

Smart Cultural Tourism Solution

Intelligent Lighting & IoT System Integration

Zhengzhou Hengling New Energy Technology Co., Ltd.

Illuminating the Future of Cultural Tourism

Website: www.hengling-energy.com

Email: info@hengling-energy.com

Smart Cultural Tourism Solution

Intelligent Lighting & IoT System Integration

Zhengzhou Hengling New Energy Technology Co., Ltd.

Illuminating the Future of Cultural Tourism

Website: www.hengling-energy.com | Email: info@hengling-energy.com

TABLE OF CONTENTS

- [1. DEMAND ANALYSIS & RESEARCH](#)
 - [2. SOLUTION DESIGN](#)
 - [3. PRODUCT CUSTOMIZATION](#)
 - [4. PROJECT IMPLEMENTATION](#)
 - [5. SYSTEM DEBUGGING & TESTING](#)
 - [6. PROJECT DELIVERY](#)
 - [7. OPERATION & MAINTENANCE](#)
-

1. DEMAND ANALYSIS & RESEARCH

1.1 Project Background

The global tourism industry is undergoing a profound digital transformation, driven by the convergence of experience economy and technological innovation. Traditional sightseeing

tourism can no longer meet modern travelers' demands for immersion, personalization, and emotional resonance. Cultural tourism destinations face unique challenges:

- **Night Economy Development:** Extending visitor stay duration and enhancing secondary consumption
- **Cultural Heritage Preservation:** Balancing modern technology with historical site protection
- **Energy Efficiency:** Reducing operational costs while maintaining visitor experience
- **Safety Management:** Real-time monitoring of crowd density and emergency response
- **Visitor Experience:** Creating memorable, shareable moments that drive social media engagement

Smart cultural tourism represents the integration of intelligent lighting systems, Internet of Things (IoT) technology, and new energy solutions to transform how visitors experience cultural destinations. This integration creates a seamless ecosystem where technology enhances rather than distracts from the cultural experience.

1.2 Stakeholder Requirements

Stakeholder	Key Requirements
Scenic Area Management	Energy efficiency, reduced maintenance costs, remote monitoring, data-driven decision making
Tourism Authorities	Safety compliance, visitor satisfaction improvement, cultural heritage protection
Visitors	Immersive cultural experience, convenient services, safety assurance, photo-worthy moments
Maintenance Teams	Predictive maintenance, easy component access, automated fault detection
Finance Departments	Low Total Cost of Ownership (TCO), rapid ROI, energy cost reduction
Local Communities	Economic development, job creation, cultural preservation

1.3 Scenic Area Parameters

Scenic Area Classification

- **Historical & Cultural Sites:** Ancient towns, heritage buildings, museum complexes
- **Natural Scenic Areas:** Mountains, lakes, forests, ecological parks
- **Theme Parks & Entertainment:** Cultural theme parks, performance venues, interactive experiences
- **Urban Cultural Districts:** Pedestrian streets, waterfront areas, night market zones

Key Operational Metrics

- **Visitor Volume:** 1,000 to 50,000+ visitors per day
- **Area Coverage:** 0.5 km² to 50+ km²
- **Operating Hours:** Extended to 16-24 hours with night tourism development
- **Environmental Conditions:** Variable temperature, humidity, weather exposure
- **Infrastructure Complexity:** Mixed indoor/outdoor, wired/wireless coverage requirements

2. SOLUTION DESIGN

2.1 Zoned Smart Lighting Architecture

Five Critical Lighting Zones for Cultural Tourism

Entrance & Welcome Zone

- High-impact first impression lighting
- Brand and cultural identity projection
- Visitor flow guidance and wayfinding
- Dynamic welcome sequences based on arrival time

Cultural Experience Zone

- Scene-specific mood lighting for heritage sites
- Projection mapping for storytelling
- Interactive light installations
- Color temperature matching cultural atmosphere

Pathway & Circulation Zone

- Adaptive brightness based on pedestrian density
- Glare-free illumination for safety
- Color-coded wayfinding for navigation
- Emergency lighting integration

Performance & Gathering Zone

- High-output dynamic lighting for shows
- Synchronization with audio and video systems
- Audience interaction capabilities
- Broadcast-quality illumination

Service & Amenity Zone

- Functional lighting for rest areas
- Charging station illumination
- Retail and F&B atmosphere lighting
- Security and surveillance lighting

2.2 Core Technologies

Adaptive Lighting Control System

- **AI-based Scene Recognition:** Machine learning algorithms analyze visitor behavior and environmental conditions
- **Human Centric Lighting (HCL):** Circadian rhythm-aligned color temperature adjustment

- **Weather Adaptive Optimization:** Automatic brightness and spectrum adjustment for fog, rain, or bright sunlight
- **Visitor Flow Responsive Dimming:** Real-time adjustment based on crowd density data

IoT Sensor Network

- **Millimeter Wave Radar:** Accurate pedestrian detection and counting
- **Environmental Sensors:** Temperature, humidity, air quality, noise monitoring
- **Light Sensors:** Ambient light measurement for adaptive control
- **Security Cameras with AI Analytics:** Crowd density analysis, anomaly detection

New Energy Integration

- **Solar-Powered Smart Poles:** Photovoltaic panels integrated into lighting infrastructure
- **Energy Storage Systems:** Lithium-ion battery banks for energy arbitrage
- **Microgrid Management:** Intelligent load balancing and peak shaving
- **Carbon Footprint Tracking:** Real-time energy consumption and emissions monitoring

Communication Technologies

- **LoRaWAN:** Long-range, low-power communication for sensor networks
- **5G/4G:** High-bandwidth connectivity for video and interactive applications
- **Bluetooth Mesh:** Local device-to-device communication for interactive experiences
- **Edge Computing:** On-site data processing for low-latency responses

2.3 Fixture Specifications

Zone	Fixture Type	Power Range	Mounting Location
Entrance Zone	High-Power Architectural Luminaire	150W-400W	Building facades, poles
Cultural Zone	Precision Projector + RGBW	50W-200W	Strategic mounting points

Zone	Fixture Type	Power Range	Mounting Location
Pathway Zone	Smart Street Luminaire	30W-120W	Poles along walkways
Performance Zone	Dynamic Stage Lighting	100W-500W	Trussing, building mounts
Service Zone	Functional LED Luminaire	20W-80W	Building mounts, poles

2.4 Control System Features

Central Management Platform

- Real-time system health monitoring dashboard
- Energy consumption analytics and reporting
- Visitor flow heat mapping and analysis
- Fault detection and automated alerting
- Scene scheduling and holiday programming
- Mobile app access for remote management

Intelligent Automation Capabilities

- Sunrise/sunset automatic activation
- Visitor density responsive dimming
- Weather condition adaptive lighting
- Emergency scenario automatic activation
- Seasonal theme automatic switching
- Energy optimization algorithms

Integration Capabilities

- Ticket system integration for visitor flow prediction
- Security and surveillance system coordination
- Public address and emergency system linkage
- Visitor mobile app interaction

- Third-party tourism platform data exchange
- Smart city platform connectivity

3. PRODUCT CUSTOMIZATION

3.1 Environmental Customization

Weather Protection

- **IP65/IP66 Ingress Protection:** Dust and water resistance for outdoor deployment
- **IK08/IK09 Impact Resistance:** Vandalism and accidental impact protection
- **Corrosion-Resistant Coatings:** C4/C5-M grade for coastal or high-humidity areas
- **Extended Temperature Range:** -30°C to +60°C operation
- **UV-Stabilized Materials:** Preventing degradation from sun exposure
- **Vibration Damping:** For windy or high-traffic areas

Cultural Heritage Protection

- **UV-Free Illumination:** Preventing artwork and artifact degradation
- **Controlled Heat Output:** Minimizing thermal impact on sensitive materials
- **Adjustable Illuminance Levels:** Meeting conservation requirements
- **Non-Intrusive Mounting:** Preserving historical architecture integrity
- **Electromagnetic Shielding:** Protecting sensitive heritage monitoring equipment

3.2 Optical Customization

Lighting Quality Parameters

- **High CRI (Ra > 90):** Accurate color rendering for cultural artifacts
- **Tunable White Technology:** 2700K-6500K color temperature range
- **RGBW Full Color System:** 16 million colors for dynamic scenes
- **Anti-Glare Optics:** UGR < 19 for visitor comfort
- **Flicker-Free Operation:** <10% flicker for camera compatibility

- **Custom Beam Angles:** Narrow spot to wide flood for specific architecture

Special Optical Features

- **Projection Mapping Optics:** High-resolution pattern projection
- **Gobo Projection:** Custom cultural symbols and patterns
- **Dynamic Water Effect:** Simulating water movement for waterfronts
- **Firefly Effect:** Creating magical atmosphere for forest areas
- **Interactive Response:** Visitor movement triggered light changes

3.3 Integration Customization

Protocol Support

- **Standard Lighting Protocols:** DALI-2, DMX512, Art-Net
- **IoT Protocols:** MQTT, CoAP, LoRaWAN
- **Building Automation:** BACnet, Modbus TCP
- **Security Systems:** ONVIF, PSIA
- **Cloud APIs:** RESTful, GraphQL for third-party integration

System Integration Options

- **Ticket & Reservation System:** Visitor flow prediction and optimization
 - **Visitor Mobile App:** Interactive lighting control, AR experiences
 - **Emergency Response System:** Automatic evacuation lighting activation
 - **Public Address System:** Audio-light synchronization
 - **Energy Management System:** Grid demand response coordination
 - **Tourism Big Data Platform:** Visitor behavior analytics
-

4. PROJECT IMPLEMENTATION

4.1 Project Timeline

Phase	Duration	Key Activities
Site Survey & Design	2-3 weeks	Photometric simulation, control philosophy, cultural impact assessment
Factory Acceptance	1 week	FAT testing, pre-configuration, scene programming
Manufacturing	3-6 weeks	Production, QC, environmental testing, cultural customization
Installation	4-10 weeks	Phased installation, night work coordination, heritage protection measures
Commissioning	2-4 weeks	Calibration, scene fine-tuning, integration testing, staff training
Total	12-24 weeks	End-to-end turnkey delivery

4.2 Installation Methodology

Site Preparation & Management

- **Cultural Heritage Protection Protocol:** Special procedures for historical sites
- **Visitor Impact Minimization:** Phased installation, temporary lighting, clear signage
- **Night Work Coordination:** Scheduling during low visitor periods
- **Safety Protocols:** Fall protection, confined space entry, electrical safety
- **Environmental Protection:** Waste management, vegetation protection

Installation Sequence

1. **Network Infrastructure:** Cabling, gateways, communication equipment first
2. **Pole & Mounting Hardware:** Structural installation and verification
3. **Fixture Installation:** Weather-sealed connections, proper aiming

4. **Control System Deployment:** Central server, edge computing nodes
5. **Sensor Network:** Calibration and communication verification
6. **Solar & Energy Storage:** Grid connection and safety testing

Quality Control Measures

- Torque verification for all mechanical connections
- Electrical safety testing (insulation resistance, grounding)
- Photometric aiming verification using laser alignment
- Communication signal strength mapping
- Waterproofing inspection and pressure testing
- Comprehensive as-built documentation with photos

4.3 Compliance Standards

International Standards

- **CIE 150:** Guide on the limitation of the effects of obtrusive light
- **EN 12464-1/2:** Lighting for work places and outdoor work places
- **IEC 60598-1/2:** Luminaires safety requirements
- **IEC 61508:** Functional safety for electrical/electronic/programmable systems
- **ISO 14001:** Environmental management systems
- **ISO 27001:** Information security management

Industry-Specific Standards

- **GB/T 31384:** Tourism public information graphical symbols
 - **LB/T 034:** Smart scenic area general outline
 - **Cultural Relics Protection Law:** Requirements for heritage site lighting
 - **Energy Conservation Law:** Mandatory efficiency requirements
 - **Fire Safety Codes:** Emergency lighting and evacuation requirements
-

5. SYSTEM DEBUGGING & TESTING

5.1 Photometric Commissioning

On-Site Measurement & Verification

- **Illuminance Measurement:** 50+ reference points across all zones
- **Uniformity Verification:** $U0 > 0.7$, $U1 > 0.5$ for pathway areas
- **Glare Assessment:** $TI < 10\%$ for visitor comfort
- **Color Temperature Accuracy:** $\pm 200K$ tolerance
- **CRI Verification:** Spectral analysis for color accuracy
- **Light Pollution Assessment:** Compliance with dark sky requirements

Scene Fine-Tuning

- Cultural atmosphere optimization with stakeholders
- Visitor flow simulation and response calibration
- Holiday and special event scene programming
- Transition smoothness between scenes
- Interactive experience refinement
- Camera and broadcast quality optimization

5.2 Functional Testing

Control System Verification

- Adaptive control response time testing (< 2 seconds)
- Sensor calibration and accuracy verification
- All scene activation and transition testing
- Emergency lighting activation test (simulated power failure)
- Cloud communication and remote control testing
- Failover and redundancy mechanism testing

IoT Integration Testing

- Visitor counting accuracy verification (95%+ target)
- Environmental sensor data validation
- Crowd density alert threshold testing
- Mobile app interaction and response testing
- Third-party system integration verification
- Data analytics dashboard accuracy confirmation

5.3 Performance Validation

Reliability Testing

- **72-hour Continuous Operation Test:** Full load stress testing
- **Environmental Chamber Testing:** Extreme temperature and humidity cycling
- **Water Ingress Testing:** IP rating verification under pressure
- **Vibration Testing:** Simulated wind and mechanical stress
- **Electrical Surge Testing:** Lightning and power surge immunity

Performance Metrics Validation

- Energy consumption baseline measurement and comparison
 - System uptime reliability testing (99.9% target)
 - Mean Time To Repair (MTTR) verification (< 4 hours target)
 - Cybersecurity penetration testing
 - 30-day trial operation monitoring
 - Independent third-party safety and quality audit (optional)
-

6. PROJECT DELIVERY

6.1 Deliverables Package

Hardware Systems Delivered

- Complete smart lighting system installation (all zones)
- Central control system with redundant servers
- IoT sensor network and communication infrastructure
- Solar photovoltaic and energy storage systems (if included)
- Edge computing nodes and network equipment
- Mobile maintenance access devices (tablets, tools)
- Spare parts inventory and specialized tools

Software Systems Delivered

- Central management platform with full licensing
- Mobile application for management and visitors
- Data analytics and reporting module
- Scene library with cultural customization
- Backup and disaster recovery system
- Cybersecurity protection suite

6.2 Documentation Package

Technical Documentation

- As-built drawings and BIM models (Revit format)
- Photometric calculation reports and verification data
- Control sequence of operations description
- Network architecture and security documentation
- Material safety data sheets (MSDS)
- Compliance certificates and test reports

Operational Documentation

- Operation and maintenance manuals (English + local language)
- Emergency response procedures and contact lists
- Troubleshooting guide with common fault scenarios
- Spare parts catalog with part numbers
- Warranty documentation and service agreements
- Training materials and video tutorials

6.3 Training Program

Training Modules

Audience	Training Content	Duration
Control Room Operators	System monitoring, alarm response, manual override, scene management	8 hours
Maintenance Teams	Component replacement, calibration, troubleshooting, safety procedures	16 hours
IT Administrators	Network management, cybersecurity, backup procedures, system updates	8 hours
Management Team	Reporting, KPI monitoring, strategic planning, ROI tracking	4 hours
Visitor Services	Mobile app guidance, interactive features, visitor assistance	4 hours
Emergency Response	Crisis procedures, evacuation lighting, authority coordination	4 hours

Training Methods

- Classroom theory sessions
- Hands-on practical exercises
- On-site simulation drills
- Video tutorials for reference
- Certification testing upon completion

- Refresher training schedule

7. OPERATION & MAINTENANCE

7.1 Predictive Maintenance System

Feature	Capability
LED Degradation Monitoring	Lumen depreciation tracking and replacement prediction
Driver Health Analysis	Temperature, voltage, and current trend analysis
Communication Monitoring	Network performance, signal strength, connectivity status
Power Quality Analysis	Voltage, current, power factor, harmonic monitoring
Sensor Calibration	Drift detection and automatic calibration alerts
Work Order Automation	CMMS ticket generation and technician dispatching

7.2 Maintenance Schedule

Frequency	Maintenance Activities
Real-time	24/7 system health monitoring, automated fault detection
Daily	Alarm review and acknowledgment, energy consumption review
Weekly	System performance analytics, backup verification
Monthly	Visual inspection, fixture cleaning, connection tightening
Quarterly	Sensor calibration, communication signal testing
Semi-annually	Photometric verification, firmware updates, security audit
Annually	Full system audit, compliance testing, major component inspection

7.3 Lifecycle Management

Phase-by-Phase Management

- **Years 1-3:** Warranty coverage, regular maintenance, software updates, performance optimization
- **Years 4-7:** LED driver replacement planning, efficiency optimization, capacity expansion evaluation
- **Years 8-12:** Technology upgrade assessment, partial refurbishment, energy storage replacement
- **Years 13-15:** Full system replacement planning, migration strategy, technology roadmap

Technology Refresh Program

- Quarterly firmware and security updates
- Annual software feature enhancements
- Bi-annual hardware technology assessment
- 5-year major system upgrade planning
- Continuous improvement based on visitor feedback

7.4 Performance Metrics & KPIs

Operational Performance

- **Energy Consumption Reduction:** 50-70% target vs. traditional systems
- **System Uptime Reliability:** 99.9%+ availability target
- **Mean Time To Repair (MTTR):** < 4 hours response target
- **Maintenance Cost Reduction:** 60%+ vs. traditional maintenance
- **Visitor Safety Incidents:** 30%+ reduction target

Business Performance

- **Visitor Stay Duration:** 25%+ increase target
- **Night Visitor Percentage:** 40%+ increase target
- **Secondary Consumption:** 30%+ revenue increase target
- **Social Media Mentions:** 100%+ increase target

- **ROI Achievement:** 3-5 year payback period target
-

Zhengzhou Hengling New Energy Technology Co., Ltd.

Smart, Sustainable, Cultural Tourism Solutions

Website: www.hengling-energy.com | Email: info@hengling-energy.com

This document contains confidential and proprietary information of Zhengzhou Hengling New Energy Technology Co., Ltd. Unauthorized reproduction or distribution is prohibited.

Zhengzhou Hengling New Energy Technology Co., Ltd. - Smart, Sustainable, Cultural Tourism Solutions

This document contains confidential and proprietary information. Unauthorized reproduction or distribution is prohibited.