NREL Transforming ENERGY | 45Th anniversary

A Peak into the Wind Systems Engineering Tools of NREL: WISDEM & WEIS

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Photo by Dennis Schroeder, NREL 55200

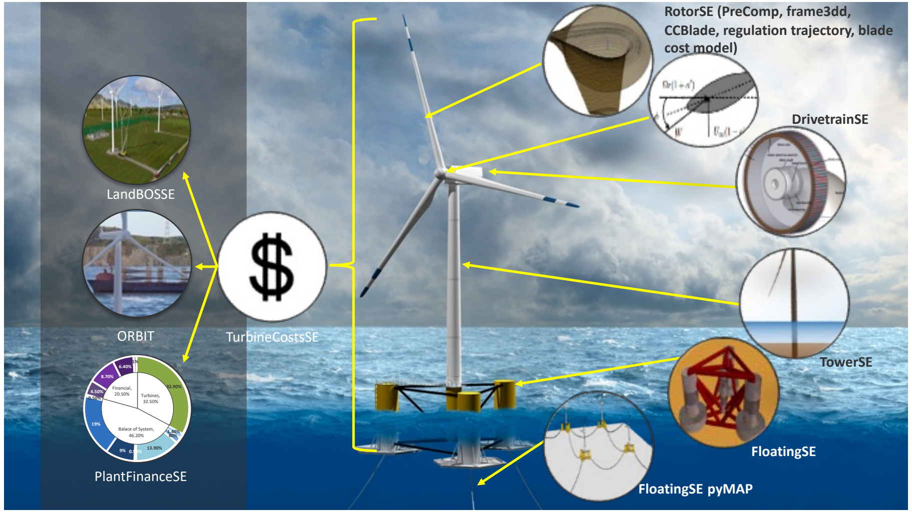
Agenda

- What are WISDEM & WEIS
- How to Compile and Run WISDEM & WEIS
- WISDEM & WEIS Input Files
- Example in WISDEM
- Example in WEIS
- Contacts, Publications, and Q&A

WISDEM

WISDEM is a conceptual design tool for wind turbines

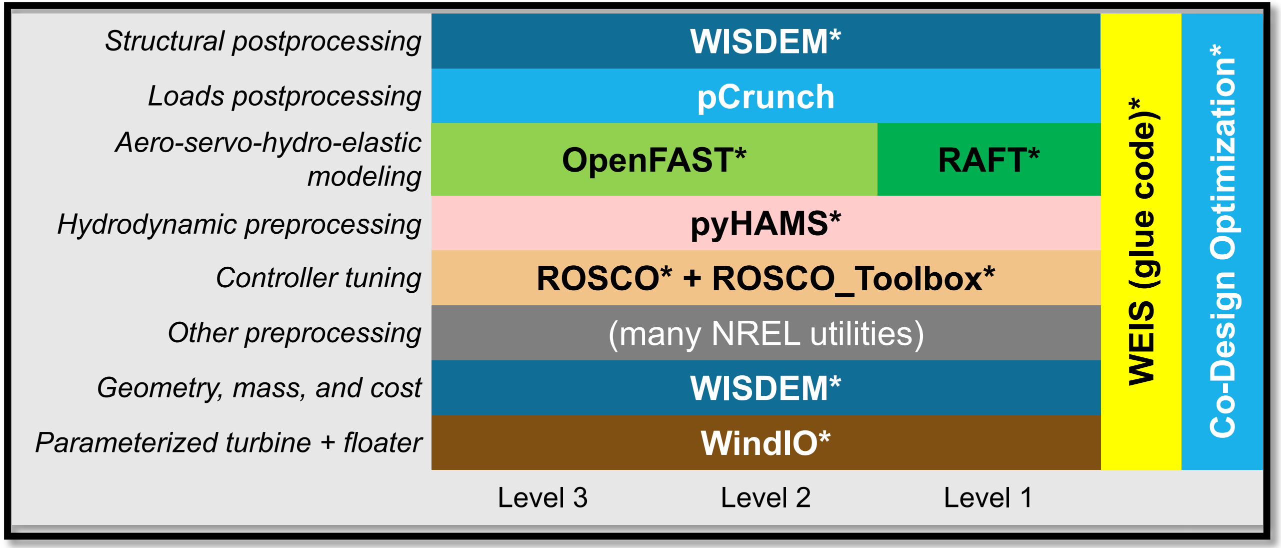
- Fully open-source
- Actively maintained and improved for more than 10 years
- It addresses all major wind turbine components
- Supports both land-based and offshore designs
- Examples and documentation available
- Used by industry and academia



WEIS

WEIS is the evolution of WISDEM and was presented yesterday by Dan Zalkind

- From steady-state models to full aeroservoelastic models
- Fully open-source, maintained, and improved
- Focus on floating designs



How to Compile and Run WISDEM & WEIS

Follow the instructions provided at

- https://github.com/WISDEM/WISDEM
- https://github.com/WISDEM/WEIS

Note: WEIS is supported on Linux and Mac, not on Windows

Use the Ubuntu subsystem or a Linux virtual machine instead

The two frameworks come with **examples**

WISDEM and WEIS Input Files

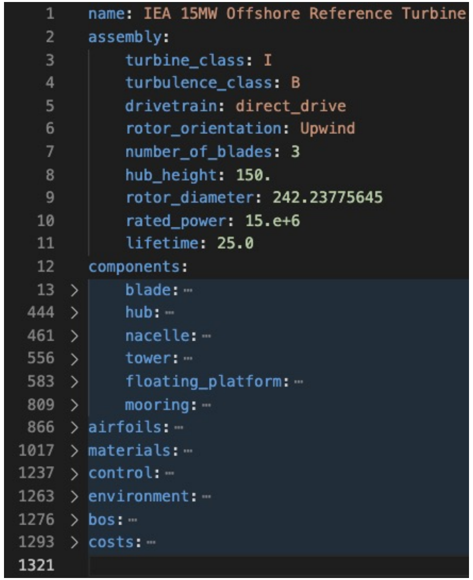
Both tools use the same three input files, all in yaml format and equipped with schemas:

1. Wind turbine definition
2. Modeling options
3. Analysis options

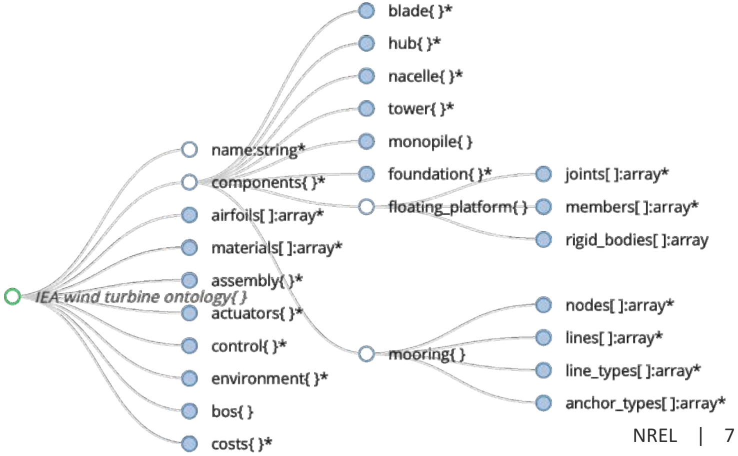
Wind Turbine Definition

A description of the wind turbine system that respects the ontology defined by IEA Wind Task 37 (https://github.com/IEAWindTask37/windIO)

- Supports land-based, fixed-bottom, and floating
- Documentation is available at https://windio.readthedocs.io/en/latest/
- You can visualize yaml schemas such as this [one](#) first converting them to json schemas with this online [tool](#) and then using this online [visualizer](#)



```
name: IEA 15MW Offshore Reference Turbine
assembly:
    turbine_class: I
    turbulence_class: B
    drivetrain: direct_drive
    rotor_orientation: Upwind
    number_of_blades: 3
    hub_height: 150.
    rotor_diameter: 242.23775645
    rated_power: 15.e+6
    lifetime: 25.0
components:
    blade: ...
    hub: ...
    nacelle: ...
    tower: ...
    floating_platform: ...
    mooring: ...
airfoils: ...
materials: ...
control: ...
environment: ...
bos: ...
costs: ...
```



Modeling Options

A .yaml file listing all the modeling options, for example specifying which sub-models are active or inactive and their settings

- Same file for WISDEM and WEIS, the latter is simply longer
- The schema contains helpful documentation

```yaml
General: ...

WISDEM:
    RotorSE: ...
    DriveSE: ...
    TowerSE: ...
    FixedBottomSE: ...
    BOS: ...

Level3:
    flag: True
    simulation: ...
    linearization: ...
    ElastoDyn: ...
    ElastoDynBlade: ...
    ServoDyn: ...
    HydroDyn: ...

ROSCO: ...

DLC_driver:
    DLCs:
        - DLC: "1.1" ...
        - DLC: "1.3" ...
        - DLC: "1.4"
        - DLC: "6.1"
```

Analysis Options

A .yaml file listing the optimization options, such as design variables, bounds, constraints, merit figure, and recorder options

```yaml
general:
    folder_output: outputs_aerostruct
    fname_output: blade_out

design_variables:
    rotor_diameter:
        flag: True
        minimum: 190
        maximum: 240
    blade:
        aero_shape: ...
        structure: ...

merit_figure: LCOE

constraints:
    blade:
        strains_spar_cap_ss: ...
        strains_spar_cap_ps: ...
        strains_te_ss: ...
        strains_te_ps: ...
        tip_deflection: ...
        stall: ...

driver:
    optimization: ...

recorder: ...
```

Run WISDEM

Run a rotor / tower / monopile optimization scaling the IEA15 to 20MW

WISDEM Example #18

An academic, but frequent, exercise:

- Start from the IEA15MW and scale the design to 20MW, sticking to 325 W m^{-2}
- Optimize
  - blade chord, twist, spar caps thickness
  - tower and monopile diameter and wall thickness
- Constraints on blade aero, structure, tower, and monopile
- Minimize LCOE

What could happen next

1. Run a design optimization of the drivetrain system
2. Tune a controller and run design load cases
3. Use loads to feed higher fidelity design model for each component
4. Iterate

WEIS comes into the game

Run WEIS

Run DLCs with ROSCO and OpenFAST

WEIS Example

WEIS is used in many ways

- Run design load cases
- Run aeroelastic stability analysis
- Run design of experiments
- Run design optimizations

Here we showcase option #1 (DLC 1.1 in this example, more DLCs are available) from the WISDEM design output at 20MW

Some Suggestions from the NREL Team for the WISDEM/WEIS Newcomers

1. Get familiar with the OpenMDAO docs and tutorials
2. Try running the WISDEM examples
3. When defining your own problem, go simple and focus on one/two components at the time
4. Add design variables and constraints incrementally
5. Focus on min mass / max AEP problems before jumping to min LCOE
6. Do not debug with MPI turned on
7. Post questions on GitHub issues
8. **Always use your design expertise!**

Contacts, Publications, and Q&A

Contacts

- garrett.barter@nrel.gov
- pietro.bortolotti@nrel.gov
- daniel.zalkind@nrel.gov

Publications:

- WISDEM - https://wisdem.readthedocs.io/en/develop/publications.html
- WEIS - https://github.com/WISDEM/WEIS/blob/develop/docs/publications.rst