

## DAFTAR PUSTAKA

- Abdelhady, S. (2023). Techno-economic study and the optimal hybrid renewable energy system design for a hotel building with net zero energy and net zero carbon emissions. *Energy Conversion and Management*, 289(May), 117195. <https://doi.org/10.1016/j.enconman.2023.117195>
- Ahmadi, S., Fakehi, A. H., Vakili, A., & Moeini-Aghtaie, M. (2020). An optimization model for the long-term energy planning based on useful energy, economic and environmental pollution reduction in residential sector: A case of Iran. *Journal of Building Engineering*, 30(September 2019), 101247. <https://doi.org/10.1016/j.jobe.2020.101247>
- Ahsan Kabir, M., Hasan, M. M., Hossain, T., Ahnaf, A., & Monir, H. (2024). Sustainable energy transition in Bangladeshi academic buildings: A techno-economic analysis of photovoltaic-based net zero energy systems. *Energy and Buildings*, 312(April), 114205. <https://doi.org/10.1016/j.enbuild.2024.114205>
- Al-Saadi, A., Al-Saadi, S., Khan, H., Al-Hashim, A., & Al-Khatri, H. (2023). Judicious design solutions for zero energy school buildings in hot climates. *Solar Energy*, 264(October), 112050. <https://doi.org/10.1016/j.solener.2023.112050>
- Alkhalidi, A. A. T. (2018). *Design of an Off-Grid Solar PV System for a Rural Shelter School of Natural Resources Engineering and Management Department of Energy Engineering Design of an Off-Grid Solar PV System for a Rural Shelter Presented by Noor Hussain Al Dulaimi – 2008203032 F. January, 11*. <https://doi.org/10.13140/RG.2.2.24352.07689>
- Anderson, K., Markel, T., Simpson, M., Leahey, J., Rockenbaugh, C., Lisell, L., Burman, K., & Singer, M. (2011). *Targeting Net Zero Energy at Fort Carson : Assessment and Recommendations. October*.
- Arjunan, K. (2020). Validity of NPV Rule and IRR Criterion for Capital Budgeting and CBA. *SSRN Electronic Journal*, November. <https://doi.org/10.2139/ssrn.3505058>
- Atess. (2023). *HPS30\_50\_100\_120\_150-datasheet.pdf*. <https://www.atesspower.com/Product/Energy/Hybrid/165.html>
- Badan Pusat Statistik. (2023). *Tingkat Diskonto*. <https://www.bps.go.id/id/statistics-table/2/Mzc5IzI=/bi-rate.html>
- Bank Indonesia. (2023). *Inflation data for 2022-2023*. Bank Indonesia. <https://www.bi.go.id/id/statistik/indikator/data-inflasi.aspx>
- Berardi, U. (2018). ZEB and NZEB. Definitions, design methodologies, good practices, and case studies. In *Handbook of energy efficiency in buildings: A life cycle approach*. (Issue May 2018). <https://dx.doi.org/10.1016/B978-0-12-812817-6.00038-3>
- Bosu, I., Mahmoud, H., & Hassan, H. (2023). Energy audit, techno-economic, and environmental assessment of integrating solar technologies for energy management in a university residential building: A case study. *Applied Energy*, 341(March), 121141. <https://doi.org/10.1016/j.apenergy.2023.121141>

- BPS-Statistics Indonesia. (2023). *Rupiah Lending Rate by Bank Group (2022-2023)*. BPS-Statistics Indonesia. <https://www.bps.go.id/id/statistics-table/2/MzgzIzI=/rupiah-credit-interest-rates-by-group-of-banks.html>
- Bunnoto, E., Prawatya, Y. E., & Taufiqurrahman, M. (2019). Perhitungan Beban Pendingin Pada Cold Storage untuk Penyimpanan Produk Hasil Laut di PT. Xinhaiyuan. *Jurnal Teknologi Rekayasa Teknik Mesin*, 1(1), 1–9.
- Cao, X., Dai, X., & Liu, J. (2016). Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. *Energy and Buildings*, 128, 198–213. <https://doi.org/10.1016/j.enbuild.2016.06.089>
- Chacko, R., Eapen, R. R., Lakaparampil, Z. V., & Thomas, J. (2023). Techno-economic analysis of low voltage DC (LVDC) for Net Zero Energy (NZE) realisation in buildings with lead acid battery storage: Tropical monsoon climate. *Journal of Energy Storage*, 70(June), 107794. <https://doi.org/10.1016/j.est.2023.107794>
- Chisale, S. W., & Mangani, P. (2021). Energy Audit and Feasibility of Solar PV Energy System: Case of a Commercial Building. *Journal of Energy*, 2021, 1–9. <https://doi.org/10.1155/2021/5544664>
- Chowdhury, N., Hossain, C. A., Longo, M., & Yaïci, W. (2020). Feasibility and cost analysis of photovoltaic-biomass hybrid energy system in off-grid areas of Bangladesh. *Sustainability (Switzerland)*, 12(4). <https://doi.org/10.3390/su12041568>
- Čorba, Z. J., Katić, V. A., Dumnić, B. P., & Milićević, D. M. (2012). In-grid solar-to-electrical energy conversion system modeling and testing. *Thermal Science*, 16(SUPPL. 1). <https://doi.org/10.2298/TSCI120224069C>
- Dekkiche, M., Tahri, T., & Denai, M. (2023). Techno-economic comparative study of grid-connected PV/reformer/FC hybrid systems with distinct solar tracking systems. *Energy Conversion and Management: X*, 18(December 2022), 100360. <https://doi.org/10.1016/j.ecmx.2023.100360>
- DEN. (2020). Neraca Energi Nasional 2020. *Laporan Kajian Penelahaan Neraca Energi Nasional 2020*, 14.
- DEN, D. E. N. (2022). Laporan Analisis Neraca Energi Nasional. *Sekretariat Jenderal Dewan Energi Nasional*, 1(1), 1–108. <https://den.go.id/publikasi/Neraca-Energi#>
- Dobos, A. P. (2014). PVWatts Version 5 Manual - Technical Report NREL/TP-6A20-62641. *National Renewable Energy Laboratory (NREL)*, September, 20. <https://www.nrel.gov/docs/fy14osti/62641.pdf>
- Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. *Energy and Buildings*, 225, 110322. <https://doi.org/10.1016/j.enbuild.2020.110322>
- Elkadeem, M. R., Kotb, K. M., Abido, M. A., Hasaniien, H. M., Atiya, E. G., Almakhles, D., & Elmorshedy, M. F. (2024). Techno-enviro-socio-economic design and finite set model predictive current control of a grid-connected large-scale hybrid solar/wind energy system: A case study of Sokhna Industrial Zone, Egypt. *Energy*, 289(March 2023), 129816. <https://doi.org/10.1016/j.energy.2023.129816>
- Eltawil, A. B., Atef, S., Attia, S., Kuwamori, K., & Megaed, T. (2023). Energy Efficiency

Comparative Analysis of Inverter-based and Traditional Air Conditioning Systems in Residential Buildings: A Case Study in Egypt. *ICEEM 2023 - 3rd IEEE International Conference on Electronic Engineering, October*, 1–4.  
<https://doi.org/10.1109/ICEEM58740.2023.10319498>

Energysys. (2017). *Sustainable solutions PowerSafe® OPzV Operation Guide for Solar Applications*. <https://www.energysys.com/en/products/batteries/powersafe/powersafe-opzv/>

Gan, C. K., Sapar, A. F., Mun, Y. C., & Chong, K. E. (2013). Techno-economic analysis of LED lighting: A case study in UTeM's faculty building. *Procedia Engineering*, 53, 208–216. <https://doi.org/10.1016/j.proeng.2013.02.028>

Gondal, I. A. (2021). Prospects of shallow geothermal systems in HVAC for NZEB. *Energy and Built Environment*, 2(4), 425–435.  
<https://doi.org/10.1016/j.enbenv.2020.09.007>

Gonzalez-Torres, M., Bertoldi, P., Castellazzi, L., & Perez-Lombard, L. (2023). Review of EU product energy efficiency policies: What have we achieved in 40 years? *Journal of Cleaner Production*, 421(June), 138442.  
<https://doi.org/10.1016/j.jclepro.2023.138442>

Gumintang, M., Sofyan, M., & Sulaeman, I. (2020). Design and Control of PV Hybrid System in Practice. In *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)*.

Hassaine, L., Olias, E., Quintero, J., & Salas, V. (2014). Overview of power inverter topologies and control structures for grid connected photovoltaic systems. *Renewable and Sustainable Energy Reviews*, 30, 796–807.  
<https://doi.org/10.1016/j.rser.2013.11.005>

Helioscope. (2023). *Total Solar Resource Factor (TSRF)*. <https://help-center.helioscope.com/hc/en-us/articles/8198877052435-Total-Solar-Resource-Factor-TSRF>

Hiendro, A., Kurnianto, R., Rajagukguk, M., Simanjuntak, Y. M., & Junaidi. (2013). Techno-economic analysis of photovoltaic/wind hybrid system for onshore/remote area in Indonesia. *Energy*, 59, 652–657.  
<https://doi.org/10.1016/j.energy.2013.06.005>

HOMER. (2016). *HOMER® Pro Version 3.7 User Manual © All rights reserved . August 2016 HOMER® Energy Boulder CO 80301 USA. August*, 1–414.

Huawei. (2012). User Manual 125 KTL. *Data Base, 3304*(January), 1–148.  
<https://support.huawei.com/enterprise/en/doc/EDOC1100165147/d5356e01/technical-data>

Huawei. (2019). *Smart String Inverter. 2–3*.  
<https://support.huawei.com/enterprise/en/doc/EDOC1100016052/27879f42/technical-specifications>

IEA. (2022). An Energy Sector Roadmap to Net Zero Emissions in Indonesia. *An Energy Sector Roadmap to Net Zero Emissions in Indonesia*.  
<https://doi.org/10.1787/4a9e9439-en>

- IEA. (2023). *Final energy consumption of buildings relative to other sectors, 2022*. IEA. <https://www.iea.org/data-and-statistics/charts/final-energy-consumption-of-buildings-relative-to-other-sectors-2022>
- Irsyad, A. R., Pasek, A. D., & Philander, E. (2021). Cooling Seasonal Performance Factor (CSPF) Application in Indonesia for Residential Air Conditioning (AC) Unit. *IOP Conference Series: Earth and Environmental Science*, 927(1). <https://doi.org/10.1088/1755-1315/927/1/012008>
- Islam, M. S., Das, B. K., Das, P., & Rahaman, M. H. (2021). Techno-economic optimization of a zero emission energy system for a coastal community in Newfoundland, Canada. *Energy*, 220, 119709. <https://doi.org/10.1016/j.energy.2020.119709>
- Jum'atullah, Irzan Zakir, & Massus Subekti. (2020). Simulasi Kuat Penerangan Gedung Bertingkat Menggunakan Software Dialux Evo 6.2. Di Gedung L1 Teknik Elektro Universitas Negeri Jakarta. *Journal of Electrical Vocational Education and Technology*, 3(2), 28–31. <https://doi.org/10.21009/jevet.0032.07>
- Karamov, D. N. (2020). Methodology for calculating the lifetime of storage batteries in autonomous energy systems with renewable power generation. *Energy Reports*, 6, 15–24. <https://doi.org/10.1016/j.egy.2020.10.030>
- Kencana, Budi Prasetyo, Hanny Berchmans, Imas Agustina, Puteri Myrasandri, Raymond Bona, Richard Randy Panjaitan, & Winne. (2018). Panduan Studi Kelayakan Pembangkit Listrik Tenaga Surya (PLTS). *Indonesia Clean Energy Development II*, November, 68.
- Khamharnphol, R., Kamdar, I., Waewsak, J., Chiwamongkhonkarn, S., Khunpetch, S., Kongruang, C., & Gagnon, Y. (2023). Techno-Economic Assessment of a 100 kWp Solar Rooftop PV System for Five Hospitals in Central Southern Thailand. *International Journal of Renewable Energy Development*, 12(1), 77–86. <https://doi.org/10.14710/ijred.2023.46864>
- Kilkis, S. (2007). A new metric for net- zero carbon buildings. *Proceedings of the Energy Sustainability Conference 2007, January 2007*, 219–224. <https://doi.org/10.1115/ES2007-36263>
- Kumar Vashishtha, V., Yadav, A., Kumar, A., & Kumar Shukla, V. (2022). An overview of software tools for the photovoltaic industry. *Materials Today: Proceedings*, 64, 1450–1454. <https://doi.org/10.1016/j.matpr.2022.04.737>
- Marszal, A. J., Heiselberg, P., Bourrelle, J. S., Musall, E., Voss, K., Sartori, I., & Napolitano, A. (2011). Zero Energy Building - A review of definitions and calculation methodologies. *Energy and Buildings*, 43(4), 971–979. <https://doi.org/10.1016/j.enbuild.2010.12.022>
- MEMR. (2019). Faktor Emisi Gas Rumah Kaca Sistem Ketenagalistrikan 2019. *Direktorat Jenderal Ketenagalistrikan ESDM Indonesia*, 5, 1–7. [https://gatrik.esdm.go.id/assets/uploads/download\\_index/files/96d7c-nilai-fe-grk-sistem-ketenagalistrikan-tahun-2019.pdf](https://gatrik.esdm.go.id/assets/uploads/download_index/files/96d7c-nilai-fe-grk-sistem-ketenagalistrikan-tahun-2019.pdf)
- Ministry of Trade. (2023). *Foreign Exchange Rate Against Rupiah*. <https://satudata.kemendag.go.id/data-informasi/perdagangan-dalam-negeri/nilai->

tukar

- Morgan Pattison, P., Hansen, M., & Tsao, J. Y. (2018). LED lighting efficacy: Status and directions. *Comptes Rendus Physique*, 19(3), 134–145. <https://doi.org/10.1016/j.crhy.2017.10.013>
- Nishijima, D. (2016). Product lifetime, energy efficiency and climate change: A case study of air conditioners in Japan. *Journal of Environmental Management*, 181, 582–589. <https://doi.org/10.1016/j.jenvman.2016.07.010>
- Noguchi, M., Athienitis, A. K., Delisle, V., Ayoub, J., & Berneche, B. (2008). Net Zero Energy Homes of the Future : A Case Study of the ÉcoTerra House in Canada. *Renewable Energy, Fig 1*, 877–882.
- Ohene, E., Hsu, S. C., & Chan, A. P. C. (2022). Feasibility and retrofit guidelines towards net-zero energy buildings in tropical climates: A case of Ghana. *Energy and Buildings*, 269. <https://doi.org/10.1016/j.enbuild.2022.112252>
- Okoe, M., Opoku, R., Uba, F., Obeng, G. Y., Sekyere, C. K. K., & Nyanor, P. (2023). Techno-economic and environmental estimation assessment of floating solar PV power generation on Akosombo dam reservoir in Ghana. *Energy Reports*, 10, 2740–2755. <https://doi.org/10.1016/j.egyr.2023.09.073>
- Omar, A. I., Khattab, N. M., & Abdel Aleem, S. H. E. (2022). Optimal strategy for transition into net-zero energy in educational buildings: A case study in El-Shorouk City, Egypt. *Sustainable Energy Technologies and Assessments*, 49. <https://doi.org/10.1016/j.seta.2021.101701>
- Palaloi, S., Nurdiana, E., & Wibowo, A. (2018). Pengujian Dan Analisis Kinerja Lampu TL Led Untuk Pencahayaan Umum. *Jurnal Standardisasi*, 20(1), 77. <https://doi.org/10.31153/js.v20i1.680>
- Panagiotidou, M., & Fuller, R. J. (2013). Progress in ZEBs-A review of definitions, policies and construction activity. *Energy Policy*, 62, 196–206. <https://doi.org/10.1016/j.enpol.2013.06.099>
- PLN. (2022). *Statistics PLN* (Issue 03002). <https://web.pln.co.id/en/stakeholders/statistical-report>
- PLN. (2023). *Tarif Adjustment*. <https://web.pln.co.id/statics/uploads/2023/06/ttl-Juli-September-2023.jpg>
- Prawitasari, A., Nurliyanti, V., Maharani, D., Utami, P., & Nurdiana, E. (2024). A systematic decision-making approach to optimizing microgrid energy sources in rural areas through diesel generator operation and techno-economic analysis : A case study of Baron Technopark in Indonesia. 13(2), 315–328.
- Purwoto, B., Jatmiko, Alimul F., M., & Fahmi Huda, I. (2007). Efisiensi Penggunaan Panel Surya Sebagai Sumber Energi Alternatif. In *Jurnal Teknik Elektro* (Vol. 18, Issue 01, pp. 10–11).
- Ramasamy, V., Zuboy, J., Woodhouse, M., Shaughnessy, E. O., Feldman, D., Desai, J., Walker, A., Margolis, R., Basore, P., Ramasamy, V., Zuboy, J., Woodhouse, M., Shaughnessy, E. O., Feldman, D., Desai, J., Walker, A., Margolis, R., & Basore, P. (2022). *U . S . Solar Photovoltaic System and Energy Storage Cost Benchmarks* ,

*With Minimum Sustainable Price Analysis : Q1 2023 U . S . Solar Photovoltaic System and Energy Storage Cost Benchmarks , With Minimum Sustainable Price Analysis : Q1 2023* (Issue September).  
<https://www.nrel.gov/docs/fy22osti/83586.pdf>.%0ANREL

- Rehman, S. (2005). Prospects of wind farm development in Saudi Arabia. *Renewable Energy*, 30(3), 447–463. <https://doi.org/10.1016/j.renene.2004.04.008>
- RETScreen. (2005). *RETScreen Software Online User Manual ®: Biomass Heating*. <https://publications.gc.ca/site/archived-archived.html?url=https://publications.gc.ca/collections/Collection/M39-114-2005E.pdf>
- Richman, E. (2012). *Standard Measurement And Verification Plan For Lighting Retrofit Projects for Buildings and Building Sites*. October, 26.
- Ritarpower. (2021). *Effect of Temperature on Long Term Life OPzV2*. <https://www.ritarpower.com/uploads/ueditor/20210611/6a8e6082d65be0cb7287ffb0739ba9c2.pdf>
- Sartori, I., Napolitano, A., & Voss, K. (2012). Net zero energy buildings: A consistent definition framework. *Energy and Buildings*, 48, 220–232. <https://doi.org/10.1016/j.enbuild.2012.01.032>
- Schleich, J., Durand, A., & Brugger, H. (2021). How effective are EU minimum energy performance standards and energy labels for cold appliances? *Energy Policy*, 149(November 2020), 112069. <https://doi.org/10.1016/j.enpol.2020.112069>
- Shukir, S. S. (2022). Solar System Inverters Types. *Journal of Advances in Electrical Devices*, 6. [www.matjournals.com](http://www.matjournals.com)
- Siriwardhana, M., & Namal, D. D. A. (2017). Comparison of Energy Consumption between a Standard Air Conditioner and an Inverter-type Air Conditioner Operating in an Office Building. *SLEMA Journal*, 20(1–2), 1. <https://doi.org/10.4038/slemaj.v20i1-2.5>
- Solargis. (2019). *Solar resource maps of Indonesia*. <https://solargis.com/maps-and-gis-data/download/indonesia>
- The World Bank. (2023). *Guidelines to implement battery energy storage systems under public-private partnership structures Disclaimer Rights and Permissions*. January. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099536501202316060/pdf>
- Torcellini, P., Pless, S., Deru, M., & Crawley, D. (2006). Zero Energy Buildings: A Critical Look at the Definition. *ACEEE Summer Study Pacific Grove*, 15. <http://www.nrel.gov/docs/fy06osti/39833.pdf>
- Trina. (2020). *Backsheet Monocrystalline Module Tsm-De19*. 19–20. [https://static.trinasolar.com/sites/default/files/Datasheet\\_Vertex\\_DE19.pdf](https://static.trinasolar.com/sites/default/files/Datasheet_Vertex_DE19.pdf)
- USAID. (2022). *Energy Performance of Buildings in Southeast Asia*. USAID. <https://www.usaid.gov/energy/efficiency/examples/southeast-asia>
- Uyan, E., Atlar, M., & Ölçer, A. I. (2023). Improving the energy efficiency of lighting systems for a marine equipment manufacturing plant through retrofitting,

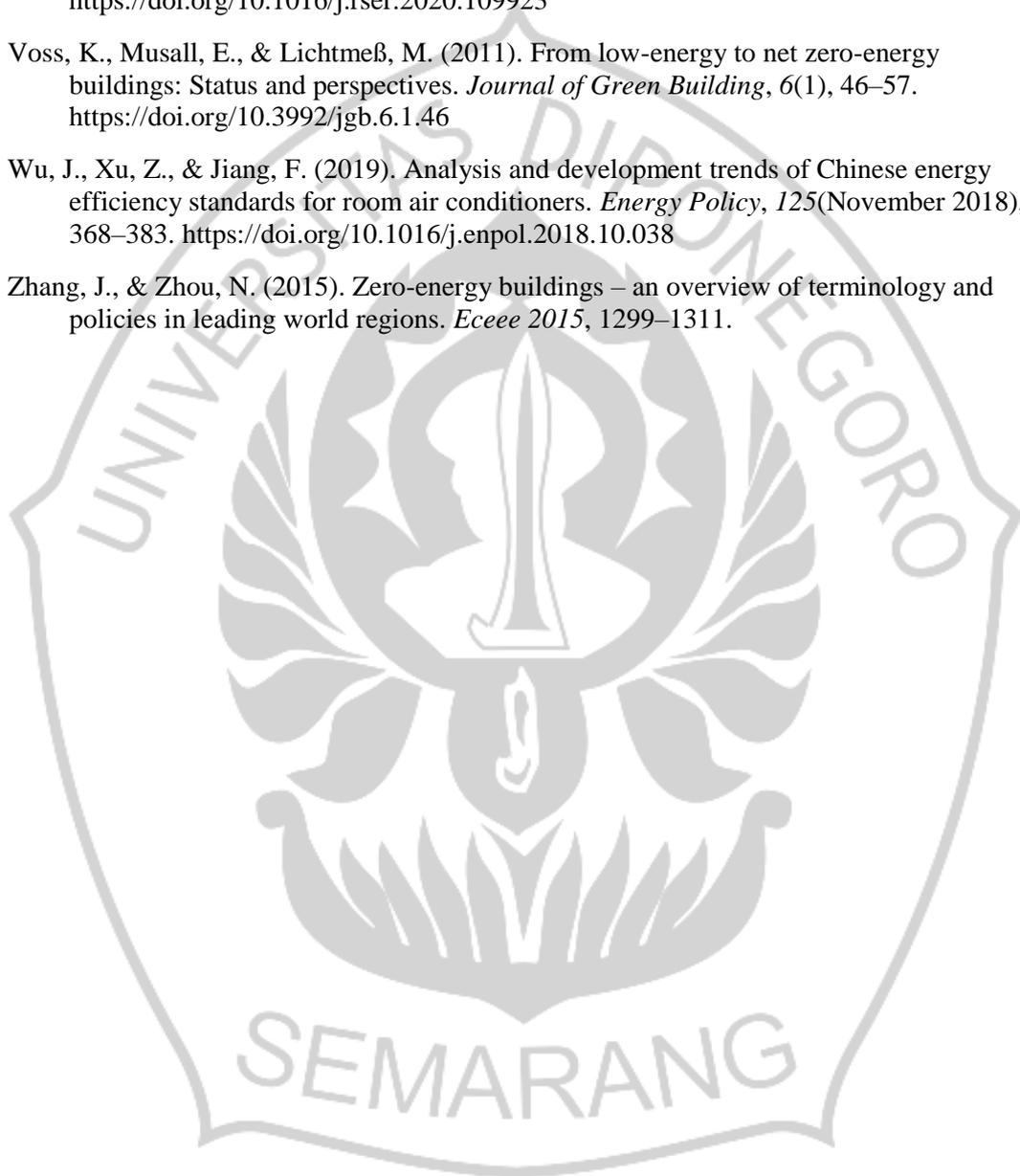
daylighting, and behaviour change. *Journal of Cleaner Production*, 413(April).  
<https://doi.org/10.1016/j.jclepro.2023.137216>

Vaziri Rad, M. A., Toopshekan, A., Rahdan, P., Kasaeian, A., & Mahian, O. (2020). A comprehensive study of techno-economic and environmental features of different solar tracking systems for residential photovoltaic installations. *Renewable and Sustainable Energy Reviews*, 129(April), 109923.  
<https://doi.org/10.1016/j.rser.2020.109923>

Voss, K., Musall, E., & Lichtmeß, M. (2011). From low-energy to net zero-energy buildings: Status and perspectives. *Journal of Green Building*, 6(1), 46–57.  
<https://doi.org/10.3992/jgb.6.1.46>

Wu, J., Xu, Z., & Jiang, F. (2019). Analysis and development trends of Chinese energy efficiency standards for room air conditioners. *Energy Policy*, 125(November 2018), 368–383. <https://doi.org/10.1016/j.enpol.2018.10.038>

Zhang, J., & Zhou, N. (2015). Zero-energy buildings – an overview of terminology and policies in leading world regions. *Eceee 2015*, 1299–1311.





# **LAMPIRAN**

**Lampiran A Perhitungan CSPF 1 PK Inverter**

Temp (°C)	$\phi_{\text{ful}}$ (W)	$P_{\text{ful}}$ (W)	$\phi_{\text{half}}$	$P_{\text{half}}$
35	2648	856	1267	269
29	2852	782	1365	246

$t_{100}$	35,0	°C
$t_0$	20,0	°C
$t_c$	27,8	°C
$t_b$	35,0	°C

$C_D$  0,25

Legend for data source:

- fixed ISO (white box)
- fetch from input (yellow box)
- calculated (blue box)

Bin	Temp (°C)	Frequency (hours)	$L_c(t_j)$	$\phi_{\text{ful}}(t_j)$	$L_{\text{CSP}}/\text{bin}$	$\phi_{\text{half}}(t_j)$	$X(t_j)$	$P_{\text{ful}}(t_j)$	$P_{\text{half}}(t_j)$	$E_{\text{ER,haf}}(t_c)$	$E_{\text{ER,ful}}(t_b)$	$E_{\text{ER,hf}}(t_j)$	$P_{\text{hf}}(t_j)$	$F_{\text{PL}}(t_j)$	$C_{\text{CSE}}/\text{bin}$	
1	21	100	176,6	3124,2	17656,0	1495,2	0,12	683,8	214,9	5,74	3,10	8,26	21,4	0,78	3255,9	
2	22	139	353,1	3090,2	49083,7	1479,0	0,24	696,1	218,8	5,74	3,10	7,89	44,8	0,81	8968,1	
3	23	165	529,7	3056,3	87397,2	1462,7	0,36	708,4	222,6	5,74	3,10	7,52	70,4	0,84	15827,4	
4	24	196	706,2	3022,3	138423,0	1446,4	0,49	720,6	226,5	5,74	3,10	7,15	98,8	0,87	24856,3	
5	25	210	882,8	2988,3	185388,0	1430,2	0,62	732,9	230,4	5,74	3,10	6,78	130,2	0,90	33020,0	
6	26	215	1059,4	2954,3	227762,3	1413,9	0,75	745,1	234,2	5,74	3,10	6,41	165,2	0,94	40252,2	
7	27	210	1235,9	2920,3	259543,1	1397,6	0,88	757,4	238,1	5,74	3,10	6,04	204,5	0,97	45526,3	
8	28	181	1412,5	2886,3	255658,8	1381,4	1,00	769,7	241,9	5,74	3,10	5,68	248,8	1,00	45041,3	
9	29	150	1589,0	2852,3	238355,9	1365,1	1,00	781,9	245,8	5,74	3,10	5,31	299,4	1,00	44909,4	
10	30	120	1765,6	2818,3	211871,9	1348,8	1,00	794,2	249,6	5,74	3,10	4,94	357,5	1,00	42899,0	
11	31	75	1942,2	2784,4	145662,0	1332,6	1,00	806,5	253,5	5,74	3,10	4,57	425,0	1,00	31871,9	
12	32	35	2118,7	2750,4	74155,2	1316,3	1,00	818,7	257,3	5,74	3,10	4,20	504,3	1,00	17649,2	
13	33	11	2295,3	2716,4	25248,1	1300,0	1,00	831,0	261,2	5,74	3,10	3,83	598,8	1,00	6587,1	
14	34	6	2471,8	2682,4	14831,0	1283,8	1,00	843,2	265,0	5,74	3,10	3,46	713,5	1,00	4281,0	
15	35	4	2648,4	2648,4	10593,6	1267,5	1,00	855,5	268,9	5,74	3,10	3,10	855,5	1,00	3422,0	
					$L_{\text{CSP}}$	1.941.630									$C_{\text{CSE}}$	368.367,2
															$F_{\text{CSP}}$	5,27

### Lampiran B Perhitungan CSPF 1,5 PK Inverter

Temp (°C)	$\varphi_{full}$ (W)	$P_{full}$ (W)	$\varphi_{half}$	$P_{half}$
35	3419	1192	1592	331
29	3682	1089	1715	302

$t_{100}$	35,0	°C	$C_D$	0,25
$t_0$	20,0	°C		
$t_c$	27,6	°C		
$t_b$	35,0	°C		

	fixed ISO
	fetch from input
	calculated

Bin	Temp (°C)	Frequency (hours)	$L_c(t_i)$	$\varphi_{full}(t_i)$	$L_{CST}/bin$	$\varphi_{half}(t_i)$	$X(t_i)$	$P_{full}(t_i)$	$P_{half}(t_i)$	$E_{EER,half}(t_c)$	$E_{EER,full}(t_b)$	$E_{EER,half}(t_i)$	$P_{half}(t_i)$	$F_{PL}(t_i)$	$C_{CSE}/bin$	
1	21	100	227,9	4033,0	22792,0	1878,6	0,12	952,6	264,3	5,89	2,87	8,62	26,4	0,78	4109,9	
2	22	139	455,8	3989,2	63361,7	1858,2	0,25	969,6	269,1	5,89	2,87	8,21	55,5	0,81	11309,0	
3	23	165	683,8	3945,3	112820,4	1837,7	0,37	986,7	273,8	5,89	2,87	7,80	87,7	0,84	19940,3	
4	24	196	911,7	3901,4	178689,2	1817,3	0,50	1003,8	278,6	5,89	2,87	7,39	123,4	0,88	31287,7	
5	25	210	1139,6	3857,5	239315,9	1796,9	0,63	1020,9	283,3	5,89	2,87	6,98	163,3	0,91	41528,9	
6	26	215	1367,5	3813,7	294016,7	1776,4	0,77	1038,0	288,0	5,89	2,87	6,57	208,2	0,94	50584,3	
7	27	210	1595,4	3769,8	335042,3	1756,0	0,91	1055,1	292,8	5,89	2,87	6,16	259,1	0,98	57168,9	
8	28	181	1823,4	3725,9	330028,1	1735,6	1,00	1072,1	297,5	5,89	2,87	5,75	317,3	1,00	57440,1	
9	29	150	2051,3	3682,0	307691,9	1715,1	1,00	1089,2	302,3	5,89	2,87	5,33	384,5	1,00	57678,1	
10	30	120	2279,2	3638,2	273503,9	1694,7	1,00	1106,3	307,0	5,89	2,87	4,92	462,9	1,00	55548,8	
11	31	75	2507,1	3594,3	188034,0	1674,2	1,00	1123,4	311,7	5,89	2,87	4,51	555,6	1,00	41667,7	
12	32	35	2735,0	3550,4	95726,4	1653,8	1,00	1140,5	316,5	5,89	2,87	4,10	666,8	1,00	23338,0	
13	33	11	2963,0	3506,5	32592,6	1633,4	1,00	1157,5	321,2	5,89	2,87	3,69	802,8	1,00	8830,8	
14	34	6	3190,9	3462,7	19145,3	1612,9	1,00	1174,6	326,0	5,89	2,87	3,28	972,9	1,00	5837,3	
15	35	4	3418,8	3418,8	13675,2	1592,5	1,00	1191,7	330,7	5,89	2,87	2,87	1191,7	1,00	4766,8	
			$L_{CST}$		2.506.436										$C_{CSE}$	471.036,5
															$F_{CSP}$	5,32

### Lampiran C Perhitungan CSPF 1 PK Standar

Temp (°C)	$\varphi_{ful}$ (W)	$P_{ful}$ (W)
<b>35</b>	<b>2235,50</b>	<b>914,70</b>
29	2407,63	836,04

$t_{100}$	<b>35,0</b>	°C		fixed ISO fetch from input  calculated
$t_0$	<b>20,0</b>	°C		
$C_D$	<b>0,25</b>			

Bin	Temp (°C)	Bin (hours)	$L_c(t_j)$	$\varphi_{ful}(t_j)$	$L_{cST}/bin$	$X(t_j)$	$P_{ful}(t_j)$	$F_{PL}(t_j)$	$C_{cSE}/bin$
1	21	100	149,0	2637,1	14903	0,06	731,2	0,76	5407
2	22	139	298,1	2608,5	41431	0,11	744,3	0,78	15184
3	23	165	447,1	2579,8	73772	0,17	757,4	0,79	27300
4	24	196	596,1	2551,1	116842	0,23	770,5	0,81	43652
5	25	210	745,2	2522,4	156485	0,30	783,6	0,82	59007
6	26	215	894,2	2493,7	192253	0,36	796,7	0,84	73153
7	27	210	1043,2	2465,0	219079	0,42	809,8	0,86	84099
8	28	181	1192,3	2436,3	215800	0,49	822,9	0,87	83558
9	29	150	1341,3	2407,6	201195	0,56	836,0	0,89	78562
10	30	120	1490,3	2378,9	178840	0,63	849,1	0,91	70411
11	31	75	1639,4	2350,3	122953	0,70	862,3	0,92	48799
12	32	35	1788,4	2321,6	62594	0,77	875,4	0,94	25039
13	33	11	1937,4	2292,9	21312	0,84	888,5	0,96	8591
14	34	6	2086,5	2264,2	12519	0,92	901,6	0,98	5085
15	35	4	2235,5	2235,5	8942	1,00	914,7	1,00	3659
					<b>LcST</b>	<b>1.638.920</b>			
							<b>CcSE</b>	<b>631.506</b>	
							<b>FcSP</b>	<b>2,60</b>	

**Lampiran D Perhitungan CSPF 1,5 PK Standar**

Temp (°C)	$\varphi_{ful}$ (W)	$P_{ful}$ (W)
<b>35</b>	<b>2043,20</b>	<b>885,50</b>
29	2200,53	809,35

$t_{100}$	<b>35,0</b>	°C	
$t_0$	<b>20,0</b>	°C	
$C_D$	<b>0,25</b>		

fixed ISO  
 fetch from input  
 calculated

Bin	Temp (°C)	Frequency (hours)	$L_c(t_j)$	$\varphi_{ful}(t_j)$	$L_{CST}/bin$	$X(t_j)$	$P_{ful}(t_j)$	$F_{PL}(t_j)$	$C_{CSE}/bin$
1	21	100	136,2	2410,3	13621	0,06	707,8	0,76	5235
2	22	139	272,4	2384,1	37867	0,11	720,5	0,78	14699
3	23	165	408,6	2357,9	67426	0,17	733,2	0,79	26429
4	24	196	544,9	2331,6	106791	0,23	745,9	0,81	42258
5	25	210	681,1	2305,4	143024	0,30	758,6	0,82	57123
6	26	215	817,3	2279,2	175715	0,36	771,3	0,84	70817
7	27	210	953,5	2253,0	200234	0,42	784,0	0,86	81415
8	28	181	1089,7	2226,7	197237	0,49	796,7	0,87	80891
9	29	150	1225,9	2200,5	183888	0,56	809,3	0,89	76055
10	30	120	1362,1	2174,3	163456	0,63	822,0	0,91	68163
11	31	75	1498,3	2148,1	112376	0,70	834,7	0,92	47241
12	32	35	1634,6	2121,9	57210	0,77	847,4	0,94	24240
13	33	11	1770,8	2095,6	19479	0,84	860,1	0,96	8317
14	34	6	1907,0	2069,4	11442	0,92	872,8	0,98	4922
15	35	4	2043,2	2043,2	8173	1,00	885,5	1,00	3542
					<b><math>L_{CST}</math></b>	<b>1.497.938</b>			
							<b><math>C_{CSE}</math></b>	<b>611.346</b>	
							<b><math>F_{CSP}</math></b>	<b>2,45</b>	

### Lampiran E Rencana Anggaran Biaya Sistem *On-Grid*

No.	Nama Barang	Spesifikasi	Satuan	Unit	Harga Satuan	Total Harga (Rp)	
<b>A</b>	<b>MODUL &amp; SUPPORT</b>						
1	Modul surya	Kristalin, 550Wp, Efisiensi min 20 %	unit	240	2.924.000	702.292.000	
2	Panel Support	Aluminum Profile, Rangka, pemberat, Accessories	kWp	132	900.000	118.890.000	
3	Grounding System	Y/G Cable 16 mm2, cable lug, cadweld, clamp C	grup	5	6.275.000	33.158.000	
<b>TOTAL A</b>						<b>854.340.000</b>	
<b>B</b>	<b>INVERTER</b>						
1	String Inverter	MPPT 120 kW Inverter	unit	1	102.000.000	102.000.000	
2	Panel AC Combiner	1 input, 1 output, SPD, pilot lamps, MCCB 3P 400A x1	unit	1	10.700.000	10.700.000	
<b>TOTAL B</b>						<b>112.700.000</b>	
<b>C</b>	<b>WIRING</b>						
1	PV - Inverter	PV1-F 1x 6mm2, 1000 Volt	mtr	900	25.000	21.780.000	
2	Inverter - AC Combiner	NYYYHY 4x95mm <sup>2</sup>	mtr	10	879.000	8.790.000	
3	AC Combiner - LVCB Tie In	NYYYHY 4x120mm <sup>2</sup>	mtr	100	895.000	89.500.000	
4	Ground System Inverter	Y/G Cable 16 mm2, cable lug, cadweld, clamp C, Rod	grup	1	12.500.000	12.500.000	
5	Monitoring System	RS485	mtr	80	6.000	440.000	
6	Aksesoris	RS 485 connector	pcs	1	484.000	484.000	
7	DC tray cable & accessories	100mm x 50mm x 3000 mm	pcs	80	217.000	17.360.000	
8	AC tray cable & accessories	150mm x 50mm x 3000 mm	pcs	70	409.000	28.630.000	
<b>TOTAL C</b>						<b>179.484.000</b>	
<b>D</b>	<b>GRID INTERCONNECTION</b>						
1	Panel Tie In	400V, MCCB 400 A, Pilot lamps, kWh meter digital	unit	1	9.500.000	9.500.000	
<b>TOTAL D</b>						<b>9.500.000</b>	
<b>E</b>	<b>ENGINEERING. INSTALATION. TESTING. COMMISSIONING AND PERMIT COST</b>						
1	Enginneering, Instalation,testing,and commissioning		kWp	132	2.000.000	264.200.000	
2	Permit fees		Lot	1	60.000.000	60.000.000	
3	Installation Kit		kWp	132	100.000	13.210.000	
<b>TOTAL E</b>						<b>337.410.000</b>	
<b>F</b>	<b>TOTAL INVESTMENT COST</b>						<b>1.493.434.000</b>
<b>G</b>	<b>INVESTMENT COST PER KWP</b>						<b>11.302.000</b>

### Lampiran F Rencana Anggaran Biaya Sistem *Hybrid*

No.	Nama Barang	Spesifikasi	Satuan	Unit	Harga Satuan	Total Harga Satuan (Rp)	
<b>A</b>	<b>MODUL DAN SUPPORT</b>						
1	Modul surya	Kristalin, 550Wp, Efisiensi min 20 %	unit	256	2.924.000	748.493.000	
2	Panel Support	Aluminum Profile, Rangka, pemberat, Accessories	kWp	141	900.000	126.720.000	
3	Grounding System	Y/G Cable 16 mm <sup>2</sup> , cable lug, cadwel, clamp C	grup	4	6.275.000	25.244.000	
4	Combiner box	20 input, 1 output, SPD, pilot lamps, MCB 20A x 10, MCCB 400A x1	unit	1	10.000.000	10.000.000	
<b>TOTAL A</b>						<b>910.457.000</b>	
<b>B</b>	<b>INVERTER</b>						
1	Hybrid Inverter	Hybrid Inverter HPS 120	unit	1	416.255.000	416.255.000	
<b>TOTAL B</b>						<b>416.255.000</b>	
<b>C</b>	<b>Battery</b>						
1	Battery	OPZV2-420	unit	250	2.734.000	683.466.000	
2	Rack Battery	Rack Battery	Unit	50	300.000	15.000.000	
<b>TOTAL C</b>						<b>698.466.000</b>	
<b>D</b>	<b>WIRING</b>						
1	PV - Combiner Box PV	PV1-F 1x 6mm <sup>2</sup> , 1000 Volt	mtr	1400	24.000	33.600.000	
2	Combiner box PV to Inverter	PV1-F 1x 120mm <sup>2</sup> , 1000 Volt	mtr	70	117.000	8.190.000	
3	Battery Cable	PV1-F 1x 16mm <sup>2</sup> , 1000 Volt	mtr	100	35.000	3.455.000	
4	Battery to Inverter	PV1-F 1x 120mm <sup>2</sup> , 1000 Volt	mtr	20	117.000	2.340.000	
5	Inverter - LVCB Tie In	NYYYYH 4x120mm <sup>2</sup>	mtr	80	895.000	71.566.000	
6	Ground System Inverter	Y/G Cable 16 mm <sup>2</sup> , cable lug, cadweld, clamp C, Rod	grup	1	12.500.000	12.500.000	
7	Monitoring System	RS485	mtr	60	6.000	330.000	
8	Aksesoris	RS 485 connector	pcs	1	484.000	484.000	
9	DC tray cable & accessories	100mm x 50mm x 3000 mm	pcs	100	216.000	21.600.000	
10	AC tray cable & accessories	150mm x 50mm x 3000 mm	pcs	20	408.000	8.160.000	
<b>TOTAL D</b>						<b>162.225.000</b>	
<b>E</b>	<b>GRID INTERCONNECTION</b>						
1	Panel Tie In	400V, MCCB 400 A, Pilot lamps, kWh meter digital	unit	1	9.500.000	9.500.000	
<b>TOTAL E</b>						<b>9.500.000</b>	
<b>F</b>	<b>ENGINEERING, INSTALATION, TESTING, COMMISSIONING AND PERMIT COST</b>						
1	Engineering, Instalation, testing, and commissioning		kWp	141	2.100.000	295.680.000	
2	Permit fees		Lot	1	60.000.000	60.000.000	
3	Installation Kit		kWp	141	100.000	14.080.000	
<b>TOTAL F</b>						<b>369.760.000</b>	
<b>G</b>	<b>TOTAL INVESTMENT COST</b>						<b>2.566.663.000</b>
<b>H</b>	<b>INVESTMENT COST PER KWP</b>						<b>18.229.141</b>

## Lampiran G Dokumentasi



**Pengukuran di panel utama dan distribusi Gedung 620**



**Pengukuran di panel utama dan distribusi Gedung 621**



**Pengukuran dan verifikasi daya (W) dari lampu**



**Pengukuran dan verifikasi daya (W) dari *air conditioner***

### Lampiran H Publikasi

No	Judul Publikasi	Jenis Publikasi	Status Publikasi	Situs Web
1	<i>The Impact of Stabilization Time on Lumen and Electrical Power in LED Tube Lamp Testing</i>	Jurnal Internasional	Terbit	<a href="https://irjiet.com/Volume-8/Issue-5-May-2024/The-Impact-of-Stabilization-Time-on-Lumen-and-Electrical-Power-in-LED-Tube-Lamp-Testing/2220">https://irjiet.com/Volume-8/Issue-5-May-2024/The-Impact-of-Stabilization-Time-on-Lumen-and-Electrical-Power-in-LED-Tube-Lamp-Testing/2220</a>
2	<i>Comparative Analysis of Photovoltaic Simulation Software with Actual Conditions of 93.6 kWp On-Grid Photovoltaic System.</i>	Jurnal Internasional	Terbit	<a href="https://irjiet.com/Volume-8/Issue-5-May-2024/Comparative-Analysis-of-Photovoltaic-Simulation-Software-with-Actual-Conditions-of-93-6-kWp-On-Grid-Photovoltaic-System/2231">https://irjiet.com/Volume-8/Issue-5-May-2024/Comparative-Analysis-of-Photovoltaic-Simulation-Software-with-Actual-Conditions-of-93-6-kWp-On-Grid-Photovoltaic-System/2231</a>
3	Kajian Tekno-Ekonomi Potensi Penghematan Energi Pencahayaan pada Gedung Pemerintah Menggunakan RETScreen	Jurnal Nasional Sinta 4	Terbit	<a href="https://ejournal.uniramalang.ac.id/index.php/g-tech/article/view/4446">https://ejournal.uniramalang.ac.id/index.php/g-tech/article/view/4446</a>