CONTRASTING MAJOR SOLAR PANEL TESTING CONDITIONS

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Annotation:
Normal Operating Cell Temperature (NOCT) is a measurement referring to the operational conditions of solar cells, defined as the temperature reached by open circuited cells in a module.

Key words: renewable energy sources, autonomous networks, solar installations, energy characteristics, volt-ampere characteristics.

In the PV industry there are various standards testing conditions to test the performance and output of solar pv modules.

Major test conditions include Normal Operating Cell Temperature (NOCT), PV Test Conditions (PTC), Standard Test Conditions (STC), Low Irradiance Conditions (LIC), High Temperature Conditions (HTC) and Low Temperature Conditions (LTC) whose basics will be explained and compared in this article.

Industry standards and certification requirements
The International Electrotechnical Commission (IEC) published the **IEC 61853 standard "Photovoltaic Module. Power Rating**" which requires testing based on a variety of climatic and geographic conditions and includes **HTC**, **LIC**, **HTC**, **NOCT** and **STC**.

There is also the **PV Test Condition (PTC)** wich is not part of that IEC standard. In the following each test condition is explained, a table further below compares the core data each of these test conditions.

Standard Test Conditions (STC)
The electric output performance of crystalline silicon and thin film PV modules are generally measured under standard test conditions (STC). STC is an **industry-wide standard** to indicate the performance of PV modules.

It specifies a module temperature of **25°C, an irradiance of 1000 W/ m² with an air mass 1.5 (AM1.5) spectrum and zero wind speed**. These correspond to the

irradiance and spectrum of sunlight incident on a clear day upon a sun-facing 37°-tilted surface with the sun at an angle of 41.81° above the horizon.

This condition approximately represents **solar noon near the spring and autumn equinoxes** in the continental United States, with surface of the cell aimed directly at the sun. However, these conditions are rarely encountered in the real-world. Being a widely used and referenced standard, STC-based performance testing is applied by **most manufacturers** and such data usually sent over to the customers.

PV Test Conditions (PTC)

PTC is an acronym for PV Test Conditions and is a US-standard that was developed at the University of Davis, California. As compared to STC, PTC is an approach to **closer meet real-world conditions** and measure the actual performance of the modules.

It specifies an insolation of 1000 W/ m² with an air mass 1.5 (AM 1.5) spectrum and an ambient temperature of 20°C at 10 meters above ground level with wind speed of 1 m/s. These differences of 20°C ambient temperature at 10 meters above ground level with 1 m/s wind speed applied under PTC results in a **cell operating temperature** of about 50°C, instead of the rather unreal 25°C under STC conditions. However, similar to STC, PTC also **overestimates** the energy a module generates under real-world conditions. Since cell voltage drops about 0.08V/ °C in environments exceeding ambient temperatures of 25°C, STC voltage ratings may actually equal to lower voltage ratings under PTC conditions, which in the end – applying **Ohm's Law** – results in reduced watts.

Normal Operating Cell Temperature (NOCT)

Normal Operating Cell Temperature (NOCT) is a measurement referring to the **operational conditions of solar cells**, defined as the temperature reached by open circuited cells in a module. Test conditions are defined as 800W/ m² irradiance, 20°C ambient temperature and wind speed of 1m/ s with the PV module at a tilt angle of 45° and its back side open to the breeze (as opposed to conditions where panels are mounted on roofs where heat builds up under the panel). Similar to the PV Test Conditions (PTC), NOCT-based testing is an **approach to mirror real-world conditions**. It is applied to calculate real available wattage on an average day and is a comparably strict parameter.

Low Irradiance Conditions (LIC). Low Irradiance Conditions (LIC) specify the testing of a module's **output performance under low irradiance conditions**, simulating and testing performance of solar panels at higher latitudes and winter.

LIC applies an insolation of 200W/ m², 25°C module temperature, zero wind speed and an air mass of AM 1.5. The detailed required solar spectral irradiance distribution

is laid down in a table in the **IEC 60904-3** (Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data).

High Temperature Conditions (HTC)
Geared to testing panel **performance at higher temperature levels**, the High Temperature Conditions (HTC) specifies testing at irradiance of 1000W/ m², 75°C module temperature, an air mass AM of 1.5 and zero wind speed.

Low Temperature Conditions (LTC)
In contrast to HTC, the **low temperature conditions (LTC)** test the performance of solar panels under comparably lower irradiance and temperature levels and are defined as solar panel testing at 500W/ m², 15°C module temperature, zero wind speed and AM 1.5.

Major Solar PV Module Test Conditions Comparison

Testing Condition	Abbreviation	Irradiance (W/ m²)	Module Temperature (°C)	Ambient Temperatue (°C	Air Mass (AM)	Wind Speed (m/ s)	Module tilt angle (°C)
High Temperature Conditions	HTC	1000	75	/	1.5	0	/
Low Irradiance Conditions	LIC	200	25	/	1.5	0	/
Low Temperature Conditions	LTC	500	15	/	1.5	0	/
Normal Operating Cell Temperature	NOCT	800	/	20	1.5	1	45
PV-USA Test Conditions	PTC	1000	/	20	1.5	1	/
Standard Test Conditions	STC	1000	25	/	1.5	0	/

Comparative table of solar panel test conditions

Conclusion:
Test conditions and long-term module performance quality
Although an industry-wide accepted standard of comparability between modules, **STC is not a sufficiently accurate standard** to mirror a panel's real-world operational and output performance, leading to the situation of certain performance decrease surprises in the long-run.

It also often happens that the panels of manufacturers do not diligently meet STC, for example because of **regularly occurring deviations** in lamp spectrum, module temperature, environment temperature and irradiation.

Moreover, and this is not only limited to testing under STC, fraudulent manufacturers tend to **manipulate the sun simulators** or use **incorrect golden panels** to attain the performance data required, leaving customers under the wrong impression that these panels have good output data. Such regular occuring frauds make independent quality control on site imperative.

As **no single test condition can fully simulate a module's performance under all major climatic and geographic conditions on planet earth**, IEC 61853 is insofar a step in the right direction as it incorporates and demands the performing of various test conditions of a module.

REFERENCES

1. Suyarov A. Power Loss Minimization in Distribution System with Integrating Renewable Energy Resources //International Journal of Engineering and Information Systems (IJEAIS). – 2021. – Т. 5. – №. 2. – С. 37-40.
2. Джуманов А. Н. и др. ИЗМЕРИТЕЛЬНЫЕ ТРАНСФОРМАТОРЫ ТОКА //World science: problems and innovations. – 2021. – С. 76-78.
3. Mamasaliev O. Theoretical Foundations of Energy Saving //International Journal of Engineering and Information Systems (IJEAIS) ISSN. – 2021. – С. 293-296.
4. Sorimsokov U. Use of alternative energy to reduce power losses and improve voltage //Gospodarka i Innowacje. – 2022. – Т. 23. – С. 20-25.
5. Suyarov A. O. et al. Renewable energy research in uzbekistan: prospects and challenges //Web of Scientist: International Scientific Research Journal. – 2022. – Т. 3. – №. 5. – С. 1490-1498.
6. Suyarov A. O. et al. Use of solar and wind energy sources in autonomous networks //Web of Scientist: International Scientific Research Journal. – 2022. – Т. 3. – №. 5. – С. 219-225.
7. Soatboy o'g'li S. U. et al. RELIABILITY OF ELECTROMAGNETIC CONVERTER //Web of Scientist: International Scientific Research Journal. – 2022. – Т. 3. – №. 5. – С. 1499-1506.
8. Soatboy o'g'li S. U. et al. THE COST OF A TRANSFORMER AND THE IMPORTANCE OF ITS HEATING //Web of Scientist: International Scientific Research Journal. – 2022. – Т. 3. – №. 5. – С. 1467-1473.

9. Suyarov A. O. et al. Renewable energy research in uzbekistan: prospects and challenges //Web of Scientist: International Scientific Research Journal. – 2022. – Т. 3. – №. 5. – С. 1490-1498.

10. Suyarova, M. X. (2019). Teaching physics in a technical university. Экономика и социум, (12), 123-125.

11. Иняминов, Ю. А., & Суярова, М. X. (2021). Принципы построения индивидуальных радиоприёмных устройств спутникового телевидения. Science and Education, 2(11), 342-349.

12. KHUSANOVNA, S. M., & GULNOZAALIEVNA, A. ADVANTAGES AND DISADVANTAGES OF USING MULTIMEDIA IN TEACHING FOREIGN LANGUAGES. XORIJIY TILLARNI O „QITISHNING DOLZARB MASALALARI: MUAMMOLAR VA YECHIMLAR, 170.

13. Суярова, М. X. (2021). УСПЕШНОЕ РАЗВИТИЕ И ЭФФЕКТИВНОЕ ФУНКЦИОНИРОВАНИЕ ТЕЛЕКОММУНИКАЦИОННЫХ СИСТЕМ РЕСПУБЛИКИ УЗБЕКИСТАН. In НАУКА, ОБРАЗОВАНИЕ, ИННОВАЦИИ: АКТУАЛЬНЫЕ ВОПРОСЫ И СОВРЕМЕННЫЕ АСПЕКТЫ (pp. 67-69).

14. Суярова, М. X., & Мустафакулов, А. А. ТВОРЧЕСКИЕ ЗАДАЧИ ПО ЭЛЕКТРОМЕХАНИКЕ. «ИННОВАЦИОН ИҚТИСОДИЁТ: МУАММО, ТАҲЛИЛ ВА РИВОЖЛАНИШ ИСТИҚБОЛЛАРИ» Халқаро илмий-амалий анжуман илмий мақолалар тўплами 20-21 май 2021 й., 418.

15. Суярова, М. X., & Джураева, Н. М. (2018). Динамическая модель по электротехнике. In Передовые научно-технические и социально-гуманитарные проекты в современной науке (pp. 53-54).