Unlocking Sustainable Growth with Renewable Energy in Uzbekistan's Agriculture

Innovations and Implementation for Agriculture

Vokhidov Akmal
Senior lecturer of TIIAME NRU

Renewable Energy's Vital Role for Uzbek Farmers

Cutting costs, boosting resilience, and leveraging government support

Addressing rising energy costs and climate risks

- Renewable energy reduces operational costs through affordable solar and wind power
- Stable, clean energy supports reliable irrigation and crop storage amid climate variability

Enhancing climate adaptation and sustainability

- Reliable renewable energy enables consistent water supply despite changing weather patterns
- Supports adoption of sustainable farming practices critical for long-term productivity

Maximizing government incentives for green technologies

- Uzbek government programs provide financial support for renewable energy adoption
- Farmers can access subsidies and technical assistance to implement clean energy solutions

Securing future productivity and profitability

- Transitioning now positions farmers to benefit from Uzbekistan's growing renewable commitment
- Clean energy adoption is essential to sustain agricultural competitiveness and income

Uzbekistan's Agricultural Energy Use: Shifting Trends 2019–2024

Analyzing diesel, grid electricity, and renewable energy consumption in agriculture

Diesel remains dominant in agricultural energy but declines from 65% in 2019 to an estimated 52% in 2024

Grid electricity use grows steadily from 30% in 2019 to 39% estimated in 2024, supporting modernization

Renewables show gradual increase, rising from 5% in 2019 to 9% in 2024, driven by regional adoption

Seasonal irrigation peaks significantly influence energy demand and fuel consumption patterns

Regional disparities exist, with northern regions adopting renewables more rapidly than others

Renewable Energy Technologies for Uzbekistan's Agricultural Sector

Comparing key technologies by benefits, challenges, costs, and regional fit

Advantages

Solar PV: Abundant sunlight, modular design

Solar Thermal: Efficient for heating needs

Wind Energy: Strong potential in northwest regions

Biogas: Utilizes agricultural waste, lowers emissions

Small Hydro: Provides reliable base load energy

Limitations & Cost Factors

Solar PV: High initial cost, storage required; moderate upfront, low O&M

Solar Thermal: Limited for electricity; moderate cost

Wind Energy: Intermittent output, storage needed; moderate to high cost

Biogas: Feedstock supply varies; low to moderate cost

Small Hydro: Site-dependent, high upfront cost

Local Suitability

Solar PV: High suitability in southern and central Uzbekistan

Solar Thermal: Ideal for greenhouse heating applications

Wind Energy: Best in Karakalpakstan and Navoi regions

Biogas: Suitable for livestock farms across agricultural zones

Small Hydro: Limited to locations with appropriate water resources

Biomass: Unlocking Agricultural Waste for Energy

Harnessing cotton stalks, reeds, and livestock waste to generate 15–17 GW of clean energy

Biomass resources: cotton stalks (2.3 million tons oil equivalent), reeds (10–12 million tons), livestock waste (>100 million m^3)

Energy potential: 15–17 gigawatts from agricultural waste biomass

Primary applications: biogas production and solid fuels for heating and cooking in rural communities

Environmental benefits: reduces pollution by converting waste into clean energy, supporting sustainable agriculture

Biomass energy fosters a clean energy transition by efficiently utilizing untapped agricultural residues

Solar Energy & Agrivoltaics: Dual-Use Innovation

Leveraging solar power for irrigation and enhanced crop yields on 175,000 ha

Annual solar irradiation ranges from **1700 to 1900 kWh/m²**, supporting robust energy generation

Potential solar capacity of **5 GW by 2026**, part of an overall **8 GW total solar target**

Applications include **irrigation pumps** and solar panels installed over crops such as **pumpkins, corn, mushrooms, and sheep grazing areas**

Water savings achieved through **microclimate effects** created by panels, reducing evaporation

Improved crop yields on **75,000 ha of inefficient orchards** and **100,000 ha of low-yield fields**

Wind & Hydropower: Powering Rural Communities

Unlocking 5 GW wind and 1.7 GW hydropower potentials with strategic deployment for reliable irrigation and remote energy needs

Wind energy potential of 5 GW, concentrated in Karakalpakstan, powers farms and irrigation systems in remote rural areas

Hydropower capacity aims to grow by **1.7 GW by 2030**, focusing on small hydropower plants (HPPs) that integrate with irrigation

Hydropower complements water resources well but faces seasonal flow variations, requiring strategic deployment for steady energy supply

Combined, wind and hydropower provide **reliable, decentralized energy solutions** critical for rural development and irrigation needs

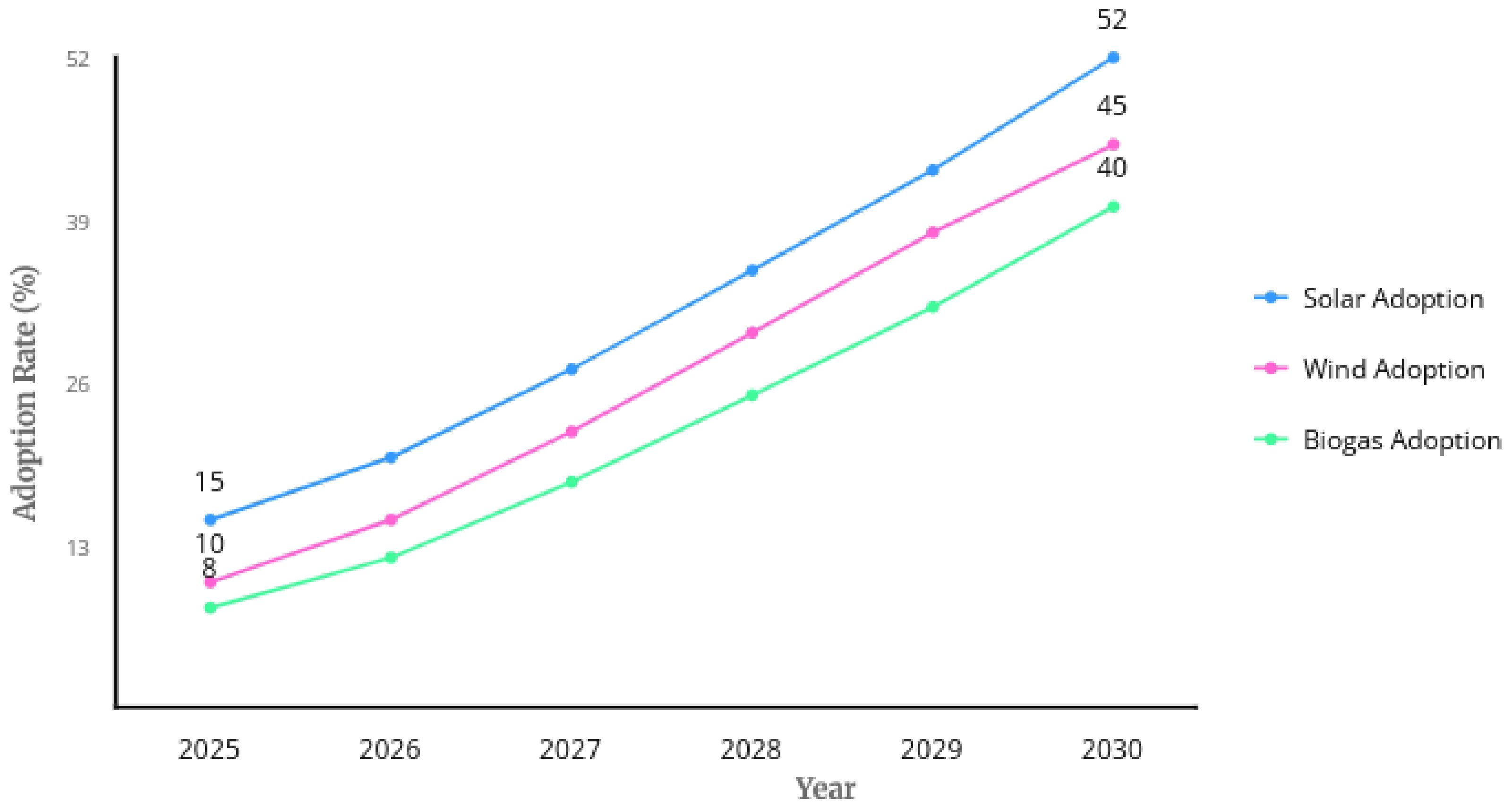
Unlocking Geothermal Energy's Stable Potential

Reliable 1 GW resource for greenhouse heating and agriculture faces infrastructure gaps

1. **Geothermal resources offer up to 1 GW potential**, primarily supporting greenhouse heating and agrosector needs
2. **Stable and reliable energy source** suitable for continuous agricultural applications
3. Current use remains limited due to **insufficient infrastructure**, restricting wider adoption
4. Significant opportunity exists for **investment and expansion** to boost agricultural sustainability
5. Expanding geothermal infrastructure can enhance **sustainable agricultural practices** and reduce energy volatility

Renewable Energy Adoption in Uzbek Agriculture (2025–2030)

Projected growth trends in solar, wind, and biogas technologies driving sustainable farming



Solar energy leads adoption due to **cost-effectiveness** and **ease of deployment**

Wind and biogas show **steady growth** fueled by regional projects and efficient waste utilization

Combined renewable adoption will **significantly reduce fossil fuel dependence** in Uzbek agriculture

Harnessing Solar Water Heating: Global Capacity and Challenges

Exploring growth trends and cost-effective innovations in flat-plate solar collectors

Annual growth rate maintained at a steady **12.85% over the past decade**

Flat-plate solar water heating collectors provide reliable hot water for homes, utilities, and social facilities

These systems reduce fossil fuel use, supporting sustainable energy goals worldwide

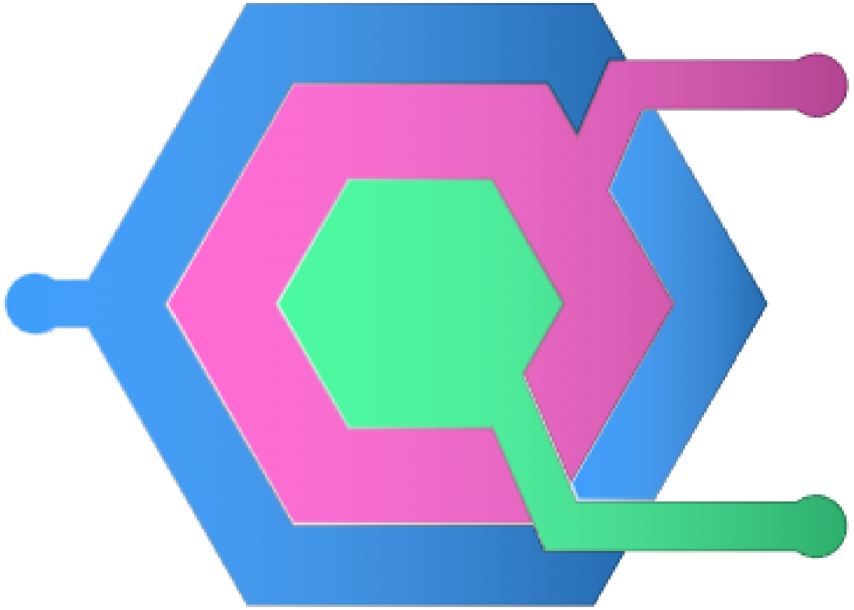
High initial costs limit widespread adoption in some regions despite benefits

This study focuses on **simple, cost-effective collectors made from local materials** to enhance economic viability

Objective: assess thermal performance and cost benefits compared to existing technologies

Optimizing Solar Water Heating: Experimental Setup & Collector Design

Innovative flat capacitive collectors tested under the climatic condition of Gulistan city



Collector Housing and Orientation

Concrete box housing a polymer container with a translucent upper part to admit solar radiation. Collector oriented east-west to maximize solar exposure.

Thermal Management

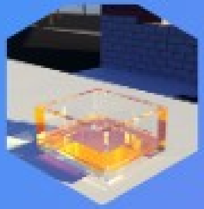
Insulation layers of low thermal conductivity materials minimize heat loss through housing walls. Black-painted bottom and sides absorb solar radiation and heat water efficiently.

Measurement Setup

Sensors recorded solar radiation flux, air and water temperatures, and wind speed every 30 minutes during daytime to evaluate performance.

Maximizing Thermal Efficiency in Solar Water-Heaters

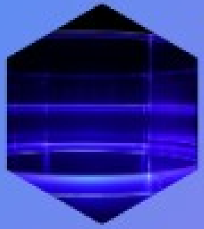
Key Factors and Heat Transfer Mechanisms for Optimal Performance



Thermal efficiency relies on effective solar radiation absorption and minimizing heat losses

Insulating materials significantly reduce wall heat loss by lowering thermal conductivity compared to concrete

Black polymer surfaces absorb solar radiation and transfer heat primarily to the water



Natural **thermogravitational convection** enhances heat distribution inside the water tank

Bottom absorption of solar radiation improves heat transfer efficiency over top-down heating

Thermal efficiency increases with water layer thickness: from **17% at 0.05 m** to **24% at 0.07 m**

Experimental Results: Thermal Performance and Energy Output

Impact of Water Layer Thickness on Seasonal Energy Gain and Efficiency

Month	Daily Solar Radiation (MJ)	Useful Energy 0.05 m Water Layer (MJ)	Thermal Efficiency 0.05 m Water Layer (%)	Useful Energy 0.07 m Water Layer (MJ)	Thermal Efficiency 0.07 m Water Layer (%)
May	62.87	10.2	16	12.4	21
June	85.33	13.75	16	18.4	22
July	105.56	18	17	22.5	24
August	94.1	17.04	18	21.51	23
September	70.22	17	18	20	24
Seasonal Total	N/A	76.99	17	94.81	24

- Seasonal useful energy increased from 76.99 MJ to 94.81 MJ when water layer thickness grew from 0.05 m to 0.07 m.
- Thermal efficiency improved from 17% at 0.05 m thickness to 24% at 0.07 m thickness.
- Daily solar radiation ranged from 62.87 to 105.56 MJ, directly influencing collector output across months.
- Thicker water layers enhance heat accumulation, confirming improved thermal performance.
- Environmental factors such as air temperature and wind speed were accounted for to ensure accurate results.

Maximizing Value from Solar Collector Installation

Technical and Economic Performance Metrics for Seasonal Water Heating

Concrete Volume

$0.44 m^3$

Concrete required per 5 m^2 collector surface

Concrete Cost

30 USD

Material cost in Uzbekistan

Construction Cost

20 USD

Includes thermal insulation, excludes labor

Average Daily Heat Output

71.4 MJ

Energy produced per day

Seasonal Heat Output

8,354 MJ

Total heat energy generated per season

Fuel Savings

570 kg coal equivalent

Coal saved per season

Payback Period

1 season

Time to recover construction cost via fuel savings

- The collector uses 0.44 m^3 of concrete costing about $30 in Uzbekistan.
- Total construction cost is approximately $20 per unit, including thermal insulation but excluding labor.
- Generates an average of 71.4 MJ daily, totaling 8353.8 MJ over the heating season.
- Saves 570 kg of coal equivalent fuel per season, reducing environmental impact.
- Economic viability is proven by a payback period of one warm season based on local fuel prices.

Maximizing Efficiency and Sustainability with Solar Water Heating

Key outcomes on performance, savings, emissions, and economic benefits

- Seasonal thermal efficiency ranges from **17% to 24%**, influenced by water layer thickness
- Significant fuel savings: **488 Nm^3 of natural gas** and **910 kg of coal** per season
- Reduces CO_2 emissions by up to **4814 kg** each warm season
- Construction costs are recoverable within one warm season, ensuring quick payback
- Supports renewable hot water supply and aligns with global efforts to reduce greenhouse gases

Geothermal Energy in Kashkadarya Region

Mapping key heat sources to drive sustainable energy and targeted infrastructure development

1

Extensive geothermal resources across Kashkadarya region

- Multiple geothermal sources identified with varied spatial distribution
- Vital for guiding local energy infrastructure planning

2

Significant thermal capacity in Mubarek and Kasan districts

- Reservoirs capable of supporting district heating needs
- Foundation for optimizing geothermal heating projects

3

Strategic value of geothermal mapping

- Enables targeted investments in renewable energy
- Supports the region's sustainable energy strategy

Maximizing Geothermal Heat for Year-Round Heating

Over 85% of geothermal energy is used for heating, but seasonal limits reduce its full potential in regions like Kashkadarya.

Over **85%** of geothermal heat extracted is used directly for **heating purposes**

In Kashkadarya, geothermal energy use is limited to the **heating season lasting 130–165 days**

Seasonal use restricts full exploitation of geothermal heat potential throughout the year

Heating systems often operate inefficiently outside the heating season, causing **underutilization** of geothermal resources

Understanding these patterns is essential to develop solutions that **maximize geothermal use year-round** for better sustainability and cost savings

Geothermal Heating: Sustainable Growth and Innovation

Advancing efficient, autonomous thermal energy solutions amid rising energy costs and stricter environmental policies

Geothermal autonomous heating systems offer **sustainable, efficient thermal energy** for local facilities

Adoption is rising due to **increasing energy costs** and **strengthening environmental policies**

Advances in **heat pump technology** and **system integration** drive broader implementation

Ongoing research focuses on **cost reduction** and **efficiency improvements** to expand viability

Geothermal heating emerges as a key option for facilities aiming for **energy independence** and **environmental responsibility**

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Thank you for attention!!!

Akmal Vokhidov
Senior Lecturer
akmalvokhidov@yahoo.com