Using the *NewTower* Feature of AeroDyn 14

Some versions of AeroDyn 12 and 13 had an undocumented **NewTower** feature to simulate the upwind influence of the tower on the rotor and an improved tower-shadow model. This was in addition to the standard (original) tower shadow, which had influence only on downwind rotors. With AeroDyn 14, we are making **NewTower** a documented and supported feature and have added the optional calculation of drag load on the tower.

AeroDyn input file

In AeroDyn 12, the primary AeroDyn input file has a section for tower shadow that looked something like this:

```
0.1      TwrShad      - Tower-shadow velocity deficit (-)
3.0      ShadHWid     - Tower-shadow half width (m)
4.0      T_Shad_Refpt - Tower-shadow reference point (m)
```

That option is still available in AeroDyn 14. However, you have the option of replacing that section with something like this:

```
NEWTOWER                     TwrShad     - Tower shadow velicity deficit or "NEWTOWER" to request the new tower model.
True                         TwrPotent   - Calculate tower potential flow (flag)
False                        TwrShadow   - Calculate tower shadow (flag)
"AeroDyn_Tower_NewDrag.dat"  TwrFile     - AeroDyn tower file name (quoted string)
True                         CalcTwrAero - Calculate aerodynamic drag of the tower at the ElastoDyn nodes.
```

AeroDyn will expect input for the new models instead of the input for the old tower-shadow model if the **TwrShad** line begins with the string **NewTower** (case insensitive, no quotes). This makes your input file two lines longer. The last line is new to this release of AeroDyn with the **NewTower** option.

- The **TwrPotent** line of the **NewTower** section is a true/false flag that tells the program to compute the potential flow around the tower with an optional Bak correction. This provides a blockage or dam effect around the tower that influences upwind rotors. These models are documented in Hansen's and Moriarty's December 2005 *AeroDyn Theory Manual*.
- The **TwrShadow** line is a true/false flag that invokes a downwind tower shadow. This shadow model is different than the original model and it uses the tower drag to compute the downwind velocity deficit. It, too, is described in the AeroDyn Theory Manual.
- The **TwrFile** line points to a file that contains details needed for the **NewTower** model. Enter the file name in quotes. The contents of the file are described below. The variation of drag coefficient with Reynolds Number (Re) and variation of tower width with elevation are specified in this file.
- The **CalcTwrAero** line is for a true/false flag, which allows calculation of drag load on the tower. This feature uses the instantaneous position, orientation, and motion of the ElastoDyn tower nodes to determine the relative wind speed and Re for each node. Then, based on the drag coefficient at that node, AeroDyn computes the drag per unit length normal to the tower

axis and converts it to the inertial frame to send to ElastoDyn through the glue code. The formula used for the magnitude of the drag is:

$0.5*\text{AirDensity}*\text{DragCoefficient}*\text{TowerWidth}*\text{RelativeNormalWindSpeed}^2$.

AeroDyn tower file

The **`TwrFile`** contains information for the **`NewTower`** features that defines the tower diameter distribution and describes how the tower drag coefficient (Cd) varies with tower section and Re. The current version of AeroDyn 14 does not allow for variation of drag with section and all must use the same set of drag coefficients. For example, all sections would be circles. Table 1 is an example input file with drag coefficients for a circular cross section.

Table 1. Example AeroDyn Tower File.

```
NREL 5.0 MW offshore baseline tower aerodynamic properties.
Used with AeroDyn 14 tower influence feature.
  12        NTwrHt      - Number of tower input height stations listed (-)
  16        NTwrRe      - Number of tower Re values (-)
   1        NTwrCD      - Number of tower CD columns (-) Note: For current version, this MUST be 1.
   0.0      Tower_Wake_Constant - Tower wake constant (-) {0.0: full potential flow, 0.1: Bak model}
---------------------- DISTRIBUTED TOWER PROPERTIES ----------------------------
TwrHtFr(-)  TwrWid(m)  NTwrCDCol(must be 1)
 0.00000     6.000         1
 0.09733     5.787         1
 0.19467     5.574         1
 0.29200     5.361         1
 0.38933     5.148         1
 0.48667     4.935         1
 0.58400     4.722         1
 0.68133     4.509         1
 0.77867     4.296         1
 0.87600     4.083         1
 0.97333     3.870         1
 1.00000     3.870         1
---------------------- Cd v. Re PROPERTIES -------------------------------------
 TwrRe  TwrCD
 0.010   1.11
 0.020   1.20
 0.122   1.20
 0.200   1.17
 0.300   0.90
 0.400   0.54
 0.500   0.31
 1.000   0.38
 1.500   0.46
 2.000   0.53
 2.500   0.57
 3.000   0.61
 3.500   0.64
 4.000   0.67
 5.000   0.70
10.000   0.70
```

Other than changing the number of rows in the **Distributed Tower Properties** and **Cd v Re Properties** sections, you must not add or remove any lines. This file is also compatible with AeroDyn 13.

- The first two lines are comments and may be used to help you identify the contents of the file.
- **NTwrHt** tells AeroDyn how many lines will appear in the **Distributed Tower Properties** section in addition to the header of column headings.
- **NTwrRe** tells AeroDyn how many lines will appear in the **Rev Cd Properties** section in addition to the header of column headings.
- **NTwrCD** tells AeroDyn how many Cd columns will appear in the **Re v Cd Properties** section in addition to the Re column. AeroDyn 14 restricts this value to 1, so all tower sections must use the same drag table.
- **Tower_Wake_Constant** is described in the *AeroDyn Theory Manual*.
- The **Distributed Tower Properties** section describes how the tower width varies with fraction height above the ground or mean sea level. Values must vary from 0 to 1, with the value of 1 corresponding to the hub height—not the top of the tower. The third column must be set to 1 on every row of the table, but a future release will allow different tower sections with different drag profiles. For instance, a tower may be circular at some elevations and octagonal at others. For now, this value must be 1 for all heights.
- The **Cd v Re Properties** section tells AeroDyn how drag coefficient varies with Re specified in millions. For instance, 1.0 is for an Re of 1,000,000. It is currently restricted to two columns, but future versions will allow for more than one section shape.