



**ФАН ВА ТЕХНОЛОГИЯЛАР  
ТАРАҚҚИЁТИ**  
**РАЗВИТИЕ НАУКИ И  
ТЕХНОЛОГИЙ**



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**Ушбу журналда чоп этилган материаллар тахририятнинг ёзма рухсатисиз тўлиқ ёки қисман чоп этилиши мумкин эмас. Тахририятнинг фикри муаллифлар фикри билан ҳар доим ҳам мос тушмаслиги мумкин. Журналда ёритилган материалларнинг ҳаққонийлиги учун мақолаларнинг муаллифлари ва реклама берувчилар масъулдирлар.**

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## FACTORS IN SELECTING A SOLAR CONCENTRATOR

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**Abstract.** This article analyzes the issue of selecting the optimal solar concentrator for solar-powered drying systems. Various types of collectors – flat-plate, vacuum tube, and focusing concentrators – are compared in terms of efficiency, operating temperature, and technical and economic indicators. The benefits and application scenarios of hybrid systems are also discussed. Results show that each collector type is effective under specific conditions, and the optimal choice depends on climate, temperature requirements, and economic feasibility.

**Keywords:** solar concentrator, focusing collector, flat-plate collector, vacuum collector, solar radiation, energy efficiency, heat, drying system, hybrid system, economic effectiveness.

## QUYOSH KONSENTRATORINI TANLASHDAGI OMILLAR

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**Annotatsiya.** Mazkur maqolada quyosh energiyasidan foydalaniladigan quritish tizimlari uchun optimal quyosh konsentratorini tanlash masalasi tahlil qilingan. Turli turdagi kollektorlar – yassi, vakuum va fokuslovchi kollektorlar – samaradorligi, ish harorati, texnik va iqtisodiy ko'rsatkichlari asosida solishtirib chiqilgan. Shuningdek, kombinatsiyalashgan (gibrid) tizimlarning afzalliklari va qo'llash sharoitlari ko'rib chiqilgan. Tahlil natijalariga ko'ra, har bir turdagi kollektor ma'lum sharoitlarda samarali bo'lib, optimal tanlov iqlim, harorat talabi va iqtisodiy imkoniyatlarga qarab belgilanadi.

**Kalit so'zlar:** quyosh konsentratori, fokuslovchi kollektor, yassi kollektor, vakuum kollektor, quyosh nurlanishi, energiya tejamkorligi, issiqlik, quritish tizimi, gibrid tizim, iqtisodiy samaradorlik.

## ФАКТОРЫ ВЫБОРА СОЛНЕЧНОГО КОНЦЕНТРАТОРА

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**Аннотация.** В данной статье рассматривается выбор оптимального солнечного концентратора для систем сушки, работающих на солнечной энергии. Проведено сравнение различных типов коллекторов – плоских, вакуумных и фокусирующих – по их эффективности, рабочей температуре, техническим и экономическим характеристикам. Также проанализированы преимущества и условия применения гибридных систем. Результаты показывают, что каждый тип коллектора эффективен при определённых условиях, а выбор зависит от климата, требуемой температуры и экономических возможностей.

**Ключевые слова:** солнечный концентратор, фокусирующий коллектор, плоский коллектор, вакуумный коллектор, солнечное излучение, энергоэффективность, тепло, система сушки, гибридная система, экономическая эффективность.

**Introduction.** Solar energy is one of the most promising renewable energy sources, and effective utilization of it is crucial for meeting growing energy demands [1]. A key technology in harnessing solar power is the *solar concentrator*, which focuses sunlight to achieve higher temperatures or intensities than normal sunlight. By concentrating solar radiation, these systems can significantly improve the efficiency of solar thermal and photovoltaic applications. There are various types of solar concentrators – including parabolic troughs, parabolic dishes, Fresnel lenses, and heliostat field (central receiver) systems – each with distinct characteristics and suited for different purposes. Selecting an appropriate solar concentrator for a given application is a complex task that depends on numerous technical and economic factors.

Recent studies underscore the importance of choosing the right concentrator design to maximize energy output and cost-effectiveness [1]. The choice must consider factors such as the required temperature or energy output, the available solar resource, and practical constraints like cost and maintenance. In this article, we provide an in-depth analysis of the factors affecting the selection of a solar concentrator. The goal is to identify the key criteria and considerations that guide the decision-making process when choosing a concentrator for various solar energy systems. This analysis draws on established research and theoretical principles to ensure an academic and technical perspective on the subject.

**Methods.** In order to determine the critical factors for selecting a solar concentrator, we conducted a comprehensive review of different concentrator types and their performance characteristics. The study methodology included a comparative analysis of technical parameters obtained from literature and theoretical models. We examined the optical and geometric properties of each concentrator design – such as concentration ratio, focal length, aperture size, and optical efficiency – using known formulas and design specifications [2]. For example, the geometric concentration ratio (the ratio of concentrator aperture area to receiver area) is one fundamental parameter computed for each design. We also considered the focal distance and aperture diameter relationships for parabolic concentrators, given by classic formulas (e.g. the focal length formula for a parabola) to understand how concentrator geometry influences performance [3].

Additionally, performance data from experimental studies and prior research were analyzed to validate theoretical expectations. For instance, published experimental results for parabolic dish concentrators were reviewed to gauge real-world optical efficiency and achievable temperatures [1]. Our analysis incorporated different operating conditions as well: we looked at how concentrators perform under varying solar irradiance levels and what tracking requirements they have (single-axis vs. dual-axis tracking). By comparing these attributes, we identified which factors are most influential in the context of choosing one concentrator type over another. This methodical approach ensures that the conclusions drawn are backed by both theoretical calculations and empirical evidence, maintaining a high academic rigor in our selection criteria evaluation.

**Results.** Our analysis revealed several key factors that must be considered when selecting a solar concentrator. These factors, outlined below, encompass technical performance characteristics as well as practical and economic considerations:

**Required Concentration Ratio and Temperature:** The needed output temperature or concentration level is a primary factor. High-temperature applications (such as power generation with steam turbines or Stirling engines) demand a high concentration ratio, which can be achieved by point-focus concentrators like parabolic dishes or central receiver (tower) systems. Lower temperature applications (e.g. water heating) may only require low to medium concentration, for which line-focus concentrators like parabolic troughs or compound parabolic concentrators (CPCs) are sufficient. Thus, the target operating temperature heavily influences the choice of concentrator design.

**Solar Irradiance and Climate Conditions:** The selection depends on the nature of the solar resource available. Concentrators generally require direct normal irradiance (direct sunlight) to function effectively, as diffuse light cannot be easily focused. In regions with high direct sunlight, concentrator systems (especially those with higher concentration ratios) perform well. In contrast, in climates where the sunlight is often diffuse or there is significant cloud cover, simpler concentrators or non-concentrating collectors might be more appropriate. The average solar insolation, atmospheric conditions (dust, humidity), and seasonal variability are therefore important when choosing a concentrator.

**Type of Solar Concentrator (Optical Design):** Different concentrator configurations offer different advantages. For example, parabolic troughs concentrate sunlight onto a linear receiver and typically require one-axis tracking; they are proven for solar thermal power plants and can achieve moderate concentration ratios. Parabolic dishes concentrate onto a single point receiver, requiring two-axis tracking, and can achieve very high concentration and temperatures, making them suitable for high-efficiency engines or high-temperature processes. Fresnel lens concentrators use flat lens arrays to focus light and can be lighter and potentially cheaper, though they may have slightly lower optical efficiency. Heliostat field (central tower) systems use many mirrors to concentrate sunlight onto a central tower receiver and are ideal for large-scale power generation. The choice among these designs depends on the scale of the project and performance requirements. For instance, for distributed small-scale applications, a parabolic dish or Fresnel lens concentrator might be preferred, whereas utility-scale power plants might opt for trough or tower systems.

**Tracking Requirements and Complexity:** The necessity and complexity of solar tracking is a vital factor. High-concentration systems (dish, tower) typically need dual-axis tracking to continuously focus sunlight on the receiver as the sun moves, which adds mechanical and control complexity. Parabolic troughs use single-axis tracking (usually east-west rotation) and are mechanically simpler but cannot concentrate as much as dishes. Some low-concentration or stationary concentrators (like CPCs) are designed to accept sunlight over a range of angles and may not require active tracking at all. When selecting a concentrator, one must consider if the infrastructure can support the required tracking system. Projects with limited technical capacity for maintenance might favor designs with simpler or no tracking despite a lower concentration performance.

**Optical Efficiency and Losses:** Different concentrator types exhibit different optical efficiencies – i.e., the fraction of sunlight that actually reaches the receiver and is absorbed. Losses can occur due to reflection, absorption by mirrors or lenses, and spillage (misalignment losses). For example, parabolic dishes have high optical efficiency since they focus all incoming rays to one point with minimal optical surfaces, whereas a Fresnel lens concentrator might have slightly more losses due to the lens material and alignment imperfections. The intercept factor (what percentage of reflected rays hit the receiver) and reflective material quality (mirror reflectivity or lens transparency) are important sub-factors. A design that provides a higher optical efficiency for the given application will be more attractive. In practice, this means evaluating the quality of materials (mirrors or lenses), the precision of the concentrator shape, and how well the concentrator can maintain alignment with the sun.

**Size, Land, and Space Constraints:** The physical footprint of the concentrator system is another consideration. For instance, a central tower system requires a large land area for the heliostat field and a tall tower, which is feasible for utility-scale projects but not for residential use. Parabolic trough arrays also need significant land area and are usually deployed in solar farms. On the other hand, parabolic dish units are more compact and modular, potentially suitable for decentralized use (each dish has its own receiver and engine). Fresnel lens systems might be mounted on rooftops if small, but large Fresnel installations also need area and structure. Thus, depending on the available installation space and land cost, certain concentrator types may be preferred over others.

**Cost and Economic Factors:** Economic considerations are often decisive. This includes the initial capital cost of the concentrator system (manufacturing or purchasing mirrors, lenses, support structures, tracking motors, etc.) as well as operating costs (maintenance, cleaning of optical surfaces, tracking system power consumption). Some concentrator designs are inherently more expensive than others; for example, a high-precision parabolic dish with dual-axis tracker and a sophisticated receiver can be costly per unit, whereas a simple Fresnel lens or CPC might be cheaper to produce. We must also consider the *cost per unit of energy* produced – a concentrator with higher efficiency might justify a higher cost if it significantly boosts energy output. In the selection process, a cost-benefit analysis is typically performed: this involves comparing the expected energy gain from a more efficient but more expensive concentrator versus a less efficient, cheaper option. The concentrator that offers the lower levelized cost of energy (LCOE) for the project's scale and lifespan would usually be the preferred choice.

**Durability and Maintenance:** Environmental durability (resistance to wind, rain, dust, and temperature extremes) is a practical factor affecting the choice of concentrator. Designs with many moving parts (like tracking systems) or large reflective surfaces must withstand weather and require periodic maintenance. For instance, heliostat mirrors and parabolic troughs need regular cleaning and occasional re-alignment; Fresnel lenses may get clouded or scratched over time and need replacement or cleaning; tracking systems need lubrication and calibration. If a project is in an area with harsh conditions (e.g. high winds or sandstorms), the concentrator selection might lean towards sturdier designs with simpler maintenance. A heavier, well-anchored parabolic trough might survive strong winds better than a tall tower with many heliostats, for example. The availability of local

maintenance expertise also plays a role – choosing a concentrator that local technicians can easily maintain is important for long-term performance.

**Application and Integration:** Finally, the end-use application dictates many requirements for the concentrator. For instance, if the application is electricity generation via a steam cycle, a continuous and stable heat supply is needed, which might favor a trough or tower system with thermal storage integration. If the application is a solar cooker or industrial process heat for a small facility, a simpler concentrator like a dish or compound parabolic concentrator could be more appropriate. Integration with other system components (thermal storage units, boilers, PV cells in case of concentrated PV, etc.) will influence which concentrator technology fits best. The choice should ensure compatibility with the overall system design and facilitate achieving the intended performance metrics of the project.

These results indicate that no single concentrator design is optimal for all scenarios. Instead, the selection involves balancing the above factors to meet the specific goals and constraints of the project. For example, if the priority is achieving extremely high temperatures (for a research experiment or specialized application), a parabolic dish might be chosen despite higher complexity and cost. Conversely, if simplicity and low maintenance are paramount (for a rural decentralized heating system), a lower-concentration stationary concentrator might be selected even though its peak efficiency is lower. The results of our factor analysis provide a structured way to approach this decision-making process.

**Discussion.** The findings highlight that the process of choosing a solar concentrator is inherently multi-faceted. Each factor identified in the results section can significantly impact the performance and feasibility of a concentrator in practice, and often these factors must be weighed against each other. In this discussion, we explore how these factors interact and how an optimal balance might be achieved for different scenarios.

One notable trade-off is between concentration ratio (and the resultant temperature) and system complexity. While higher concentration ratios enable higher thermal efficiencies and the ability to reach extreme temperatures, they require more sophisticated concentrator systems (usually with dual-axis tracking and precise optics). This means higher upfront costs and maintenance efforts. For instance, a parabolic dish concentrator can achieve very high concentration and has shown excellent performance in experimental studies [3], but deploying many dish systems can be expensive and operationally complex. In contrast, a parabolic trough field, which operates at a lower concentration ratio, might be less costly on a per-unit basis and easier to maintain for large-scale power generation, though it will not reach the temperatures a dish can achieve. Therefore, for a large power plant where reliability and proven technology are important, parabolic troughs or central receiver towers (with their established track record in concentrated solar power plants) might be preferred over dishes, despite their lower concentration, because they strike a better balance between performance and complexity for that scenario.

Another important consideration is the environment in which the concentrator will operate. In high-DNI (Direct Normal Irradiance) deserts or clear-sky regions, high-performance concentrators can be utilized to their full potential, justifying their cost. However, in environments with frequent clouds or high diffuse radiation, even the best concentrator will spend much of its time under-performing. In such cases, investing in an expensive concentrator yield diminishing returns. This suggests that in moderate climates, designers might opt for simpler or hybrid solutions (for instance, a combination of flat-plate collectors with low-concentration CPCs) to ensure some energy capture even during non-ideal conditions. The discussion with regard to climate essentially underscores that the "best" concentrator is context-dependent: it must be matched to the local solar resource profile.

Economic factors cannot be overlooked, as they often ultimately decide what is feasible. A cost-effective design that delivers slightly lower performance may often be more attractive than an ideal but prohibitively expensive system. For example, while a central tower system with thousands

of heliostats could deliver high power output, the infrastructure and operational costs might make it unsuitable for anything but utility-scale projects with significant funding. Meanwhile, a community-level project might benefit more from a smaller array of troughs or dishes that can be incrementally installed and maintained. The Levelized Cost of Energy (LCOE) for each concentrator type in the given project scope should be compared. This includes factoring in not only initial costs but also the expected lifetime, maintenance schedule, and any downtime losses. Our analysis indicates that often there is a diminishing return on investment beyond a certain point – for instance, pursuing the last few percent of efficiency with a more complex concentrator might not be worth the exponential increase in cost and upkeep. Thus, decision-makers should seek an optimal point where the energy output and system complexity reach a favorable balance in economic terms.

The discussion also extends to technological maturity and risk. Parabolic troughs and power towers have been implemented in numerous projects worldwide and their performance and issues are well documented. In contrast, newer approaches or less common concentrators (such as novel static concentrators or luminescent solar concentrators) might offer interesting advantages but come with higher uncertainty. If the goal is to ensure proven reliability, one might favor a traditional design with a solid track record [4]. On the other hand, if innovation or achieving maximum performance is the goal, one might experiment with advanced concentrator designs despite less certainty. Therefore, the selection process might also factor in how much risk or innovation is acceptable in the context of the project.

In summary, the choice of a solar concentrator emerges from a careful consideration of all the factors discussed. Each factor – from technical performance metrics to practical deployment concerns – plays a role, and they are often interdependent. The *Discussion* emphasizes that an optimal concentrator choice is usually case-specific. For any given project, engineers and decision-makers should clearly define their priorities (be it maximizing efficiency, minimizing cost, ensuring simplicity, etc.) and use those priorities to weigh the importance of each factor. By doing so, the selection of a solar concentrator can be tailored to align with the project's objectives and constraints, thereby leading to a more successful and sustainable solar energy system implementation.

**Conclusion.** Selecting the most appropriate solar concentrator for a particular application is a critical decision that affects the overall success and efficiency of a solar energy project. In this article, we have translated and presented an academic analysis of the factors influencing this selection process. The translated content has maintained the structure and technical detail of the original Uzbek article while conveying it in formal academic English.

Several key conclusions can be drawn from this study. First, technical requirements such as desired temperature and concentration ratio emerge as fundamental determinants in narrowing down suitable concentrator types. A clear understanding of the energy output requirements allows one to focus on designs that can meet those needs. Second, environmental and site conditions must align with the concentrator's operational characteristics – high-performance concentrators should be matched with high solar resource availability, and simpler systems might be more robust under less ideal conditions. Third, economic and operational factors (including cost, maintenance, and lifespan) often dictate what is practical in the real world; the best technical solution may fail if it is not economically viable or too complex to maintain. Achieving an optimal balance among performance, cost, and complexity is therefore essential.

The analysis also underlines that the decision is highly context-specific. There is no one-size-fits-all solution in the selection of solar concentrators. For each new project or research endeavor, the factors outlined should be revisited and evaluated in combination. For instance, a remote rural heating project will weigh simplicity and low maintenance much more heavily than peak efficiency, leading to a different choice than a utility-scale power plant where efficiency and land usage might dominate considerations.

In conclusion, a systematic approach to selecting a solar concentrator – one that accounts for technical performance, climatic suitability, economic feasibility, and practical constraints – is necessary to ensure the chosen technology delivers the expected benefits. By carefully considering

the factors detailed in this article, engineers and researchers can make informed decisions and tailor solar concentrator solutions to their specific needs, thereby improving the effectiveness of solar energy utilization. This comprehensive evaluation of selection criteria contributes to the broader effort of optimizing renewable energy systems to meet global energy challenges [5]. Future work in this area may include developing decision support tools or models that quantitatively score different concentrator options based on multi-criteria analysis, which would further aid in making objective and optimal choices for solar concentrator deployments.

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## ZARYADLASH QURILMALARIDA CHIQISH TOKINI PROGNOZLASH DOLZARBLILIGI

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**Annotatsiya.** Ushbu maqolada yurtimizda elektr transport vositalariga bo'lgan talabning ortib borayotgani va bu holat zaryadlash infratuzilmasini rivojlantirish zaruratini keltirib chiqarayotgani yoritilgan. Ayniqsa, zaryadlash qurilmalarida chiqish tokini yuqori aniqlik bilan prognozlash zarurati — zaryadlash tezligi, akkumulyator ishonchliligi va xizmat muddati bilan chambarchas bog'liq ekanligi ko'rsatib o'tilgan. Mazkur masalani hal etishda vaqtli ketma-ketliklar bilan ishlovchi sun'iy neyron tarmoqlari, xususan LSTM modeli qo'llanilib, yuqori aniqlikdagi bashoratlash imkoniyati asoslab berilgan.

**Kalit so'zlar:** elektr transport vositasi, prognozlash, sun'iy neyron tarmoqlari, LSTM, kuchlanish, zaryadlash quvvati, harorat, tarmoq yuklamasi, ish vaqti, energiya sarfi va sikllar soni.

## АКТУАЛЬНОСТЬ ПРОГНОЗИРОВАНИЯ ВЫХОДНОГО ТОКА В ЗАРЯДНЫХ УСТРОЙСТВАХ

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**Аннотация.** В статье подчеркивается растущий спрос на электромобили в нашей стране и необходимость развития зарядной инфраструктуры. В частности, было показано, что необходимость высокоточного прогнозирования выходного тока в зарядных устройствах тесно связана со скоростью зарядки, надежностью аккумулятора и сроком службы. Для решения этой задачи были использованы искусственные нейронные сети, работающие с временными последовательностями, в частности модель LSTM, и продемонстрирована возможность высокоточного прогнозирования.

**Ключевые слова:** электромобиль, прогнозирование, искусственные нейронные сети, LSTM, напряжение, мощность зарядки, температура, нагрузка на сеть, время работы, потребление энергии и количество циклов.