Middle East Energy

50 YEARS

# Smart grid applications: from design, retrofit, upgrades, and operation

By

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The power grid across the Middle East is undergoing its most significant transformation in decades. With Saudi Arabia aiming for 130 GW of renewable capacity by 2030, the GCC region in accelerating towards ambitious renewable energy targets. This challenge extends beyond adding generation.

The real question is how to integrate variable solar and wind power into grids originally designed for one-way power flow from centralized fossil fuel plants. Thus, grid modernization is no longer optional.

According to recent analysis, upgrading infrastructure to accommodate large-scale variable renewable energy sources has become crucial for the GCC's energy transition goals. Smart grid technologies enable bidirectional power flow, real-time optimization, and adaptive capacity management across networks that must balance stability with the intermittency inherent in renewable generation.



## 1. What Makes a Grid "Smart"

Smart grids differ from conventional infrastructure through their ability to monitor conditions continuously, respond automatically to changing demands, and optimize performance based on real-time data.

This transformation relies on sensors embedded throughout the network, communication systems that connect distributed assets, and analytics platforms that turn data streams into operational decisions.

For grid operators in the region, this means moving from static, schedule-based operations to dynamic management, which includes:

- IoT-enabled switchgear providing visibility into equipment health and loading conditions.
- Intelligent monitoring systems tracking parameters like temperature, partial discharge, and contact resistance across transformers and circuit breakers.
- Asset management platforms correlating data from multiple sources to identify emerging issues before they escalate into failures.

UTEC's approach integrates hardware and software across this ecosystem. The GearAir, Enerswit+ Smart RMU, and Smart Transformer series exemplifies equipment designed with intelligence built in and not retrofitted as an afterthought. These systems arrive monitoring-ready, with IoT capabilities and multi-voltage support aligned to Saudi Electricity Company standards and broader regional requirements.

## 2. Building Intelligence from the Ground Up

When designing new substations or distribution networks, the opportunity exists to embed smart capabilities from the specification stage. This approach proves more cost-effective than retrofitting and ensures interoperability across the system.

Modern design principles emphasize flexibility and future scalability. Network architecture must accommodate not just current renewable penetration levels but anticipated growth over the equipment's 30-year service life. This includes provisioning for data flow and communication infrastructure alongside traditional electrical specifications.

For projects under development in Saudi Arabia and the broader GCC, standards compliance becomes critical. Equipment must meet SEC requirements while remaining compatible with evolving grid codes as renewable integration deepens. UTEC addresses this through modular design philosophy, enabling incremental upgrade of systems as operational needs change.

The value of this approach compounds over time. Equipment specified with monitoring capabilities from installation provides baseline performance data immediately, enabling more accurate degradation tracking and maintenance planning throughout the asset lifecycle.

## 3. Modernizing Existing Infrastructure

The reality for most grid operators is that their infrastructure predates smart grid concepts. In the GCC, where installed power capacity reached 272 gigawatts as of 2023, the path forward requires incremental modernization of legacy systems rather than complete replacement.

### 3.1 Strategic Retrofit Opportunities

Retrofit opportunities center on adding intelligence to existing equipment through sensors and monitoring systems.

- Transformers gain visibility into oil condition, thermal performance, and partial discharge activity.

- Switchgear receives contact resistance tracking and thermal imaging.
- Circuit breakers get equipped with operating cycle counters and diagnostic capabilities.

UTEC's E Series and C50 Transformer Monitors demonstrate this approach, providing comprehensive coverage of On-Load Tap Changer operation, bushing health, and dissolved gas analysis when added to existing assets. The data integrates into Dynamic Rating's LIFESTREAM platform, creating unified visibility across previously isolated equipment.

This strategy delivers measurable benefits without the capital expenditure and extended outages required for replacement. Operators can prioritize critical assets first, scaling deployments based on budget availability and operational priorities while maintaining service continuity.

## 4. Dynamic Rating: Optimizing Capacity in Real-Time

Traditional equipment ratings is a conservative approach that assume worst-case environmental conditions. It protects equipment but systematically underutilizes capacity. Research indicates that transmission lines typically operate well below their true thermal limits under actual conditions.

Dynamic rating technology adjusts capacity limits based on real-time environmental and operating conditions. Studies have shown capacity increases of 10-40% depending on climate, geography, and specific equipment characteristics. For grids integrating variable renewable generation, this capability proves particularly valuable.

### 4.1 The UTEC-Dynamic Rating Partnership: Environmental Intelligence Meets Grid Operations

UTEC's collaboration with Dynamic Rating, a global leader in environmental monitoring and weather intelligence, brings together complementary expertise. Equipment capacity is fundamentally influenced by environmental conditions:

- ambient temperature affects cooling efficiency
- wind speed determines convective heat transfer
- humidity impacts dielectric strength
- solar radiation contributes thermal loading

Dynamic Rating's sensor networks capture these parameters with meteorological precision. The data flows into UTEC's monitoring systems and integrates with Dynamic Rating's LIFESTREAM platform, where thermal models calculate real-time capacity limits for individual assets.

For overhead transmission lines, this means adjusting ampacity ratings hour-by-hour based on actual weather rather than seasonal assumptions. Transformers can be loaded more aggressively during cool, windy conditions while automatically backing off during hot, still periods. Substation equipment benefits from coordinated optimization across multiple assets simultaneously.

### 4.2 Regional Value Proposition

The operational value extends beyond raw capacity gains. Dynamic rating enables higher renewable energy integration by maximizing transmission capacity when solar and wind generation peaks.

It defers capital expenditure on new infrastructure by extracting more utilization from existing assets. Grid reliability improves through better understanding of actual operating margins rather than relying on conservative estimates.

For the GCC region, where intra-regional electricity trade currently represents less than 1% of total generation compared to 5% in Europe, dynamic rating capabilities become increasingly relevant as interconnection projects with Iraq, Egypt, and Jordan come online.

## 5. Operational Excellence Through Smart Grid Integration

The shift from reactive to predictive operations defines modern grid management. Real-time visibility across distributed assets creates the foundation for proactive intervention. Dynamic Rating's LIFESTREAM platform serves as the operational nerve center, correlating equipment health data with environmental conditions and load patterns.

When dissolved gas levels trend upward in a transformer, the system triggers maintenance planning before failure occurs. Abnormal contact resistance in a circuit breaker generates alerts days or weeks ahead of operational impact. Performance trending identifies assets approaching end-of-life conditions, informing capital planning decisions.

These capabilities translate directly into operational benefits.

- Utilities across the region report reduced unplanned outages through early fault detection.
- Maintenance scheduling optimizes resource deployment rather than reacting to emergencies.
- Asset life extends through condition-based operation that avoids both under-utilization and overstress.
- Safety improves as operators gain visibility into equipment approaching thermal or electrical limits.

## 6. The Path Forward: Supporting the Region's Energy Transition

As the GCC electricity sector continues evolving, complexity will only increase. Distributed energy resources, electric vehicle charging, data center loads, and green hydrogen production will add variability and unpredictability to networks.

AI and machine learning applications will enable increasingly sophisticated predictive analytics. Grid edge intelligence and autonomous operations will shift decision-making closer to the network edge.

### 6.1 UTEC's Commitment to the Region's Energy Future

UTEC's commitment to continuous innovation in smart grid technologies positions the company to support this evolution. The comprehensive lifecycle approach ensures customers can modernize incrementally rather than facing disruptive wholesale changes. Strategic partnerships like the collaboration with Dynamic Rating deliver integrated solutions that address real operational challenges.

For Saudi Arabia's Vision 2030 goals and the broader GCC energy transition, smart grid capabilities provide the operational foundation for ambitious renewable targets. The question is how quickly and effectively the region can deploy the intelligence required to manage increasingly complex power systems reliably and efficiently.

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