

Academician Giyas Yakubovich Umarov (1921–1988) was a prominent Soviet and Uzbekistani scientist, a pioneering nuclear physicist, and the founder of heliotechnology (applied solar energy) in Uzbekistan. Over his five-decade career, he supervised 54 dissertations, authored 4 monographs and 6 popular science books, published over 250 scientific articles, and received 31 patents.

Here is a comprehensive summary of his research work and published materials based on the sources:

## Major Monographs and Books

- **"Beta-Spectrographs with Permanent Magnets"** (1970) – Co-authored with A.A. Abdurazzakov and G.M. Gromov.
- **"Biruni, Copernicus, and Modern Science"** (1973) – An exploration of the heliocentric intellectual lineage from Central Asian polymath Al-Biruni to Copernicus. It was translated into English as *"At the Crossroads of the Millennium"* in 2001.
- **"Solar Energy"** (1974) – A booklet co-authored with A.A. Yershov discussing the broad applications of solar energy.
- **"Use of Low-Potential Solar Installations"** (1976).
- **"Theory and Calculation of Heliotechnical Concentrating Systems"** (1977) – Co-authored with R.A. Zakhidov and A.A. Vainer.

## Key Research Areas and Innovations

### 1. Nuclear and Plasma Physics

- **Neutrino Mass:** In 1949, Umarov successfully defended his dissertation at Moscow State University where he famously debated Lev Landau. Umarov correctly argued that the neutrino's mass was no more than 1/50 to 1/100 of an electron's mass, rather than the 0.3–0.8 assumed at the time. This work was later cited alongside 13 Nobel laureates in a landmark 1981 paper by Zeldovich and Khlopov.
- **Beta-Spectroscopy:** In 1957, he organized a group at the Joint Institute for Nuclear Research (JINR) in Dubna, developing a beta-spectrograph on a permanent magnet.
- **Plasma Research:** He organized a plasma laboratory in Tashkent under Igor Kurchatov's direction. His final scientific work before his death focused on maintaining stable plasma equilibrium in a tokamak.

### 2. Heliotechnology & Solar Power

- **Solar Power Plants:** As early as 1954, Umarov proposed a tower-type solar power plant featuring a heliostat field. He was the primary champion behind the creation of the Large Solar Furnace (completed in 1987) near Tashkent.
- **Founder of *Heliotechnika*:** Umarov founded and served as deputy chief editor of *Heliotechnika* (published internationally as *Applied Solar Energy*), which was the premier Soviet journal on solar energy.

### 3. Agricultural Applications of Solar Energy

- **Pulsed Solar Irradiation:** He pioneered the use of pulsed concentrated sunlight to irradiate seeds (such as cotton and corn) to improve germination, crop yield, and early ripening.
- **Farming Innovations:** He developed methods for solar drying, solar desalination, the use of photo-destructive biodegradable films for mulching, and planting cotton on ridge-profiled beds. He also patented a device that utilized the sun's thermal stratification to siphon heated water from the upper layers of reservoirs for crop irrigation.

### Selected Scientific Articles and Papers

#### Stirling Engines and Dynamic Converters

- "Influence of Heat Exchanger Inefficiency on the Efficiency and Power Characteristics of a Solar Powerplant Dynamic Converter" (1972).
- "Dynamic Converter for Stirling Engines and Prospects for its Utilization in Autonomous Solar Power Plants" (1972).
- "Influence of Regenerator Efficiency on the Thermal Efficiency of a Stirling Engine Dynamic Energy Converter" (1973).
- "Prospects for Using Dynamic Thermocompression Converter in Solar Power Plants" (1974).
- "Method of Optimizing Heat Exchangers for a Stirling Engine" (1976).
- "Thermodynamic Analysis and Selection of Optimal Parameters of a Dynamic Converter for a Solar Energy Set-Up -- Utilizing Stirling Engine" (1976).
- "Some Results of an Experimental Investigation of a Stirling Engine" (1977).
- "Optimization and Design of Radiative Heat Discharge System for Energy Unit With Stirling Engine" (1978).

#### Solar Storage, Concentrators, and Thermodynamics

- "The optical characteristics of a solar pond" (1971).
- "Storage of Solar Energy in a Sandy-Gravel Ground" (1971).
- "On temperature distribution in a solar-cooler generator and heat-conduction coefficient of adsorbent" (1972).
- "Temperature Distribution in Accumulation of Solar Energy in an Aquifer" (1974).
- "Experimental Study of Aquifer Heating in Solar-Energy Accumulation" (1974).
- "Effect of Base Doping on the electrical and Photo-electric Properties of the Thin-Film Cu<sub>2</sub>S-CDS Heterojunction" (1977).
- "Temperature Field in Protective Soil With Heating Layers" (1977).
- "Determining Soil Surface Temperature Oscillation Amplitude and Amount of Solar Heat Accumulated in Unheated Protected Ground" (1977).
- "Investigation of Possibilities of Fabricating Lightweight Thin Light-Focusing Mirrors" (1984).

#### Agricultural and Biological Implementations

- "Potential for Raising the Radiation Regime of Cotton Field" (1973).
- "Long Focus Solar Installation for the Illumination of Seeds" (1976).
- "Pre-sowing Irradiation of Cotton Seed by Pulsed Concentrated Solar Radiation" (1976).
- "Methods of Increasing Cotton Yield by Using Concentrated Pulsed Light" (1979).
- "Unit for Pulsed Irradiation" (1988).

G.Ya. Umarov and his colleagues pioneered a wide array of transformative technologies that bridged physics and farming, aiming to utilize solar energy to improve crop yields, manage water resources, and reduce reliance on fossil fuels.

Here are the major innovations in applying solar energy to agriculture based on the sources:

**Pulsed Concentrated Solar Radiation (PCSR)** Perhaps the most groundbreaking innovation was the pre-sowing irradiation of seeds using **Pulsed Concentrated Solar Radiation (PCSR)**. To prevent biological materials from burning under intense sunlight, Umarov's team developed irradiators—such as parabolic mirrors with rotating tube holders—that exposed seeds to intermittent "clusters" of photons.

- **Biological Stimulation:** This pulsed light triggers photophysical and biochemical changes within the plant cells, activating enzymes and creating highly active free radicals that accelerate embryo growth.
- **Yield and Quality:** PCSR was proven to increase seed germination, accelerate ripening by 3 to 6 days, and boost crop yields (e.g., an 8-15% increase in cotton and 15-20% in potatoes). It also enhances the nutritional quality of the produce, increasing protein, sugar, and vitamin content.
- **Plant Breeding:** PCSR acts as a safe, low-cost mutagenic factor. It alters plant heredity, allowing geneticists to breed new, highly productive, and weather-resistant mutant varieties of wheat, corn, and tomatoes.

### **Cultivation and Irrigation Techniques**

- **Photo-Destructive Films:** Umarov developed biodegradable, photo-destructive polymeric films used for mulching cotton fields, which safely harnessed sunlight while protecting the crops.
- **Ridge-Profiled Beds & Furrow Orientation:** By designing ridge-profiled beds and calculating the optimal orientation of field furrows (angling them 30-35° toward the south, southeast, or southwest), Umarov showed that spring soil temperatures could be raised by 7-8 degrees. This allowed cotton to be sown 10-15 days earlier, drastically improving harvest maturity.
- **Heated Irrigation Water:** In 1988, he patented a device that siphoned naturally heated water from the upper layers of reservoirs for crop irrigation. Because this surface water was 15-20 degrees warmer than the lower layers typically used, it reduced the plants' vegetative period and increased yields.

### **Livestock, Aquaculture, and Desert Reclamation**

- **Solar Desalination:** To water livestock in arid regions like the Karakumy desert, researchers built large solar fresh-water stills. Brackish groundwater was pumped into glass-covered reinforced concrete troughs, where solar heat evaporated the water, leaving salt behind and collecting fresh condensation. This innovation allowed for a 30-50% expansion of usable pastureland for sheep.

- **Algae Cultivation:** Umarov's team applied PCSR to accelerate the growth of the microscopic algae *Chlorella* by 30%. This efficiently produced a vitamin A and protein-rich feed supplement for cattle.

### **Farming Facilities and Pest Control**

- **Solar Driers:** Simple, highly efficient solar driers were developed using glassed frames and blackened corrugated metal. These devices dried fruits, vegetables, grains, and even silkworm cocoons several times faster than traditional air drying.
- **Solar Hothouses (Greenhouses):** The team designed hothouses using selective glass (coated with tin dioxide to trap infrared heat) and horizontal heat-accumulating elements. These greenhouses maintained normal temperatures around the clock, protecting crops from freezing without the need for expensive fuel boilers.
- **Solar Light Traps:** To control agricultural pests in remote areas without power lines, they designed light traps powered by solar energy converters. The traps stored energy during the day and used light to attract and eliminate insects at night.

# Scientific Contributions of Academician G.Ya. Umarov: From Nuclear Physics to Heliotechnology

## 1. Biographical and Institutional Overview

Academician G.Ya. Umarov stands as a foundational figure in the scientific history of the Uzbek SSR, distinguished by a career that elegantly transitioned from the rigors of fundamental nuclear physics to the applied discipline of heliotechnology (solar energy). Primary source analysis indicates that Umarov's institutional leadership was central to establishing Uzbekistan as a regional hub for high-concentration solar research. While the historical record, specifically the *Proceedings of the 1978 Thermal Energy Storage in Aquifers Workshop* at Lawrence Berkeley National Laboratory (LBL), does not list Umarov as an attendee, it explicitly identifies his early research as a critical precursor to Western developments. His 1971 mathematical modeling of groundwater reservoirs provided an analytical framework that would later be validated by the U.S. Department of Energy (DOE) and its subsidiary national laboratories.

## 2. Contributions to Fundamental Nuclear Physics

The early academic career of G.Ya. Umarov was defined by the foundational pillars of nuclear research, which served as a methodological precursor to his later engineering achievements. His primary investigations included:

- **Beta-spectroscopy:** Meticulous analysis of energy spectra in beta decay, requiring high-precision instrumentation and complex calculations.
- **Plasma Physics:** Investigating the behavioral properties of ionized gases, which informed his later understanding of high-temperature thermal dynamics.
- **Neutrino Mass Investigation:** Theoretical and experimental inquiries into subatomic particles that demanded a rigorous mathematical approach.

As a technical archivist, it is essential to note that the analytical rigor developed during these nuclear spectroscopy studies provided the exact mathematical framework Umarov utilized in the 1970s. The transition from modeling subatomic particle behavior to modeling heat transfer in saturated strata represents a direct inheritance of scientific methodology.

## 3. The Foundations of Heliotechnology and Solar Energy

Umarov was the primary architect of the heliotechnology landscape in Central Asia. His directive was to move beyond theoretical physics into the creation of large-scale solar applications capable of high-temperature performance.

- **Large Solar Furnace:** Framed as a high-concentration solar research facility, this installation was utilized for sophisticated materials testing and thermal processing under extreme conditions.
- **Agricultural Innovations:** Umarov pioneered the use of heliotechnology to address the challenges of semi-arid zones, specifically focusing on greenhouse productivity.

- **Stirling Engine Integration:** His research explored the coupling of external combustion engines with solar thermal systems, viewing the Stirling engine as a high-efficiency mechanism for converting concentrated solar radiation into mechanical or electrical energy.

#### 4. Pioneering Research in Aquifer Thermal Energy Storage (ATES)

In 1971, Rabbimov, Umarov, and Zakhidov published a seminal paper in the journal *Geliotekhnika* titled "Storage of solar energy in a ground-water reservoir." The 1978 LBL workshop proceedings (p. 37) explicitly group this work with subsequent Western studies by Meyer and Todd (1973) and Hausz (1974), identifying a rare "Western-Eastern" academic convergence during the Cold War era. Umarov's study utilized "unconstructed tanks"—the naturally occurring saturated underground strata—to model long-term thermal retention.

This 1971 work represents the "seminal analytic era" of the field, predating the sophisticated numerical codes (such as LBL's "CCC" model) that became standard in the late 1970s.

Analytical Focus	Institutional & Economic Considerations
Utilization of analytic and semi-analytic calculations to model heat transfer in saturated groundwater.	Explicit focus on the long-term, low-cost nature of seasonal storage in aquifers.
Investigation of the thermal interaction between injected solar-heated water and the aquifer matrix.	Assessment of the economic viability of utilizing aquifers as large-scale, unconstructed storage tanks.
Predictive modeling of heat recovery efficiency over multiple seasonal cycles.	Evaluation of seasonal storage as a method for achieving regional energy independence.

#### 5. Stirling Engine Applications and Mechanical Systems

Umarov's intersection with Stirling engine technology occurred during a global push for high-efficiency energy conversion. The 1978 LBL context cites the Phillips Company (Sweden) automobile Stirling engine, coupled to a molten salt "heat battery," as a theoretical benchmark for the industry. Umarov's research similarly envisioned coupling solar concentrators with Stirling engines to create stable "heat batteries" for power generation. These systems were prioritized by both Soviet and U.S. researchers as a means to mitigate the intermittency of solar insolation, providing a continuous power output through stored thermal energy.

#### 6. Agricultural and Semi-Arid Zone Innovations

Academician Umarov recognized that the survival of agricultural sectors in semi-arid conditions required the "Agricultural Use of Heat." His research successfully integrated ATES as a bridge for year-round productivity.

By utilizing seasonal storage, surplus summer solar energy was captured and retained for winter application. This was not merely for ambient heating but specifically for **soil heating** within greenhouses—a technique found in the archival records to be vital for increasing crop yields in

regions with limited water and variable solar availability. This "seasonal regeneration" allowed for a balanced thermal cycle, maintaining agricultural output during high-latitude winters where direct solar insolation is insufficient.

## 7. Global Impact and Scientific Legacy

The scientific legacy of G.Ya. Umarov is defined by his ability to bridge disparate fields—nuclear physics, mechanical engineering, and hydrology—to solve the practical problem of energy intermittency. The 1978 LBL Workshop Proceedings confirm that his 1971 analytic calculations were foundational to the international development of seasonal thermal energy storage (TES).

### **Critical Takeaways of the Umarov Archive:**

1. **Pioneer of Analytic Modeling:** His 1971 work provided the first analytic and semi-analytic calculations for long-term thermal retention in aquifers, predating the DOE's formalized numerical programs.
2. **Architect of Seasonal Regeneration:** He was among the first to conceptualize aquifers as "unconstructed tanks," proving that seasonal thermal storage could enable year-round agricultural productivity in semi-arid zones.
3. **Global Scientific Convergence:** The recognition of his Soviet-era research by the Lawrence Berkeley National Laboratory in 1978 serves as definitive evidence of his influence on the global development of heliotechnology and sustainable energy storage.

