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Optimizing Electrical Efficiency and Thermal Performance of AMD Ryzen 3 2200G Processor through Undervolting in Synthetic Benchmarks and Gaming Scenarios

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Abstract. Undervolt is a term that refers to a way to make a computer device run on lower electrical power than the manufacturer's provisions. To do undervolting requires a good experience for user and computer devices that are good or specialized for undervolt purposes such as processors. This study aims to find the optimal minimum voltage that the processor can use without causing performance degradation or instability, and temperature drops that the processor produces while it is running. In this study, the author tested a processor device with the type of AMD Ryzen that already supports the undervolting process from the factory. AMD Ryzen 3 2200G processor is one of the processors with 14nm fabrication, where this processor promises significant performance with the number of cores, memory chace capacity, and power efficiency. On this day, many games demand the use of an aggressive processor. Of course, this will consume power on a larger processor. The author conducted several test scenarios to get the best performance. It was found that the scenario with undervolt at 1.25V showed the best performance.

Keywords: undervolt, processor, AMD, game

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1. Introduction

The promotion of Green Energy and Green Computing has been gaining momentum due to their interconnected nature in addressing the environmental impact of energy consumption. These two initiatives share a common objective of promoting environmental responsibility and sustainability. By working together, they contribute to broader efforts to curb greenhouse gas emissions, conserve natural

resources, and combat climate change. The synergy between green computing and green energy lies in their commitment to reducing IT operations' environmental footprint and energy usage. By integrating these approaches, a more sustainable and eco-friendly future can be envisioned for information technology and energy production. Green computing is the behavior of using computing resources efficiently, by maximizing energy, extending hardware life, minimizing paper usage, and several other technical matters[1], [2]. The main targets of green computing are the earth, people, and profits [3]. Undervolt is one of the methods for implementing green computing. Undervolt is the process of reducing the voltage on the CPU, intending to maximize the use of voltage power [4]–[6]. With this voltage drop, it is expected to reduce electricity consumption without significantly reducing CPU performance [7].

According to developer Valve Steam Store, as of July 2022, 33% of users are AMD Central Processing Unit (CPU), with 32.05% using a 4-core CPU configuration and 0.92% using an Acceleration Processing Unit (APU) Vega 8 [8]. Based on this data, the writer can conclude that there are still quite a lot of Ryzen 3 2200G CPU users.

In this study, the authors conducted research to analyze the effect of undervolt on the AMD Ryzen 3-2200G processor. This study examines the impact of undervolt on electrical efficiency and temperature tested using Synthetic Benchmarks and several Games. The author will undervolt the processor to find a better power efficiency point than the factory specifications of this processor. This analysis will be adjusted to the user's computer usage scenario.

Anja Rabich wrote research in her journal entitled "Software-based Undervolting Faults in AMD Zen Processors". This study examines whether Zen processors are vulnerable to hardware errors used in power management that allow voltage and or frequency manipulation and exploit these hardware errors [9].

Anja Rabich's research has similarities with the author's research in the form of an analysis of the effect of undervolting on the stability of processors used on a software basis to manipulate voltages. The difference from this study is that undervolting is carried out on the processor using the Dynamic Voltage and Frequency Scaling (DVFS) mechanism, namely manipulating the voltage without changing the clock frequency on the processor.

Adam Muc, Tomasz Muchowski, Marcin Kluczyk, Adam Szeleziński (2020), wrote research in his journal entitled "Analysis of the Use of Undervolting to Reduce Electricity Consumption and Environmental Impact of Computers". This study discusses the analysis of the effect of undervolt on the Intel Core i5-6600 desktop processor found in the programming laboratory and the Intel i7-7700HQ mobile processor found on the laptop along with the analysis of accessories connected to the computer [10].

This research has something in common with the author, namely undervolting analysis which is carried out to reduce electricity consumption and temperature performance of computer-generated processors. The difference in this study is the processor used and the undervolting method used is voltage manipulation in the BIOS while the author uses AMD Ryzen Master software.

The author uses AMD Ryzen Master because by using the software, the voltage manipulation process can be carried out more easily because it is supported by an easy-to-understand user interface and there are scenario presets that can be set according to user needs. In addition, by using software, users can apply settings without having to restart the PC, whereas through the BIOS, the voltage manipulation process is carried out during the boot process and enters BOIS mode.

2. Methods

In this test, it is necessary to prepare the hardware and software that will be used and carry out the default test to analyze the scenario that will be used in the undervolt test.

2.1. Hardware

Personal Computer in the form of a desktop for research and supporting devices. The following are the specifications:

- Operating System : Windows 10 Pro
- Processor : AMD Ryzen 3 2200G
- Memory : VENGEANCE LPX 16GB (2 x 8GB)
- SSD : VGen NVME Hyper 256 GB
  VGen SSD 2.5" SATA
- GPU : Vega 8 Graphics onboard
- PSU : Infinity 450W 80+ Bronze
- Motherboard : GigaByte B450M Gaming
- Cooling : PC Cooler S83V2 HSF
- Thermal Paste : Deepcool Z3
- Case : mATX Infinity + Triple Fan RGB
- Power meter : Watt Meter

2.2. Software

• Ryzen Master is used for voltage manipulation on the processor
• Cinebench R20 is used as a CPU test
• Hwinfo64 to detect and analyze hardware information on computer systems.
• Unigine is used as a CPU and GPU test when undervolting
• MSI Afterburner is used to monitor clock frequency, voltage, and frame rate in playing games.
• GTA V and Genshin Impact are used to benchmark CPU-based and GPU-intensive games.

2.3. Undervolting Scenario

The Speed (Mhz) and Voltage Control (V) settings in the Ryzen Master program are modified to undervolt the AMD Ryzen 3-2200G processor. The average core voltage value is 1.316 Volts and the maximum is 1.320 Volts based on the parameters at the default testing stage. The maximum Core Clock is 3.693 GHz, and the average Core Clock is 3.441 GHz. Table 1 shows Undervoltage scenarios.

Table 1. Undervoltage scenarios

No	Voltage Core	Core Clock
1	1.3 V	3600 Mhz
2	1.275 V	3600 Mhz
3	1,25 V	3600 Mhz
4	1,225 V	3600 Mhz

In these researchers need parameters that will be used as the basis for the analysis of the use of undervolting on the processor. In the first stage, testing is carried out on the system using the initial device of the system.

This test is carried out by running the Cinebench R20 software which is used as a CPU test and will be run 10 times. The second is testing the APU by running the Unigine Valley software which is run 10 times. The third test is to run the GTA V benchmark contained in the game and play Genshin Impact, GTA V, Need For Speed Pay Back, PUBG PC games for 20 minutes.

During testing, a Watt Meter installed in the system is intended to monitor the power used in the PC. Hwinfo64 software is used for hardware performance monitoring and MSI Afterburner is used to display game FPS. The room temperature during testing was 27.8 Celsius.

3. Results and Discussion

At this stage, the authors conducted initial testing using the default settings. This is used as an initial standard reference which will then be compared with the four predetermined scenarios. This initial test was carried out by running the computer 10 times.

3.1. Default Tests

Cinebench R20 and Unigine Valley synthetic benchmark tests on the default system can be seen in the Figure 1 until figure 2 and table 2 until table 5.

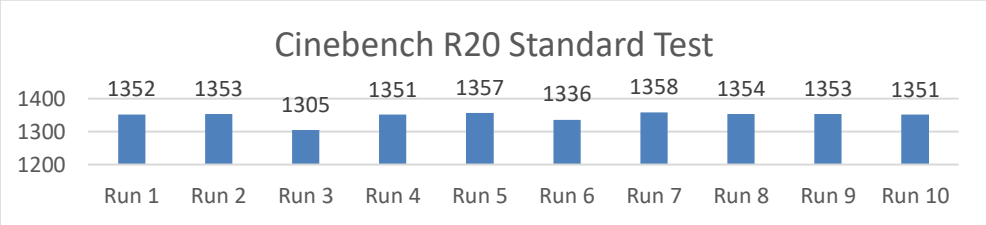

Figure 1. Cinebench R20 Standard Test Chart

Table 2. Cinebench CPU Voltage Performance

Average CPU Voltage (V)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Min	0,856	0,852	0,850	0,850	0,850	0,850	0,850	0,856	0,853	0,850
Avg	1,320	1,316	1,317	1,318	1,311	1,309	1,318	1,315	1,316	1,320
Max	1,364	1,381	1,352	1,394	1,366	1,369	1,372	1,366	1,345	1,347

Table 3. Cinebench CPU Core clock

Average Core Clock (Hz)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Min	1569	2540	2538	1597	1597	1597	1597	1597	2360	1597
Avg	3464	3451	3442	3434	3420	3429	3438	3442	3455	3441
Max	3565	3562	3569	3544	3550	3569	3569	3562	3562	3693

Table 4. Cinebench CPU temperature

Cinebench CPU temperature (°C)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Min	37,1	37,1	37	39,8	38,9	37	39,6	38,7	38,3	37,7
Avg	63,68	63,83	63,74	65,81	61,83	59,44	63,64	63,59	64	69,3
Max	68,3	68,5	68,6	69,1	69,1	68,7	69,1	69,2	69	64,93

During the Cinebench R20 test, was repeated 10 times, each run read by the watt meter consumed 0.008 kWh of power for 5 minutes, and the average consumption of electric power was 96.39 Watts on a system with a maximum load of 104.8 Watts and a minimum of 40 watts.

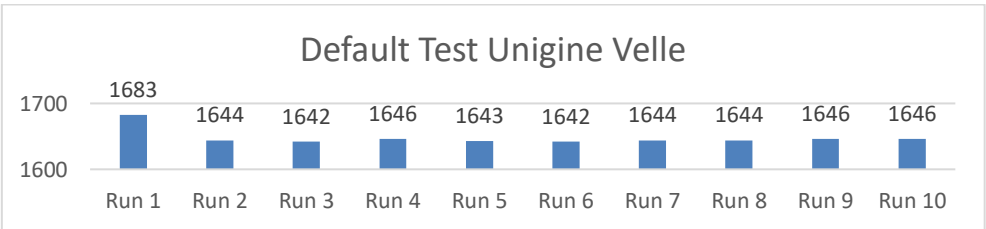

Figure 2. Diagram Default Test Unigine Velley

Table 5. Unigine Velley Temperature Standard

Unigine Valley CPU Temperature (°C)										
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10

Min	41,4	46,1	46,3	44,5	42,3	43,9	43	44,7	44,6	44
Avg	50,11	50,39	50,28	50,04	48,82	49,7	49,64	49,92	49,75	49,77
Max	53,9	52,6	52,7	52,6	52,4	52,4	52,4	52,3	52,2	52,3

During the Valley test, was repeated 10 times, each run that was read by the watt meter consumed 0.008 kWh of power for 5 minutes, and the average consumption of electric power was 96.39 Watts on a system with a maximum load of 104.4 Watts and a minimum of 40 Watts.

The next test is the Genshin Impact game, with the game graphic setting being the default High and a scenario of playing the game for 20 minutes.

Table 6. Genshin Impact test data

Parameter	Min	Max	Avg
FPS	18	59,7	38,6
Watt Meter	88,3	107,8	105,01
CPU Temperature (°C)	47,5	66,25	51,36

The next test is the GTA V game with the game graphics setting set to high, the default game benchmark running for 3 minutes and 20 seconds, and playing casually for 20 minutes.

Table 7. GTA V benchmark test data

Parameter	GTA V Benchmark			GTA V Test		
	Min	Max	Avg	Min	Max	Avg
FPS	7,6	269,5	99,2	39,4	98,1	54,7
Watt Meter (W)	71,3	112,4	109,09	96,2	114,6	111,01
CPU Temperature(°C)	39,25	61,25	55,03	50,5	57	55,42

The next test is the game Need For Speed Payback, with the game graphic setting set to Very High with the default game benchmark, and playing it casually for 20 minutes.

Table 8. NFS payback test data

Parameter	Min	Max	Avg
FPS	17,5	60,7	32
Watt Meter (W)	89,2	123	114,9
CPU Temperature (°C)	55,75	71,75	57,72

The last test is playing the PUBG PC game casually for 20 minutes while the graphics are set to Very Low.

Table 9. PUBG PC test data

Parameter	Min	Max	Avg
FPS	3,3	61,7	44,4
Watt Meter (W)	73,7	114	105
CPU Temperature (°C)	51,75	64	54,79

3.2. Test Findings

The percentage data acquired in comparison to the default data is as follows based on the aforementioned scenario.

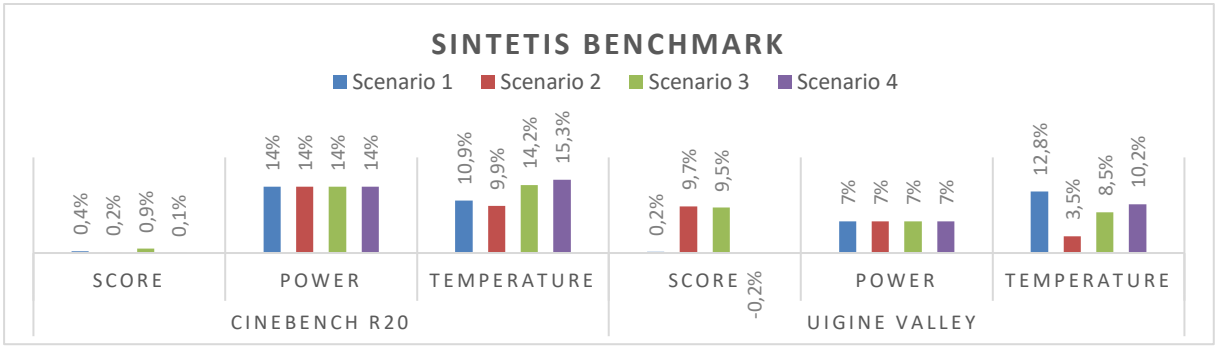

Figure 3. A percentage chart for Cinebench R20

Based on Figure 3, we can see that the third scenario had a greater average score rise with a value of 0.9%, and the fourth scenario had the best temperature decrease value with a value of 15.3%, according to the Cinebench R20 simulated test findings.

Also based on Figure 3, we can see that the second scenario had a greater average score rise with a value of 9.7%, and the first scenario had the best temperature decrease value with a value of 12.8%, according to the results of the Unigine Valley synthetic test.

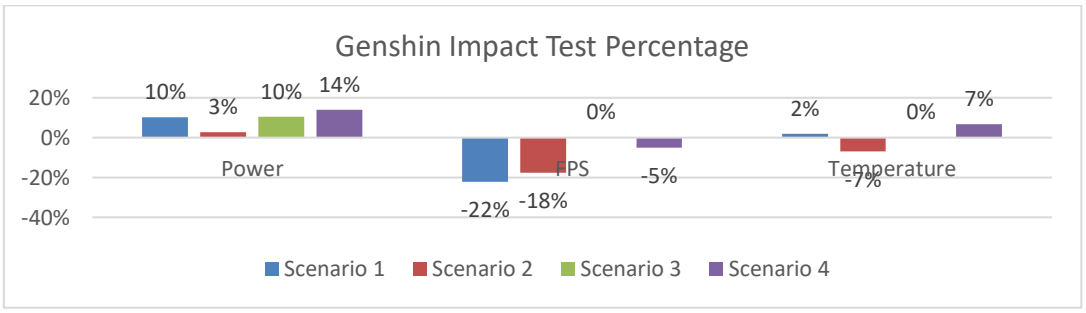

Figure 4. Percentage Diagram for Genshine Impact

Figure 4 shows that Genshine Impact was tested for 20 minutes, and the results showed that the fourth scenario had a higher average decrease in power consumption with a value of 14%. The third scenario could operate optimally without a reduction in FPS and temperature.

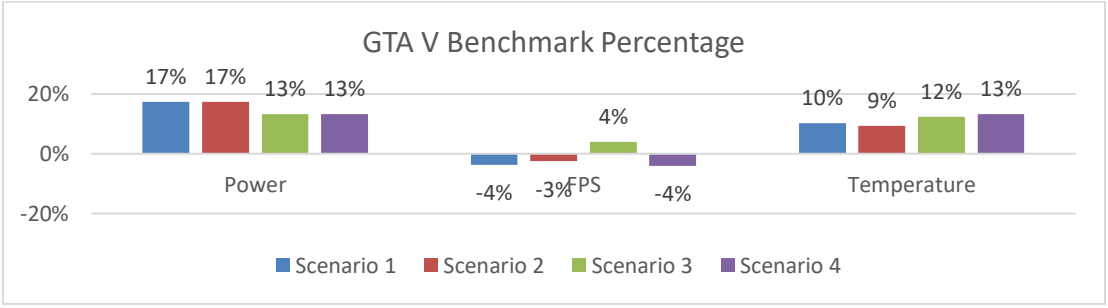

Figure 5. Benchmark Percentage Chart for GTA V

Figure 5 shows that the first and second scenarios had a larger average drop in power consumption with a value of 17%, while the third scenario had a higher average rise in FPS, according to the results of the GTA V Benchmark test, which lasted for 3 minutes and 20 seconds. Better with a value of 4%, and the best temperature reduction value is in the fourth scenario with a value of 13%.

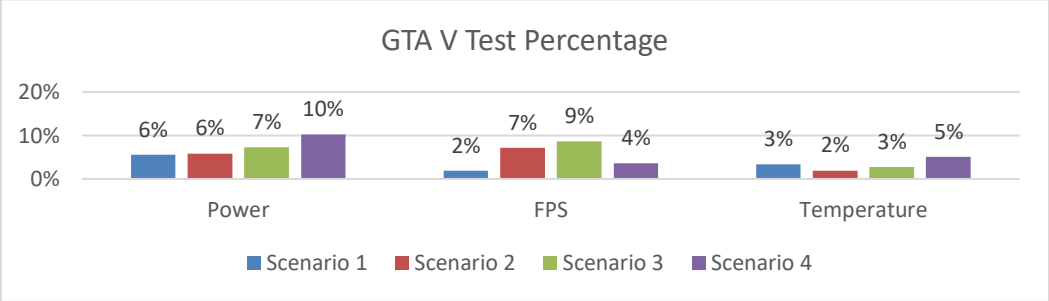

Figure 6. A percentage chart for GTA V

The fourth scenario has a higher average decrease in power consumption with a value of 10%, the third scenario has a better average FPS increase with a value of 9%, and the fourth scenario has a temperature reduction value of 5%, according to the results of testing the GTA V game, which lasts for 20 minutes, as shown in figure 6.

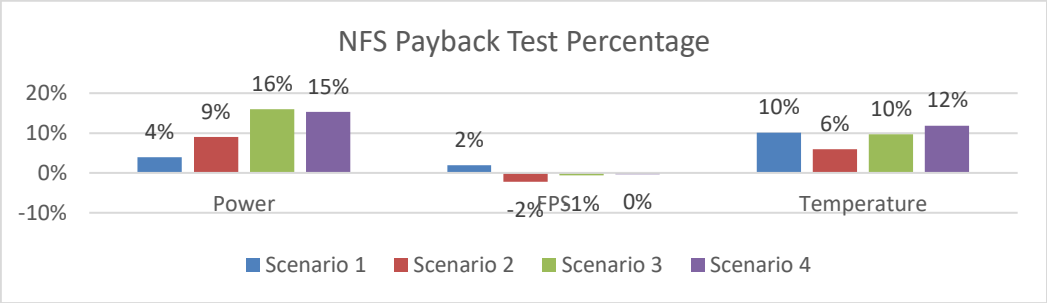

Figure 7. Diagram of the NFS Payback Percentage

The third scenario has a higher average power consumption decrease with a value of 16%, the first scenario has a better average FPS increase with a value of 2%, and the fourth scenario has an average temperature decrease of 12%, according to the results of testing the game Need For Speed Pay Back, which lasts for 20 minutes, as shown in figure 7.

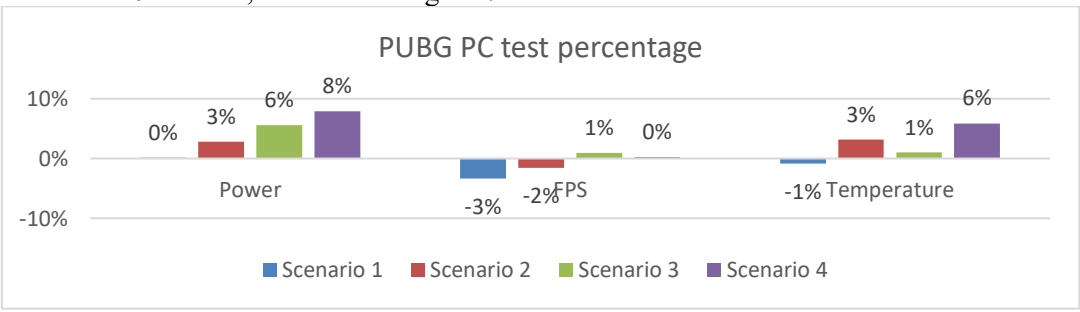

Figure 8. A percentage chart for PUBG PC.

According to the results of 20 minutes of testing the PUBG PC game, the 4th scenario had an average decrease in power consumption of 8%, the 1st scenario had an average decrease in FPS of 3%, and the 4th scenario had an average decrease in temperature of 6%, as shown in figure 8.

4. Conclusion

Based on the configuration results of the 4 test scenarios that the researchers have discussed, the researchers draw the following conclusions: Scenario 1's undervolting configuration has a low percentage value in several tests and the lowest result shows a performance decrease of -22% when testing the Genshine Impact game. Scenario 3 undervolting configuration has a high presentation value in each test when compared to the default test and the other three scenarios which have the best efficiency value of 16% and a decrease in processor working temperature at 14.2%. Scenario 3 undervolting configuration is a configuration that can affect the best processor performance compared to the other three scenarios because in all comparisons scenario 3 shows a stable and high percentage in each test.

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References

[1] E. Koutroulis and K. Kalaitzakis, "Development of an integrated data-acquisition system for renewable energy sources systems monitoring," 2003. [Online]. Available: www.elsevier.com/locate/renene

[2] M. Uddin, A. Shah, R. Alsaqour, and J. Memon, "Measuring efficiency of tier level data centers to implement green energy efficient data centers," *Middle East J Sci Res*, vol. 15, no. 2, pp. 200–207, 2013, doi: 10.5829/idosi.mejsr.2013.15.2.2356.

[3] M. Anwar, "Green Computing and Energy Consumption Issues in the Modern Age," *IOSR J Comput Eng*, vol. 12, no. 6, pp. 91–98, 2013, doi: 10.9790/0661-1269198.

[4] E. Maroudas, S. Lalis, N. Bellas, and C. D. Antonopoulos, "Exploring the potential of context-aware dynamic CPU undervolting," *Proceedings of the 18th ACM International Conference on Computing Frontiers 2021, CF 2021*, pp. 73–82, 2021, doi: 10.1145/3457388.3458658.

[5] M. Shuaib *et al.*, "A Novel Optimization for GPU Mining Using Overclocking and Undervolting," *Sustainability (Switzerland)*, vol. 14, no. 14, Jul. 2022, doi: 10.3390/su14148708.

[6] D. G. Mahmoud, D. Dervishi, S. Hussein, V. Lenders, and M. Stojilovic, "DFAulted: Analyzing and Exploiting CPU Software Faults Caused by FPGA-Driven Undervolting Attacks," *IEEE Access*, vol. 10, pp. 134199–134216, 2022, doi: 10.1109/ACCESS.2022.3231753.

[7] H. Zamani, D. Tripathy, L. Bhuyan, and Z. Chen, "SAOU: Safe adaptive overclocking and undervolting for energy-efficient GPU computing," *ACM International Conference Proceeding Series*, no. August, 2020, doi: 10.1145/3370748.3406553.

[8] "Steam Hardware & Software Survey." https://store.steampowered.com/hwsurvey/processormfg/ (accessed Mar. 05, 2023).

[9] A. Rabich, "Software-based Undervolting Faults in AMD Zen Processors," *its.uni-luebeck.de*, no. August, 2020.

[10] A. Muc, T. Muchowski, M. Kluczyk, and A. Szeleziński, "Analysis of the use of undervolting to reduce electricity consumption and environmental impact of computers," *Rocznik Ochrona Srodowiska*, vol. 22, no. 2, pp. 791–808, 2020.