

DAFTAR PUSTAKA

- [1] Martin O. L. Hansen, "Aerodynamics of Wind Turbines Second Edition," London • Sterling, VA, 2008.
- [2] M. P. R. M. Shailendra Sao, "Analysis of NACA 4415 Blade profile For Horizontal Axis Wind Turbine Using Various Aerodynamic Characteristics," 2017. [Online]. Available: www.erppublication.org
- [3] N. T. Burton, D. Jenkins, and E. B. Sharpe, *Wind Energy Handbook Wind Energy Handbook, Second Edition*. 2011. [Online]. Available: www.wiley.com.
- [4] N. Alom, "Influence of curtain plates on the aerodynamic performance of an elliptical bladed Savonius rotor (S-rotor)," *Energy Syst.*, vol. 13, no. 1, pp. 265–280, Feb. 2022, doi: 10.1007/s12667-021-00428-w.
- [5] R. Lanzafame and M. Messina, "Design and performance of a double-pitch wind turbine with non-twisted blades," *Renew. Energy*, vol. 34, no. 5, pp. 1413–1420, May 2009, doi: 10.1016/j.renene.2008.09.004.
- [6] R. H. Barnes, E. V. Morozov, and K. Shankar, "Improved methodology for design of low wind speed specific wind turbine blades," *Compos. Struct.*, vol. 119, pp. 677–684, Dec. 2014, doi: 10.1016/j.compstruct.2014.09.034.
- [7] Emmanuel Branlard, "Wind Turbine Aerodynamics and Vorticity-Based Methods." [Online]. Available: <http://www.springer.com/series/11859>
- [8] Y. A. Katsigiannis, G. S. Stavrakakis, and C. Pharconides, "Effect of Wind Turbine Classes on the Electricity Production of Wind Farms in Cyprus Island," *Conf. Pap. Energy*, vol. 2013, pp. 1–6, May 2013, doi: 10.1155/2013/750958.
- [9] K. A. H. Al-Gburi, B. A. J. Al-quraishi, F. B. Ismail Alnaimi, E. S. Tan, and A. H. S. Al-Safi, "Experimental and Simulation Investigation of Performance of Scaled Model for a Rotor of a Savonius Wind Turbine," *Energies*, vol. 15, no. 23, 2022, doi: 10.3390/en15238808.
- [10] K. A. H. Al-Gburi, F. B. I. Alnaimi, B. A. Al-quraishi, E. Sann Tan, and M. M. Maseer, "A comparative study review: The performance of Savonius-type rotors," *Mater. Today Proc.*, pp. 343–349, 2022, doi:

10.1016/j.matpr.2021.09.226.

- [11] L. Chen, J. Chen, and Z. Zhang, "Review of the Savonius rotor's blade profile and its performance," *J. Renew. Sustain. Energy*, vol. 10, no. 1, 2018, doi: 10.1063/1.5012024.
- [12] N. R. Maldar, C. Y. Ng, and E. Oguz, "A review of the optimization studies for Savonius turbine considering hydrokinetic applications," *Energy Convers. Manag.*, vol. 226, no. September, p. 113495, Dec. 2020, doi: 10.1016/j.enconman.2020.113495.
- [13] P. M. Kumar, K. Sivalingam, S. Narasimalu, T.-C. Lim, S. Ramakrishna, and H. Wei, "A Review on the Evolution of Darrieus Vertical Axis Wind Turbine: Small Wind Turbines," *J. Power Energy Eng.*, vol. 07, no. 04, pp. 27–44, 2019, doi: 10.4236/jpee.2019.74002.
- [14] S. H. Chaklasiya, R. R. Saxena, and P. V Ramana, "Review on Performance Evaluation of Helical Savonius Wind Turbine," vol. 4, no. 1, pp. 1464–1471, 2018.
- [15] Ismail, E. A. Pane, G. Haryanto, T. Okviyanto, and R. A. Rahman, "A better approach for modified bach-type savonius turbine optimization," *Int. Rev. Aerosp. Eng.*, vol. 14, no. 3, pp. 159–165, 2021, doi: 10.15866/irease.v14i3.20612.
- [16] J. V. Akwa, H. A. Vielmo, and A. P. Petry, "A review on the performance of Savonius wind turbines," *Renew. Sustain. Energy Rev.*, vol. 16, no. 5, pp. 3054–3064, Jun. 2012, doi: 10.1016/j.rser.2012.02.056.
- [17] A. Dewan, A. Gautam, and R. Goyal, "Savonius wind turbines: A review of recent advances in design and performance enhancements," *Mater. Today Proc.*, no. xxxx, 2021, doi: 10.1016/j.matpr.2021.05.205.
- [18] N. Alom and U. K. Saha, "Evolution and progress in the development of savonius wind turbine rotor blade profiles and shapes," *J. Sol. Energy Eng. Trans. ASME*, vol. 141, no. 3, pp. 1–15, Jun. 2019, doi: 10.1115/1.4041848.
- [19] A. G. Chitura, P. Mukumba, and N. Lethole, "Enhancing the Performance of Savonius Wind Turbines: A Review of Advances Using Multiple Parameters," *Energies*, vol. 17, no. 15, 2024, doi: 10.3390/en17153708.
- [20] S. F. Dorel, G. A. Mihai, and D. Nicusor, "Review of specific performance

- parameters of vertical wind turbine rotors based on the SAVONIUS type,” *Energies*, vol. 14, no. 7. MDPI AG, Apr. 01, 2021. doi: 10.3390/en14071962.
- [21] D. Wafula, C. Otieno, and J. Ngugi, “An experimental investigation into performance characteristics of H-shaped and Savonius-type VAWT rotors,” *Sci. African*, vol. 10, p. e00603, 2020, doi: 10.1016/j.sciaf.2020.e00603.
- [22] M. A. Kamoji, S. B. Kedare, and S. V Prabhu, “Experimental investigations on single stage modified Savonius rotor,” *Appl. Energy*, vol. 86, no. 7–8, pp. 1064–1073, 2009, doi: 10.1016/j.apenergy.2008.09.019.
- [23] Frank M. White, *Fluid Mechanics*, 7th ed. McGraw-Hill series in mechanical engineering, 2011.
- [24] Z. Tasneem *et al.*, “An analytical review on the evaluation of wind resource and wind turbine for urban application: Prospect and challenges,” *Developments in the Built Environment*, vol. 4. Elsevier Ltd, Nov. 01, 2020. doi: 10.1016/j.dibe.2020.100033.
- [25] N. Alom and U. K. Saha, “Examining the aerodynamic drag and lift characteristics of a newly developed elliptical-bladed savonius rotor,” *J. Energy Resour. Technol. Trans. ASME*, vol. 141, no. 5, May 2019, doi: 10.1115/1.4041735.
- [26] N. Alom and U. K. Saha, “Four Decades of Research into the Augmentation Techniques of Savonius Wind Turbine Rotor,” *J. Energy Resour. Technol. Trans. ASME*, vol. 140, no. 5, May 2018, doi: 10.1115/1.4038785.
- [27] S. Meri AR and H. Bin Salleh, “Numerical Investigation of Savonius Rotor Elliptical and the Design Modification on a Blade Shape,” in *Lecture Notes in Mechanical Engineering*, 2020, pp. 177–185. doi: 10.1007/978-981-13-8297-0_20.
- [28] A. Sanusi, S. Soeparman, S. Wahyudi, and L. Yuliati, “Experimental study of combined blade savonius wind turbine,” *Int. J. Renew. Energy Res.*, vol. 6, no. 2, pp. 615–619, 2016.
- [29] S. Sharma and R. K. Sharma, “Performance improvement of Savonius rotor using multiple quarter blades – A CFD investigation,” *Energy Convers.*

- Manag.*, vol. 127, pp. 43–54, Nov. 2016, doi: 10.1016/j.enconman.2016.08.087.
- [30] N. Mishra, A. Jain, A. Nair, B. Khanna, and S. Mitra, “Numerical and Experimental Investigations on a Dimpled Savonius Vertical Axis Wind Turbine,” *Int. J. Renew. Energy Res.*, vol. 10, no. 2, pp. 646–653, 2020, doi: 10.20508/ijrer.v10i2.10566.g7935.
- [31] N. Alom and U. K. Saha, “Performance evaluation of vent-augmented elliptical-bladed savonius rotors by numerical simulation and wind tunnel experiments,” *Energy*, vol. 152, pp. 277–290, Jun. 2018, doi: 10.1016/j.energy.2018.03.136.
- [32] M. R. Shouman, M. M. Helal, and A. A. El-haroun, “Numerical prediction of improvement of a Savonius rotor performance with curtaining and fin addition on blade,” *Alexandria Eng. J.*, vol. 61, no. 12, pp. 10689–10699, 2022, doi: 10.1016/j.aej.2022.03.079.
- [33] S. A. Meri *et al.*, “Performance Evaluation of Savonius Wind Turbine Based on a New Design of Blade Shape,” *Int. J. Mech. Eng. Technol.*, vol. 10, no. 01, pp. 837–846, 2019.
- [34] H. H. Al-Kayiem, B. A. Bhayo, and M. Assadi, “Comparative critique on the design parameters and their effect on the performance of S-rotors,” *Renewable Energy*, vol. 99, Elsevier Ltd, pp. 1306–1317, Dec. 01, 2016, doi: 10.1016/j.renene.2016.07.015.
- [35] P. Forooghi, A. Stroh, F. Magagnato, S. Jakirlić, and B. Frohnepfel, “Toward a Universal Roughness Correlation,” *J. Fluids Eng. Trans. ASME*, vol. 139, no. 12, 2017, doi: 10.1115/1.4037280.
- [36] M. Kadivar, D. Tormey, and G. McGranaghan, “A review on turbulent flow over rough surfaces: Fundamentals and theories,” *Int. J. Thermofluids*, vol. 10, p. 100077, 2021, doi: 10.1016/j.ijft.2021.100077.
- [37] S. R. J. Gahraz, T. M. Lazim, and M. Darbandi, “Wind tunnel study of the effect zigzag tape on aerodynamics performance of a wind turbine airfoil,” *J. Adv. Res. Fluid Mech. Therm. Sci.*, vol. 41, no. 1, pp. 1–9, 2018.
- [38] S. Nugroho, B. Nugroho, E. Fusil, and R. Chin, “Effects of varied roughness coverage area on drag in a turbulent boundary layer using

- numerical simulations,” *Ocean Eng.*, vol. 287, no. September, pp. 0–8, 2023, doi: 10.1016/j.oceaneng.2023.115721.
- [39] N. Fujisawa, “On the torque mechanism of Savonius rotors,” 1992. doi: 10.1016/0167-6105(92)90380-S.
- [40] K. H. Wong, J. S. Y. Foo, W. T. Chong, S. Mat, and J. H. Ng, “Experimental investigation into the effects of endplate designs for a Savonius turbine,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1372, no. 1, 2024, doi: 10.1088/1755-1315/1372/1/012010.
- [41] E. Nensy Irawan, K. I. Yamashita, and G. Fujita, “Comparison of Non-Overlap and Overlap Savonius Wind Turbines in the Physics Aspect Using Computational Fluid Dynamics Method,” *J. Phys. Conf. Ser.*, vol. 2780, no. 1, 2024, doi: 10.1088/1742-6596/2780/1/012031.
- [42] X. H. Wang, J. S. Y. Foo, A. Fazlizan, W. T. Chong, and K. H. Wong, “Effects of endplate designs on the performance of Savonius vertical axis wind turbine,” *Energy*, vol. 310, no. September, p. 133205, 2024, doi: 10.1016/j.energy.2024.133205.
- [43] M. S. M. Shamsuddin and N. M. Kamaruddin, “Experimental study on the characterization of the self-starting capability of a single and double-stage Savonius turbine,” *Results Eng.*, vol. 17, no. September 2022, 2023, doi: 10.1016/j.rineng.2022.100854.
- [44] N. Alom, S. C. Kolaparthi, S. C. Gadde, and U. K. Saha, “Aerodynamic design optimization of elliptical-bladed savonius-style wind turbine by numerical simulations,” 2016. doi: 10.1115/OMAE2016-55095.
- [45] Y. Kurniawan, D. D. D. P. Tjahjana, and B. Santoso, “Experimental Studies of Performance Savonius Wind Turbine with Variation Layered Multiple Blade,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 541, no. 1, 2020, doi: 10.1088/1755-1315/541/1/012006.
- [46] S. K. Gupta, A. P. Pandey, A. Sawla, and P. Baredar, “A Brief Review on Design and Performance Study of Vertical Axis Wind Turbine Blades,” *Int. Res. J. Eng. Technol.*, vol. 03, no. 07, pp. 465–471, 2016.
- [47] J. Vicente, H. Antonio, and A. Prisco, “A review on the performance of Savonius wind turbines,” *Renew. Sustain. Energy Rev.*, vol. 16, no. 5, pp.

- 3054–3064, 2012, doi: 10.1016/j.rser.2012.02.056.
- [48] N. Alom and U. K. Saha, “Drag and lift characteristics of a novel elliptical-bladed savonius rotor with vent augmenters,” *J. Sol. Energy Eng. Trans. ASME*, vol. 141, no. 5, Oct. 2019, doi: 10.1115/1.4043516.
- [49] B. F. Blackwell, R. E. Sheldahl, and L. V Feltz, “SAN D76-0131 Wind Tunnel Performance Data for TWO-and Three-Bucket Savonius Rotors.”
- [50] A. J. Alexander and B. P. Holownia, “WIND TUNNEL TESTS ON A SAVONIUS ROTOB,” 1978.
- [51] O. Mojola, “On the aerodynamic design of the savonius windmill rotor,” *J. Wind Eng. Ind. Aerodyn.*, vol. 21, pp. 223–231, 1985.
- [52] Sumiati., R., M. Luthfi Artia, U G S Dinata and Gusriwandi, “Pengaruh Overlap Ratio pada Model Turbin Savonius terhadap Karakteristik Koefisien Daya Berdasarkan Eksperimen Pada Wind Tunnel,” *J. Tek. Mesin*, vol. 30, no. Desember, pp. 153–158, 2022, doi: <https://doi.org/10.30630/jtm.15.2.971>.
- [53] M. Zemamou, M. Aggour, and A. Toumi, “Review of savonius wind turbine design and performance,” *Energy Procedia*, vol. 141, no. December, pp. 383–388, 2017, doi: 10.1016/j.egypro.2017.11.047.
- [54] W. T. Chong, S. C. Poh, A. Fazlizan, and K. C. Pan, “Vertical axis wind turbine with omni-directional-guide-vane for urban high-rise buildings,” *J. Cent. South Univ. Technol. (English Ed.)*, vol. 19, no. 3, pp. 727–732, Mar. 2012, doi: 10.1007/s11771-012-1064-8.
- [55] P. K. Talukdar, A. Sardar, V. Kulkarni, and U. K. Saha, “Parametric analysis of model Savonius hydrokinetic turbines through experimental and computational investigations,” *Energy Convers. Manag.*, vol. 158, no. October 2017, pp. 36–49, 2018, doi: 10.1016/j.enconman.2017.12.011.
- [56] R. V. Lates Mihai, “CFD Analysis and Theoretical Modelling of Multiblade Small Savonius Wind Turbines,” 2014. doi: <https://link.springer.com/book/10.1007/978-3-319-09707-7>.
- [57] U. K. Saha, S. Thotla, and D. Maity, “Optimum design configuration of Savonius rotor through wind tunnel experiments,” *J. Wind Eng. Ind. Aerodyn.*, vol. 96, no. 8–9, pp. 1359–1375, Aug. 2008, doi:

10.1016/j.jweia.2008.03.005.

- [58] T. Hayashi, Y. Li, and Y. Hara, "Wind tunnel tests on a different phase three-stage Savonius rotor," *JSME Int. Journal, Ser. B Fluids Therm. Eng.*, vol. 48, no. 1, pp. 9–16, Feb. 2005, doi: 10.1299/jsmeb.48.9.
- [59] N. Fujisawa and F. Gotoh, "Experiments in Fluids Visualization study of the flow in and around," 1992.
- [60] K. S. Jeon, J. I. Jeong, J. K. Pan, and K. W. Ryu, "Effects of end plates with various shapes and sizes on helical Savonius wind turbines," *Renew. Energy*, vol. 79, no. 1, pp. 167–176, 2015, doi: 10.1016/j.renene.2014.11.035.
- [61] S. Sivasegaram, "Secondary Parameters Affecting the Performance of Resistance-Type Vertical-Axis Wind Rotors," 1978.
- [62] Takenori Ogawa, "The effects of a deflecting Plate and rotor End Plates," 1986.
- [63] M. B. Salleh, N. M. Kamaruddin, and Z. Mohamed-Kassim, "The effects of deflector longitudinal position and height on the power performance of a conventional Savonius turbine," *Energy Convers. Manag.*, vol. 226, no. August, p. 113584, Dec. 2020, doi: 10.1016/j.enconman.2020.113584.
- [64] V. J. Modi and M. S. U. K. Fernando, "On the performance of the savonius wind turbine," *J. Sol. Energy Eng. Trans. ASME*, vol. 111, no. 1, pp. 71–81, 1989, doi: 10.1115/1.3268289.
- [65] U. K. Saha and M. J. Rajkumar, "On the performance analysis of Savonius rotor with twisted blades," *Renew. Energy*, vol. 31, no. 11, pp. 1776–1788, 2006, doi: 10.1016/j.renene.2005.08.030.
- [66] M. A. Kamoji, S. B. Kedare, and S. V. Prabhu, "Performance tests on helical Savonius rotors," *Renew. Energy*, vol. 34, no. 3, pp. 521–529, 2009, doi: 10.1016/j.renene.2008.06.002.
- [67] A. Damak, Z. Driss, and M. S. Abid, "Experimental investigation of helical Savonius rotor with a twist of 180° ," *Renew. Energy*, vol. 52, pp. 136–142, 2013, doi: 10.1016/j.renene.2012.10.043.
- [68] J. H. Lee, Y. T. Lee, and H. C. Lim, "Effect of twist angle on the performance of Savonius wind turbine," *Renew. Energy*, vol. 89, no.

- October, pp. 231–244, Apr. 2016, doi: 10.1016/j.renene.2015.12.012.
- [69] A. S. Grinspan, U. K. Saha, and P. Mahanta, “Experimental investigation of twisted bladed savonius wind turbine rotor,” *Int. Energy J.*, vol. 5, no. 1, pp. 1–9, 2004.
- [70] B. Plourde, J. Abraham, G. Mowry, and W. Minkowycz, “An experimental investigation of a large, vertical-axis wind turbine: Effects of venting and capping,” *Wind Eng.*, vol. 35, no. 2, pp. 213–222, 2011, doi: 10.1260/0309-524X.35.2.213.
- [71] N. Fujisawa and F. Gotoh, “Pressure Measurements and flow Visualization Study Of a Savonius,” *J. Wind Eng. Ind. Aerodyn.*, vol. 39, no. 6, pp. 51–60, 1992, doi: [https://doi.org/10.1016/0167-6105\(92\)90532-F](https://doi.org/10.1016/0167-6105(92)90532-F).
- [72] J. Chen, K. Jan, L. Zhang, L. Lu, and H. Yang, “Influence of phase-shift and overlap ratio on savonius wind turbine’s performance,” *J. Sol. Energy Eng. Trans. ASME*, vol. 134, no. 1, 2012, doi: 10.1115/1.4004980.
- [73] A. S. Saad, I. I. El-Sharkawy, S. Ookawara, and M. Ahmed, “Performance enhancement of twisted-bladed Savonius vertical axis wind turbines,” *Energy Convers. Manag.*, vol. 209, no. December 2019, 2020, doi: 10.1016/j.enconman.2020.112673.
- [74] Y. Nakayama, “Drag and Lift,” *Introd. to Fluid Mech.*, pp. 177–201, 2018, doi: 10.1016/B978-0-08-102437-9.00009-7.
- [75] A. Chauvin and D. Benghrib, “Drag and lift coefficients evolution of a Savonius rotor,” *Exp. Fluids*, vol. 8, no. 1–2, pp. 118–120, 1989, doi: 10.1007/BF00203076.
- [76] K. Irabu and J. N. Roy, “Study of direct force measurement and characteristics on blades of Savonius rotor at static state,” *Exp. Therm. Fluid Sci.*, vol. 35, no. 4, pp. 653–659, 2011, doi: 10.1016/j.expthermflusci.2010.12.015.
- [77] K. Ermiş, M. Çalışkan, and A. Okan, “The effects of surface roughness on the aerodynamic drag coefficient of vehicles,” vol. 6, no. 2012, pp. 189–195, 2022.
- [78] N. Martin, K. Walton, L. Blunt, and R. Miller, “The Limitations of ‘ Ra ’ to Describe Surface Roughness,” *Proc. ASME Turbo Expo 2015 Turbine Tech.*

- Conf. Expo. GT2015*, vol. Proceeding, no. June, 2015, doi: 10.1115/GT2015-43329.
- [79] K. Walton, L. Blunt, and R. Miller, "The Limitations of ' Ra ' to Describe Surface Roughness GT2015-43329 THE LIMITATIONS OF U SING ' R A ' TO DESCRIBE SURFAC E ROUGHNESS," no. March 2016, 2015, doi: 10.1115/GT2015-43329.
- [80] W. Chakroun, I. Al-mesri, and S. Al-fahad, "Effect of Surface Roughness on the Aerodynamic Characteristics of a Symmetrical Airfoil Greek symbols : Subscript :," pp. 547–564, 2004.
- [81] M. D. Pilinski, B. M. Argrow, and S. E. Palo, "Drag coefficients of satellites with concave geometries: Comparing models and observations," *J. Spacecr. Rockets*, vol. 48, no. 2, pp. 312–325, 2011, doi: 10.2514/1.50915.
- [82] M. H. Nasef, W. A. El-Askary, A. A. AbdEL-hamid, and H. E. Gad, "Evaluation of Savonius rotor performance: Static and dynamic studies," *J. Wind Eng. Ind. Aerodyn.*, vol. 123, pp. 1–11, 2013, doi: 10.1016/j.jweia.2013.09.009.
- [83] M. Amiri, A. R. Teymourtash, and M. Kahrom, "Experimental and numerical investigations on the aerodynamic performance of a pivoted Savonius wind turbine," *Proc. Inst. Mech. Eng. Part A J. Power Energy*, vol. 231, no. 2, pp. 87–101, Mar. 2017, doi: 10.1177/0957650916677428.
- [84] G. Sakti, T. Yuwono, and W. A. Widodo, "Experimental and numerical investigation of I-65-type cylinder effect on the savonius wind turbine performance," *Int. J. Mech. Mechatronics Eng.*, vol. 19, no. 5, pp. 115–125, 2019.
- [85] S. A. Prince, C. Badalamenti, and D. Georgiev, "Experimental investigation of a variable geometry vertical axis wind turbine," 2021, doi: 10.1177/0309524X20935134.
- [86] M. Al-Ghriybah and D. H. Didane, "Performance Improvement of a Savonius Wind Turbine using Wavy Concave Blades," *CFD Lett.*, vol. 15, no. 9, pp. 32–44, 2023, doi: 10.37934/cfdl.15.9.3244.
- [87] N. Alom, B. Borah, and U. K. Saha, "An insight into the drag and lift

characteristics of modified Bach and Benesh profiles of Savonius rotor,” in *Energy Procedia*, 2018, vol. 144, pp. 50–56. doi: 10.1016/j.egypro.2018.06.007.

- [88] S. Roy and A. Ducoin, “Unsteady analysis on the instantaneous forces and moment arms acting on a novel Savonius-style wind turbine,” *Energy Convers. Manag.*, vol. 121, pp. 281–296, 2016, doi: 10.1016/j.enconman.2016.05.044.
- [89] Y. Kurniawan, D. D. Dwi Prija Tjahjana, and B. Santoso, “Experimental study of savonius wind turbine performance with blade layer addition,” *J. Adv. Res. Fluid Mech. Therm. Sci.*, vol. 69, no. 1, pp. 23–33, 2020, doi: 10.37934/ARFMTS.69.1.2333.
- [90] R. Sumiati, *Rancangan Bangun Rotor Turbin Angin Hybrid Savonius Tipe U Empat Tingkat*, no. November. Seminar Nasional Energi Telekomunikasi dan Otomasi (SNETO) 2015 ISBN 978-602-73246-0-2, 2015.

