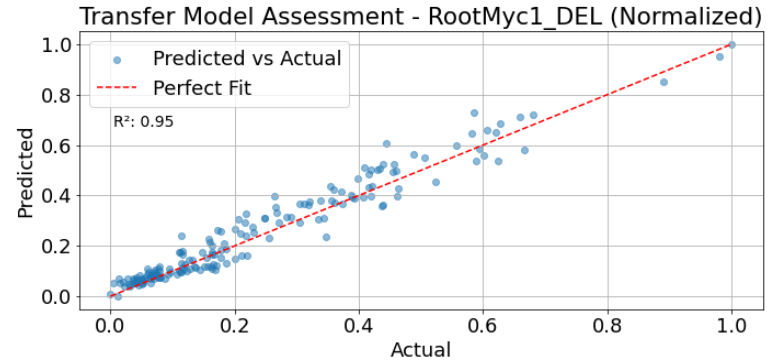
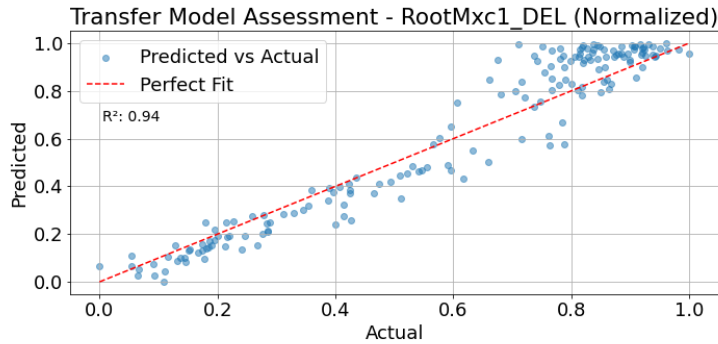
Results

ANN model of NREL 5MW, simulation database



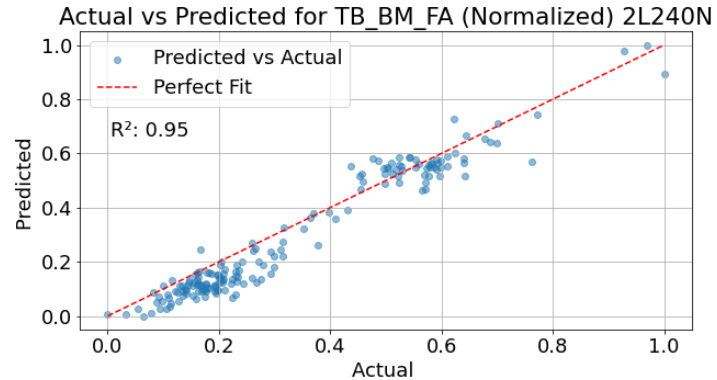
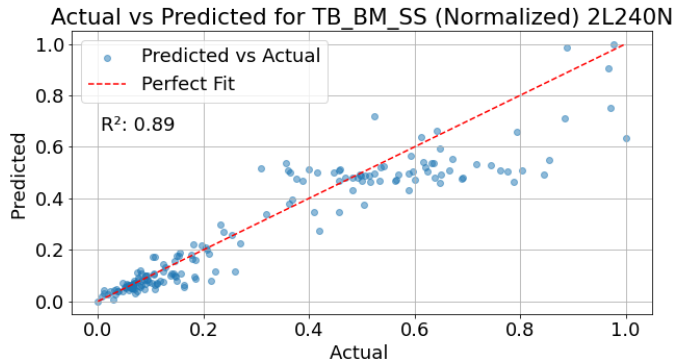
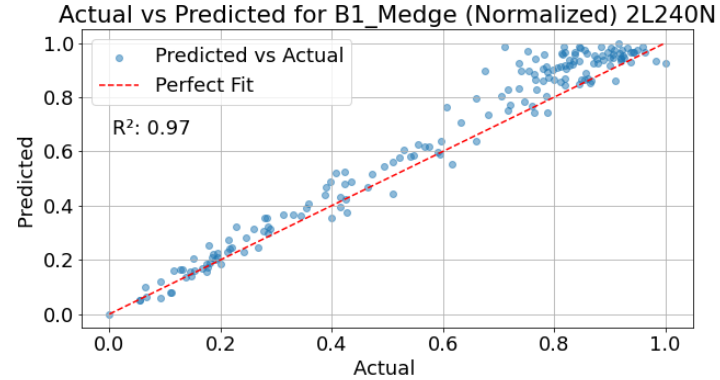
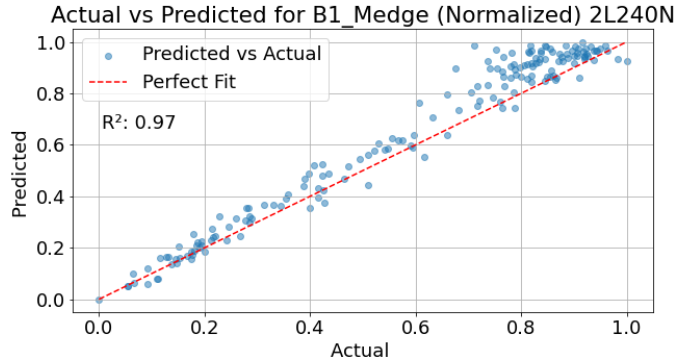
Results

TL model of Senvion 5MW, RAVE database

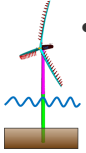


Results +

ANN model of **Senvion 5MW**, only RAVE database



Take-away



- **ANN model based on simulation data**

- NREL5MW RWT
- OpenFAST

- **Transfer learning model based on RAVE measurement data**

- Worse prediction on tower base DEL (side-to-side)
- **Hydro conditions** are not included

- **ANN model based on the purely RAVE measurement data**

- Prediction performance over the transfer learning method
- **Dataset size**

Further optimization

- Include hydro conditions
- Datasize variations
- Wake influence



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Thank you!



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*Any ideas on
further TL
application?*