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TASK 40 REPORT 2020

Downwind turbine technologies

Downwind turbines are expected to reduce levelized cost of energy (LCOE) in larger and lighter rotors and floating offshore wind turbines, due to their lower requirements for stiffness and its advantages in aerodynamic stability and alignment of the rotor.

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However, downwind turbines had not succeeded in the market for decades due to technical problems, as fatigue and lack of experiences, progresses in design standards, and design and analysis methods have contributed to the development of downwind turbines in recent years. Following the trend toward larger offshore wind turbines, downwind turbines drew the interests again, and some demonstration projects were launched. Modern design and analysis methods of downwind turbines can be verified using the accumulated data to evaluate their benefits and problems nowadays.

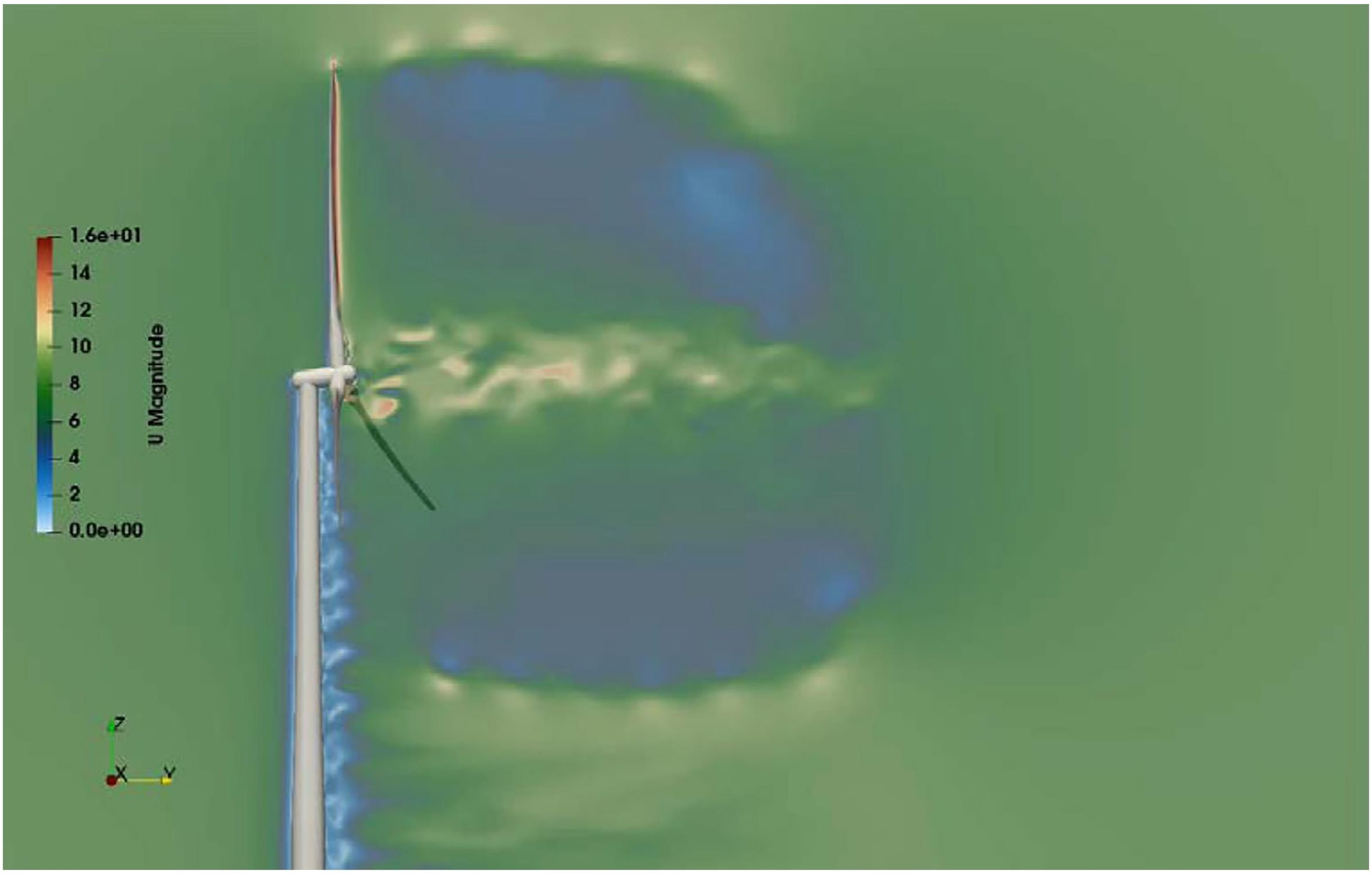

FIGURE 1. CFD RESULTS OF 2 MW BASELINE DOWNWIND TURBINE AT IWES.

The objective of Task 40 is to coordinate international research and investigate the benefits of downwind turbine technologies, is expected to publish IEA Wind TCP Recommended Practices on relevant technologies as well as journal and conference papers.

Task 40 consists of following Work Packages (WPs) regarding downwind turbine technologies.

- WP1 Model development and verification: 2 MW baseline model (WP1-1), tower shadow (WP1-2), nacelle-rotor interaction (WP1-3), stability and control (WP1-4), and complex terrain (WP1-5).
- WP2 design and LCOE assessment: blade optimization (WP2-1), and scalability benefits (WP2-2).

TABLE 1. COUNTRIES PARTICIPATING IN TASK

Table 1. Task 40 Participants in 2020		
	Country/Sponsor	**Institution(s)**
1		
2		
3		
4		

Tabel ligger som billedfil. Er det muligt at få den som tekst?

- WP3 Recommended practices: standard evaluation (WP3-1), and recommended practices (WP3-2).

Progress and achievements

IEA Wind TCP Task 40 was approved for a three-year period of work in June 2017 and launched officially in March 2018 and ended in February 2021.

WP1 conducts model development and verification. An aeroelastic model of a 2 MW baseline downwind turbine model was developed in WP1-1. In addition, CAD data and measurement data of a commercial 2 MW downwind turbine in some typical operating conditions were provided for further evaluation and verifications in other Sub-WPs. Fundamental research (Figure 1 and 2) [1][2][3] and three tower shadow models of downwind turbines were reported [4][5][6] in WP1-2 for aeroelastic analysis using blade-element and momentum method. The nacelle-rotor aerodynamic interaction was shown to increase the power and load of downwind turbines [7], and two nacelle/spinner-blade interaction models were proposed [8][9] in WP1-3. One of the advantages of downwind turbines is the load reduction in storm conditions by passive yaw idling. As its environmental condition, which is not defined in design standards clearly, long-term wind direction change, was proposed and validated through numerical and experimental results [10][11] in WP1-4. 3D wind was measured at a typical complex terrain were reported [12] in WP1-5.

LCOE assessment 10 MW downwind turbines using the system engineering approaches was conducted in WP2. Downwind turbine was compared with two upwind turbines with 6 m (Case-1) and 11 m (Case-2) of maximum blade pre-bending in Class-I condition (Figure 3). The low stiffness blade of downwind turbine shows drawback in power production as the rotor area shrinks in power production. On the other hands, it shows lighter blades and RNA. As a total, it shows the larger downwind turbine is promising for lower LCOE [13]. Research results in [13][14][15] also provided candidates of the Recommended Practices. Furthermore, WP2 research contributed for the development of other super large wind turbines [16].

WP3 gathered candidates for IEA Wind TCP Recommended Practices by integrating and summarizing the achievements in WP1 and WP2, such as analysis models, system engineering models, and design conditions.

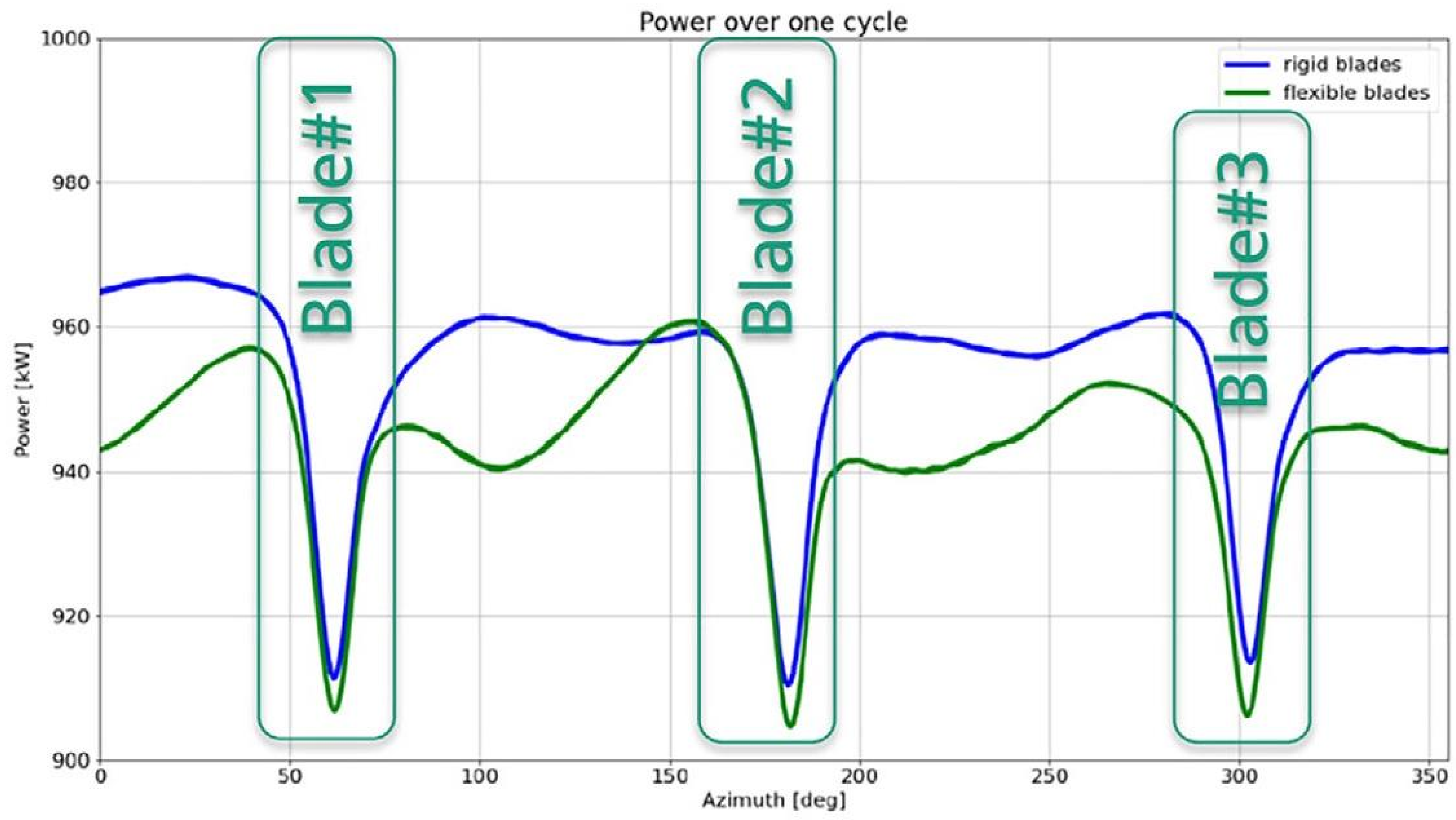

FIGURE 2. COMPARISON OF TOWER SHADOW EFFECTS ON DOWNWIND TURBINES WITH RIGID AND FLEXIBLE BLADES ON BY CFD/FSI AT IWES.

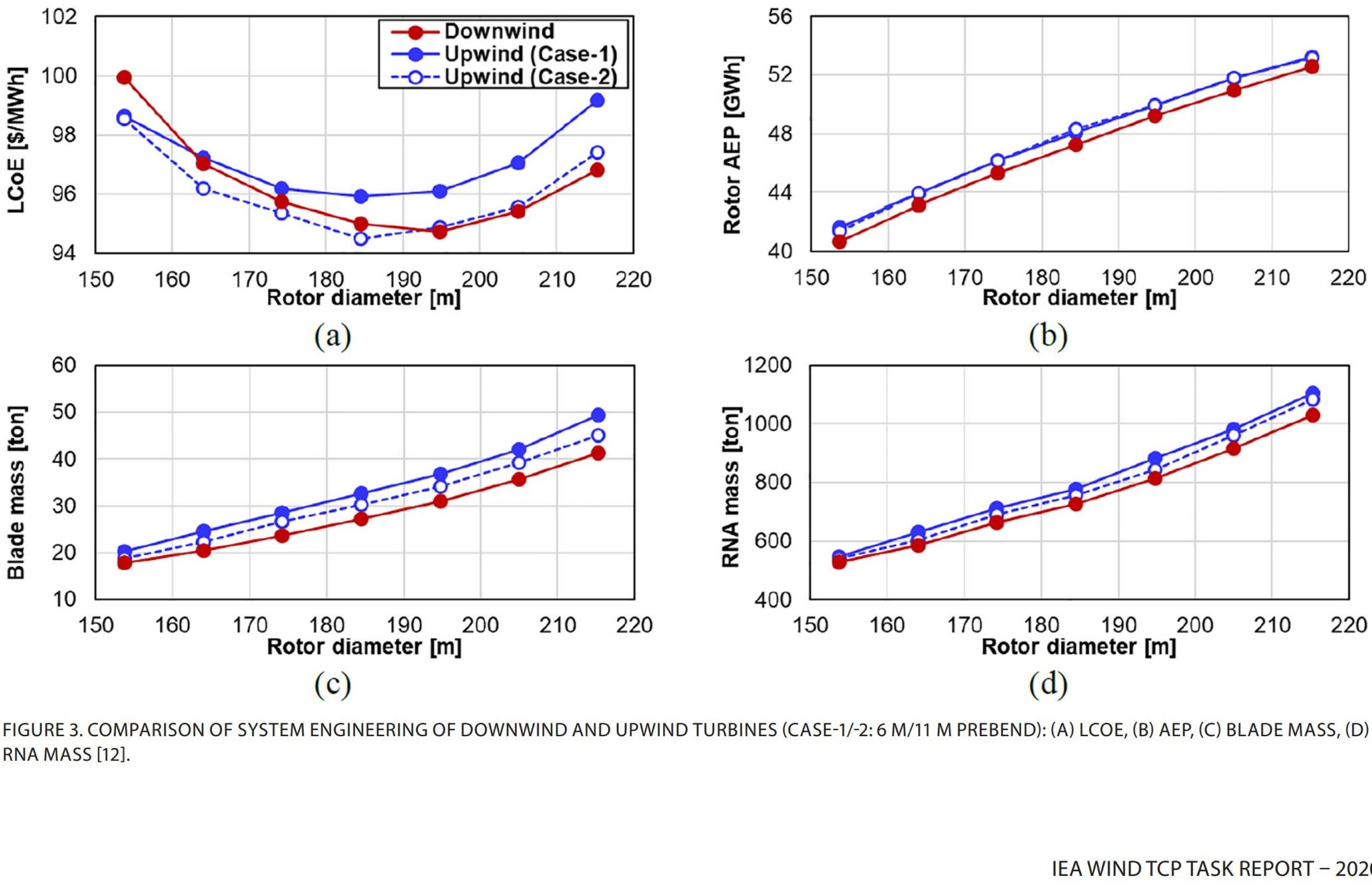

FIGURE 3. COMPARISON OF SYSTEM ENGINEERING OF DOWNWIND AND UPWIND TURBINES (CASE-1/-2: 6 M/11 M PREBEND): (A) LCOE, (B) AEP, (C) BLADE MASS, (D) RNA MASS [12].

Outcomes and significance

The main outcomes of Task 40 are followings regarding downwind turbine technologies:

- Organize a global network that coordinates research and verification efforts.
- Identify and quantify perceived technical benefits and risks and propose resolutions.
- Quantify opportunities for lower LCOE of larger systems.
- Identify potential barriers and improvement in standards, regulations and propose recommended practices.

Task 40 identifies, resolves, and innovates technologies of downwind turbine design and analysis for the further LCOE reduction and the proliferation of onshore and offshore wind power plants through the collaboration.

Next steps

- Investigate the influences of inflow wind tor the tower shadow effect.
- Validate/verify the rotor-nacelle aerodynamic interaction model.
- Implement the models in the aeroelastic code and evaluated their effects on fatigue.
- Investigate noise/infrasound emitted from downwind turbines.
- Propose the phase 2 of Task 40.

Task contact

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IEA Wind Task 40 website: https://community.ieawind.org/task40/home

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