QUYOSH ENERGETIKASIDA FOTOELEMENTNING NOMINAL ISH HARORATI – NOCT STANDARTI: LIC, HTC, LTC SHAROITLARI

Murodov Muzaffar Xabibullayevich t.f.n. dotsent,
Ismoilov Hasanboy Abduvali o‘g‘li o‘qituvchi,
Namangan davlat texnika universiteti

Matchanova Firuza Karimbeganovna o ‘qituvchi
Namangan tumani 25-maktab
https://doi.org/10.5281/zenodo.17062301

Annotatsiya. Ushbu maqolada quyosh panellarining real ish sharoitlarida samaradorligini baholovchi muhim standartlar – NOCT, LIC, HTC va LTC haqida so‘z yuritiladi. Mualliflar NOCT (Nominal Operating Cell Temperature) standartining mohiyatini, uni boshqa STC va PTC kabi standartlardan farqi hamda modulning dizayni va haroratga nisbatan barqarorligi haqidagi jihatlarni tahlil qilgan. Maqolada yuqori va past harorat hamda past yoritilish sharoitlaridagi ishlash ko‘rsatkichlari orqali quyosh panellarini tanlashda to‘g‘ri qaror qabul qilish imkoniyati yaratadi. Shuningdek, modulning haroratga bog‘liq energiya yo‘qotishlari va real samaradorligini hisobga olish zarurligi qayd etilgan.

Kalit so‘zlar: NOCT standarti, harorat koeffitsienti, LIC (past yoritilish), HTC (yuqori harorat), LTC (past harorat), real ish sharoitlari, foydali ish koeffitsienti, termogramma tahlili, quvvat yo‘qotishlari, energiya prognozi.

Baholashni yagona mezonga solish borasida standart sinov sharoitlari muhim hisoblanadi. Har bir quyosh paneli turli iqlim, harorat va yoritilish sharoitlarida har xil ishlaydi standart sinov sharoitlari yordamida barcha panellar bir xil sharoitda test qilinadi, natijalar taqqoslanadigan bo‘ladi. Bu investorlar, muhandislar va xaridorlar uchun aniq qaror qabul qilish imkonini beradi[1].

[1] IEC 61853-1:2011. Photovoltaic (PV) modules – Performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating. International Electrotechnical Commission (IEC), Geneva.

NOST – bu Nominal Operating Cell Temperature degan ma’noni bildiradi. Bu standart turli iqlim va tabiiy muhit sharoitlarida quyosh panellarining real ishlashini tahlil qilishga qaratilgan.

NOST STC (Standard Test Conditions) yoki PTC (PVUSA Test Conditions) kabi nazorat ostidagi laboratoriya sharoitlari emas, balki ochiq havoda, tabiiy muhitda o‘tkaziladigan sinovlarni nazarda tutadi.

Real ish sharoitlarining modul hosil qiladigan quvvatga ta'sirini baholash uchun qo'shimcha parametrlar qabul qilindi. NOCT kontseptsiyasi paydo bo'ldi – ya'ni bu, modulning odatiy ish sharoitidagi harorati. Quyosh elementining nominal ish harorati (NOCT) 800 W/m^2 yoritilganlik va 20 °C tashqi muhitning harorati ta`siri ostida o'lchanadi. Bunda elektr zanjiri ochiq, modulning qiyalik burchagi janubga yo'naltirilgan holda 45°. NOCT ko‘rsatkichlari qanchalik kichik bo'lsa, modul real sharoitlarda shunchalik yaxshi ishlaydi[2].

NOCT modullarning sinov sharoiti emas, u faqat modul parametrlaridan bittasi xolos. Shuningdek, NOCT fotoelementlar uchun aniq bir belgilangan haroratini ham bildirmaydi. Gap shundaki shundaki, modulning dizayni va uni tayyorlangan materiali uning qizish qobiliyatiga ta'sir qiladi. Odatda modul atrof-muhit haroratidan 15-30 daraja yuqori haroratga ega. Real sharoitda yaxshi sifatga ega modullar harorati 40-45 °C dan ortib yuqori darajada qizib ketmaydi va shu bilan qizdirilganda kamroq quvvat yo'qotadi. Yomon sifatli modullar esa o‘ta qizib ketadi. O'rtacha NOCT uchun harorat taxminan 48 °C[3].

AQShda 330 ga yaqin quyosh modullari sinovdan o'tkazildi va unga ko‘ra, aksariyat modullarda 45 ºC yoki undan pastroq bo'lgan NOCT ko‘rsatkichi qayd etildi.

---

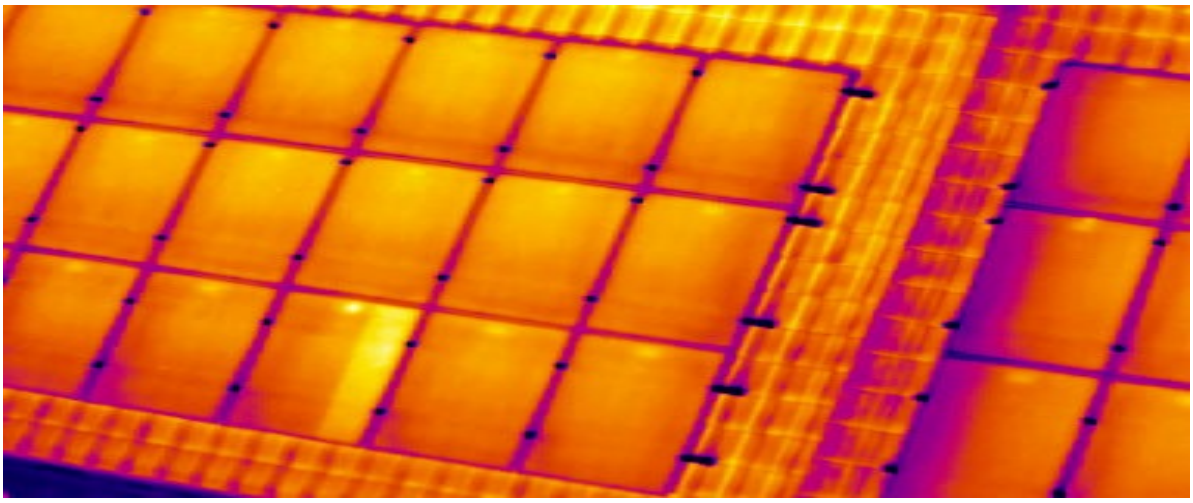
[2] King, D.L., Boyson, W.E., Kratochvil, J.A. (2004). Photovoltaic Array Performance Model. Sandia National Laboratories, SAND2004-3535.
Skoplaki, E., & Palyvos, J.A. (2009). On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. Solar Energy, 83(5), 614-624.

[3] Emery, K. (2011). Solar Photovoltaic Characterization. In: Markvart, T., & Castaner, L. (eds), Practical Handbook of Photovoltaics: Fundamentals and Applications, Elsevier.

Eng past NOCT ko‘rsatkichi esa 43ºC ga teng bo‘lib, ular faqat 33 ta modulda qayd etildi va jami sinovdan o'tgan modullarning 10% ini tashkil etdi. Sinovda asosan polikristal modullardan foydalanilgan edi. Shuningdek, yana 30 ga yaqin modullar NOCT ko‘rsatkichi 49÷50ºC ni tashkil etdi.

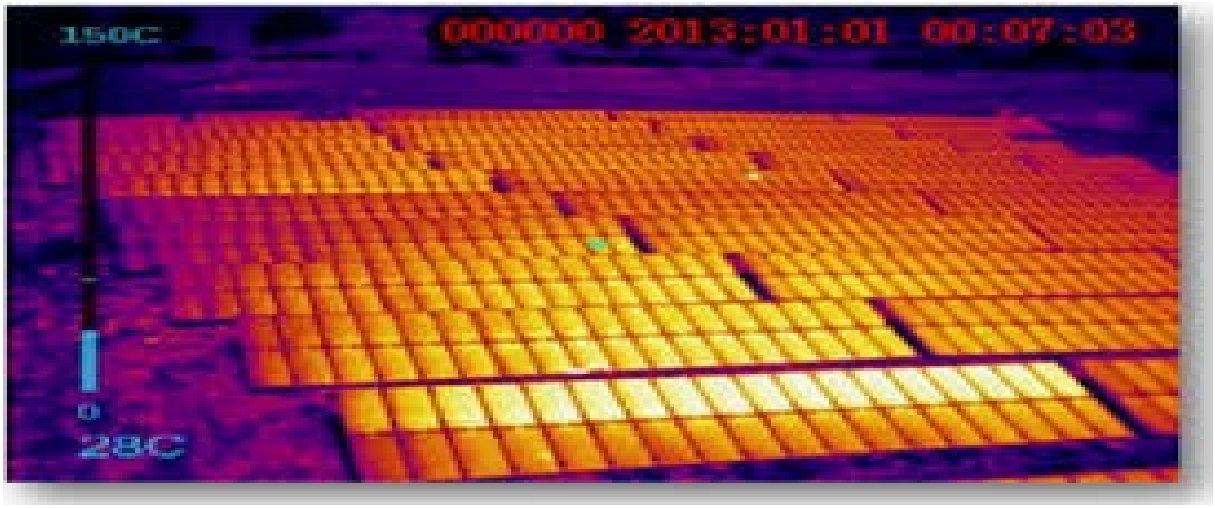
Fotoelektrik modullarda tok, kuchlanish va quvvatning harorat bog‘iq ravishda o‘zgarishi

Albatta, modulning harorati quyosh batareyasining qayerga va qanday o'rnatilishiga bog'liq bo'ladi – tomga, tayanchga, maxsus konstruksiyaga va hokazo (1- va 2-rasmlar). Quyosh batareyasini sovutishning shartlari shunga bog'liq – turlicha o'rnatilgan quyosh modullarining haroratidagi farq 10-15 darajagacha yetishi mumkin. Issiq yoz fasllarida quyosh panellari 75-80 °C gacha, ekvatorial hududlarda esa 80-90 °C gacha qiziydi[4]. Quyosh panellarining o‘ta qizib ketishi nafaqat uning ishlash muddatini qisqartiradi, balki uning F.I.K ini ham kamaytiradi. 25 °C haroratda F.I.K.=0,46 ga teng bo‘lgan zamonaviy galliy-arsenid asosidagi quyosh panellarining sirti 70 °C ga qiziganda ishlab chiqargan quvvatining 20% ni, 90 °C da esa 30% ni yo'qotadi.



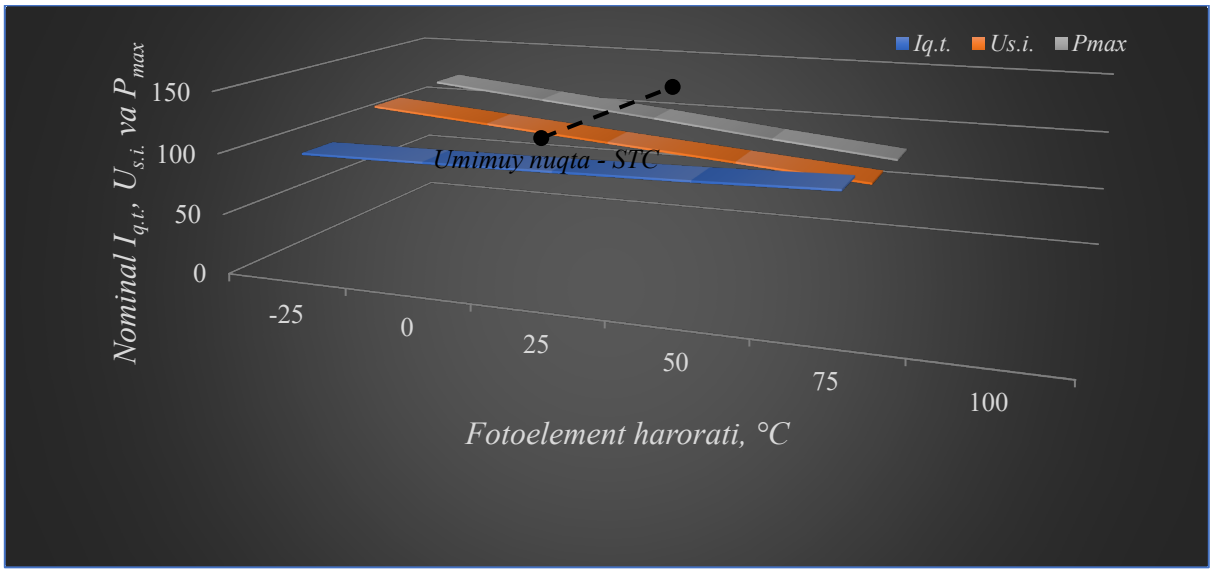
1-rasm. Tomda joylashgan, ishchi holatdagi fotoelektrik modul termogrammasi

[4] ASTM G173-03(2012). Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface. ASTM International.



2-rasm. Tayanchga o‘rnatilgan, ishchi holatdagi fotoelektrik batareya termogrammasi

Quyosh elementining kuchlanishi STC dagi haroratning (25 °C) har bir darajaga o‘zgarishi uchun taxminan 0,08V ga to‘g‘ri keladi. Shuning uchun, agar STC dagi kuchlanish 17 V bo'lsa, u holda real ish sharoitida u 15 yoki 16 V bo'lishi mumkin (3-rasm).



3-rasm. $I_{q.t.}$, $U_{s.i.}$ va P_{max} ga haroratning ta’siri

$$I_{q.t.}\ harorat\ koeffisienti\ +0.057\,\%/°\mathrm{C}$$

$$U_{s.i.}\ harorat\ koeffisienti\ -0.346\,\%/°\mathrm{C}$$

$$P_{max}\ harorat\ koeffisienti\ -0.478\ \%/℃$$

NOCT sharoitida boshqa barcha parametrlari teng bo‘lgan holda, harorati 43 °C bo'lgan modul 50 °C haroratli modulga qaraganda taxminan 3% ko'proq energiya ishlab chiqaradi. Eng yaxshi quyosh panellari minimal NOCTga ega bo‘lgan panellardir. NOCT ko‘rsatkichi 50 °C dan yuqori bo'lgan panellarni sotib olmagan ma`qulroqdir[5].

Low Irradiance Conditions (LIC) – past nurlanish (yoritilganli) sharoitlari.

Low Irradiance Conditions (LIC) – quyosh modulining kam yoki kuchsiz yorug'lik sharoitida ishlashini aniqlash uchun ishlatiladi va quyosh panellarining yuqori kengliklardagi, qishdagi ishlash xarakteristikalarini tanishtiradi. LIC sharoitlari deganda yoritilganlik 200 W/m², modul harorati 25 °C, shamolsiz ob-havo va AM 1,5 ga mos keladigan spektrni nazarda tutiladi. Spektral taqsimot IEC 60904-3 (Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data) standarti jadvalida keltirilgan.

High Temperature Conditions (HTC) – yuqori harorat sharoitlari.

Modullar harorati yuqori – 75 °C, yoritilganlik 1000 W/m² va AM 1,5 ga mos keluvchi spektrda sinovdan o‘tkaziladi.

Low Temperature Conditions (LTC) – past harorat sharoitlari.

HTC dan farqli o‘laroq, bu sharoitda modul harorati 15 °C, yoritilganlik 500 W/m², shamol tezligi 0 ga teng bo‘lgan va AM 1,5 ga mos spektrini nazarda tutiladi[6].

Shunday qilib, standartlar fotoelektrik modullarning real ish parametrlarini tushunish uchun kerak bo‘ladi. Shu jumlada NOST ham. Quyida uchta standartlar haqiqiylik darajasi bo‘yicha siloshtirma jadval keltirilgan (1-jadval).

Masalan, STC bo‘yicha panel 300 W bo‘lsa, PTC sharoitida 285 W, NOST bo‘yicha esa 270 W ishlab chiqarishi mumkin.

[5] Green, M.A. (2003). Solar Cells: Operating Principles, Technology, and System Applications. UNSW, Australia.
[6] Honsberg, C., & Bowden, S. PV Education Website, https://www.pveducation.org.

Standart	Maqsadi	Haqiqiylik darajasi
STC	Laboratoriyada maksimal quvvatni o‘lchash	Past
PTC	Real sharoitga yaqin nazoratli sinov	O‘rta
NOST	Haqiqiy tabiatdagi uzoq muddatli ish	Yuqori

Energiya ishlab chiqarishni prognoz qilish bo‘yicha esa loyiha bosqichida STC – panelning maksimal imkoniyatlarini ko‘rsatadi, PTC – haqiqatga yaqin prognoz beradi, NOST esa – aniq ishlashga asoslangan uzoq muddatli prognoz beradi. Bu ma’lumotlar quyosh elektr stansiyalarining foydaliligini aniqlashda juda muhim.

Adabiyotlar:

1. IEC 61853-1:2011. Photovoltaic (PV) modules – Performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating. International Electrotechnical Commission (IEC), Geneva.

2. King, D.L., Boyson, W.E., Kratochvil, J.A. (2004). Photovoltaic Array Performance Model. Sandia National Laboratories, SAND2004-3535.

3. Skoplaki, E., & Palyvos, J.A. (2009). On the temperature dependence of photovoltaic module electrical performance: A review of efficiency/power correlations. Solar Energy, 83(5), 614–624.

4. Emery, K. (2011). Solar Photovoltaic Characterization. In: Markvart, T., & Castaner, L. (eds), Practical Handbook of Photovoltaics: Fundamentals and Applications, Elsevier.

5. ASTM G173-03(2012). Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37° Tilted Surface. ASTM International.

6. Green, M.A. (2003). Solar Cells: Operating Principles, Technology, and System Applications. UNSW, Australia.

7. Honsberg, C., & Bowden, S. PV Education Website, https://www.pveducation.org.