QUANTA TECHNOLOGY

CAPABILITIES

Quanta Technology, LLC

Smart Solutions. Real Results

About Quanta Technology

Quanta Technology is an expertise-based, independent technical consulting and advisory services company specializing in the electric power and energy industries. Our experts have years of practical working experience in the electric power industry and are trusted to develop custom solutions to the industry's most challenging and complex problems.

Our mission is to provide value to our clients with industry-best technical and business expertise, holistic and practical advice and thought leadership. To do this, we draw from a vast network of experienced power system experts from around the world. This ensures that our approach is efficient, objective and credible, reducing our clients' risk and resource requirements.

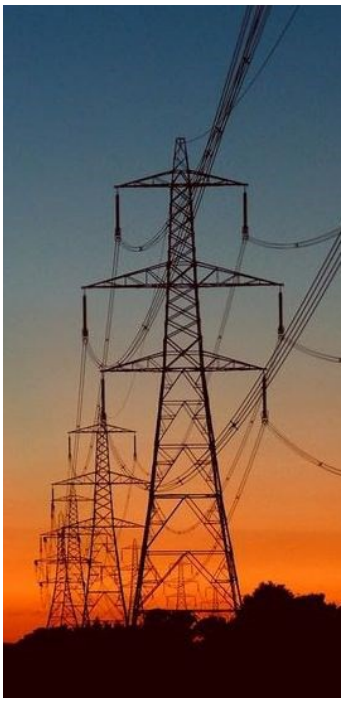
We are the independent consulting arm of Quanta Services (NYSE: PWR). Headquartered in Houston, TX, Quanta Services is a member of the S&P 400 with 2015 revenue of $7.57billion. It is the largest specialty engineering constructor in North America, serving energy companies and communication utilities by providing end-to-end services, including the planning, design, installation, maintenance and repair of virtually every type of network infrastructure.

As part of the Quanta Services family, Quanta Technology is able to deliver comprehensive solutions that span the spectrum from management consulting, all the way through to engineering, procurement and construction, covering the entire life-cycle of our clients' projects.

Quanta Technology is headquartered in Raleigh, North Carolina, with regional offices in Boston, Chicago, Oakland, California and Toronto, Canada.

Areas of Expertise

- Transmission & Distribution
- Protection & Control
- Automation & Testing
- Asset Operations
- Asset Management
- Emerging Technology Storage, Integration & Microgrids
- Communications
- Enterprise Integration
- Auditing
- Regulatory Compliance
- Synchrophasors & Wide Area Monitoring
- Smart Grid Strategies
- Engineering Staff Training & Augmentation



Our Team

- Industry-recognized staff, many with over 25 years of practical experience serving utility industry
- Talented mid-level and junior staff poised to become industry leaders
- Numerous patents, books and published articles
- Industry thought leaders - actively involved in the development of industry standards and evolving planning and operation practices
- Numerous IEEE Fellows, Senior Fellows and Life Members

Quanta Technology provides a full spectrum of consulting services that span the entire spectrum of the electric utility power transmission and distribution system.

Transmission

Quanta Technology provides industry-leading expertise in transmission system strategy, capital expansion planning, operational analysis, and contingency and risk assessment. Our experts can support ERO compliance and system infrastructure optimization for expansion and capacity utilization, assist in management of the increasing operations complexities and help maintain operational integrity through the loss of institutional knowledge via staff attrition. In addition, we can provide your organization with a range of solutions and thorough analysis for your most complicated problems to the efficient execution of routine studies.

Our Transmission team assists clients with challenges in the areas of interconnection queues, regional planning, cost recovery, economic studies and control center upgrades. Transmission systems analysis includes steady state and dynamic analysis, planning and operations, and support for regulatory services. Components of an economic assessment include PROMOD/ GRIDVIEW/GE-MAPS, dB conversion PROMOD to PowerBase analysis and market impact studies of Smart Grid, distributed generation and load management.

Distribution

Quanta Technology knows that one of the major challenges in this area is integrating Distributed Energy Resources (DERs) and increased loads due to distributed generation, distributed energy storage, PEVs and microgrids. Our Distribution team can assist with planning and operations, real-time monitoring and control and load forecasting and automation in order to optimize the distribution system to provide reliability and power quality.

Distribution systems directly impact the utility's service to its customers and sustain the frontal impact of today's distributed resource and energy demand management enabling technologies, such as smart metering, demand response, programmable and communicating devices (e.g., smart thermostats and load cycling switchers), advanced energy storages, Plug-in Hybrid Electric Vehicles (PEVs), etc. Proper distribution planning and engineering to leverage and support these technologies are quickly becoming a necessity. Quanta Technology has many of the world's experts in distribution planning, reliability and engineering. We have helped numerous utilities meet their distribution challenges

Protection & Control

Protection and control technologies continue to evolve. Quanta Technology offers expertise in the areas of strategy development, technology roadmap creation, understanding the impact of change on existing procedures, personnel and system architectures, changes to hardware and software requirements, changes to the methods and tools used for engineering, configuration, commissioning methods and tools. We can help with the process of making the decision to adopt new technology and assist in the roll-out when applicable. Our Protection & Control team also provides an array of services related to protection system modeling, sensitivity studies, coordination studies and protection system risk assessments, and more. We have developed a suite of in-hours applications to fully leverage the functionality of computer aided protection engineering software tools to help our clients analyze the effectiveness of their protection systems.

Automation & Testing

Power System Automation and Testing includes intensive needs analysis and implementation planning in order to develop a coordinated, cost-justified and defensible plan for T&D system automation improvements. This can be part of the overall enterprise process and technology integration effort. Simulation and testing are critical to providing reliable automation solutions for system operators. Quanta Technology provides both Real-Time Digital Simulation (RTDS™) and Synchrophasor/Wide-Area Monitoring, Protection and Control (WAMPAC) simulation and testing capabilities.

All Your Testing Needs With No Constraints

- Large scale real-time simulations
- Distributed generation
- Advanced power electronics
- Protection & control testing
- Wide area protection & control testing with PMU
- Smart Grid implementation
- IEC 61850 testing
- Education & training

RTDS™ Simulation & Testing Laboratory

We offer vendor-neutral power system application testing using our Real-Time Digital Simulator (RTDS). As protection schemes become more complex, encompassing wider geographic areas and involving newer and emerging technologies, it becomes both more important to confirm that schemes operate as designed, and harder to perform this validation in a manner that reflects real-world conditions. The unique closed-loop environment offered by the RTDS allows hardware-in-the-loop testing which provides considerably better results than off-line simulations. Our services include verifying the concept and protection scheme, building the model, designing test protocols, running the simulations on the RTDS, cataloguing the results and making any applicable recommendations.

Synchrophasor/WAMPAC Simulation

Wide-area monitoring based on synchrophasor technology uses Phasor Measurement Units (PMUs), Phasor Data Concentrators (PDCs) and associated communication to transmit information at very high rates. PMUs and PDCs are becoming an increasingly important asset in electrical networks and their ability to perform as intended is critical. Our PMU/PDC Simulation is intended to test the capability of PDCs, synchrophasor applications and synchrophasor/WAMPAC systems to properly handle the synchrophasor data as called for in NERC PRC- 002-2 (draft) standard .

Enterprise Technology Integration

Many of today's enabling technologies – such as Smart Grid, Smart Metering, Demand Response, Home Automation and Home Area Network, Distributed Renewable Resources, Plug-in Hybrid Electric Vehicles, etc. – are capable of transforming the utility paradigms and business processes, from the way the energy delivery system is engineered to the way it serves its customers. Establishing and implementing an enterprise integration plan that aligns business and technology is fundamental to managing the transformational changes, mitigating business risks, and maximizing benefits from the technologies.

Quanta Technology can help develop, justify and implement the enterprise integration plan that focuses on the enabling technologies, as well as utility enterprise systems, such as geospatial information system, enterprise resource planning and field force automation. We tailor the plan to your specific needs. A typical engagement may include some or all of these services:

- Business and technology assessments
- Gap analyses and mitigation assessment
- Enterprise integration plan
- Business case
- Implementation plan
- Implementation and post-implementation support

Sustainable Energy Resources Planning & Management

Quanta Technology offers independent and objective assistance with managing the impacts of integrating renewable and distributed energy resources into the grid that is both vendor- and solution-neutral. Focus areas include the development of regulations and procedures, the design of system architectures and control and protection schemes, performing theoretical and real-world studies and tests, both in the lab and field environments, assisting in technology and equipment selection... and avoiding the costly pitfalls of mistakes in any one of the former areas.

We have both the expertise and experience in designing and running prototyping and pilot projects, and doing proof-of-concept work related to the introduction and effect of emerging technologies, thereby reducing our client's risk exposure in terms of time, money and reputation.

Asset Operations

Quanta Technology helps clients meet today's utility challenges in terms of higher expectations of reliability, increasing pressure to lower costs and increase earnings, Smart Grid support and distributed sustainable energy technologies, and aging in both the workforce and the utility infrastructure. We provide expertise to complement the utility's internal expertise and provide professional resources to augment utility staff that has been stretched thin due to attrition and the aging workforce.

- Standards & Design – Engineering standards, equipment utilization, distribution design, system analysis
- Asset Condition & Maintenance Management – Transformer analysis, maintenance management, expert witness support

Asset Management

A common challenge to today's utility engineers is to extend the life of existing power delivery assets through a better understanding of asset condition and operational issues that significantly impact the remaining asset life, and implementation of maintenance practices to support operating objectives. Quanta Technology can assist with deciding how to best allocate resources – time, money, personnel – for equipment assets to achieve optimal output... an output that can be any combination of cost, safety, reliability or electrical performance.

Our Results Oriented Asset Management program (QT-ROAM^{SM}) is an asset renewal program designed to maintain accepted levels of T&D performance. We don't offer a one-size fits all approach. Different customers have different requirements, as well as different data available to act as input to the decision making process – so we customize our approach based on specific customer needs using a combination of expert knowledge, data analytics and benchmark data to create a tailored solution. We can assist with strategy formulation, tools and methodology selection and set-up, training, effectiveness evaluations, interpretation of data, forecasting of future performance and recommendations of necessary actions.

Utility Telecommunications Network Planning

Telecommunications networks in electric utilities have undergone a tremendous transition over the last few years. Networks are evolving from multiple, independent single-purpose (i.e., SCADA only, protection only or corporate specific networks), to more of a single platform network supporting different data types, each type with its own performance requirements. In the new age of IT/OT convergence, managed Ethernet, IP, MPLS and numerous wireless technologies are offered by vendors, and the utility must decide on a migration path appropriate for its environment. With Smart Grid requirements to overlay on top of the telecommunications infrastructure, the utility has communications challenges that have never before been encountered.

Regulatory & Compliance

Quanta Technology stands behind its services and will provide support as necessary to utilities for regulatory compliance, regulatory filings and resolution of disputes and litigation between energy market stakeholders. Our consultants have successfully supported companies with audits of NERC's Reliability Standards, regulatory filings and rate cases involving energy delivery infrastructure improvements, reliability improvements and advanced metering and demand response infrastructures. We have also provided expert witness support regarding power system outage analyses. Our service offerings are flexible and can be tailored to meet the client's specific needs.

Applied Research & Development

Quanta Technology's Applied Research & Development (AR&D) team uses proven experts from its Transmission, Distribution, Protection, Automation, WAMPAC and other specialty areas to convert advanced concepts and ideas from diverse fields into power system applications that improve concrete aspects of power system operations and/or planning. We place a strong emphasis on creation of intellectual property focusing on areas that can benefit our clients the most. Some examples include measurement based real-time voltage instability monitoring and prediction, synchrophasor-based system simulation and rules-based protection evaluation.

Among the types of R&D projects our team gets involved with are renewables, microgrids, energy storage systems, synchrophasor technology and probability-based risk management. In addition to supporting utilities with their R&D needs, Quanta Technology collaborates and partners with organizations to assist with research and early development and adoption of new technologies (e.g., Smart Grid projects supported by the Department of Energy (DOE), ARPA-e, NYSERDA and others).

We have recently established a Sustainable Energy Technology Integration Laboratory facility (QT-STIL^{SM}) to help utilities with finalizing design and testing of Distributed Energy Resources (DER) integration relative to distribution system controls and operation. This will help clients to gett from the proof-of-concept design stage to the proof-of-value performance evaluation of the integrated DER systems (renewable generation and energy storage) in a controlled lab environment.

Selected Project Experience **Applications**	Transmission	Distribution	Protection	Automation	Enterprise	Sustainable	Telecomms	Asset Ops	Asset	Regulatory
SynchroPhasor Integration (Control Center Capability Expansion)	♦									
Economic Planning, Congestion Assessment & Resource Integration Study (CARIS)	♦									
Load Flow Studies and Transient Stability Studies	♦	♦						♦		
Offshore Wind Farm Interconnection Studies	♦					♦				
Strategic Renewable Transmission Study (SMARTransmission)	♦									
Synchrophasor-Based Tracking Three Phase State Estimator & Applications	♦									
System Planning	♦	♦								
Downtown Secondary Network Assessment		♦								
Distribution Electric Load Forecasting		♦								
Electric Vehicle Impact Study		♦				♦				
Impact Study of Interconnection of Solar PV, WTG, BESS & SOFC		♦						♦		
Study to Investigate T&D Loss	♦	♦								
Advance Distribution Protection & Automation			♦							
System of the Future, Smart Grid Strategy					♦					
Wide-Area Protection Simulator Development & Coordination Study				♦						
PDC Specification Project				♦						
NASPInet Design and Specifications				♦						
RTDS Testing of Aurora Attack Prevention Technologies				♦						
CEM Advanced Technology Strategy, Roadmap & AMI Feasibility Study					♦					
Distribution Grid Operations Strategy, DA Strategy, DMS					♦					
Smart Grid Solution Architect & Owners Engineer					♦					
Development of Large-Scale Energy Storage Test Facility						♦				
Energy Storage Integration & Development						♦				
Impact/Sensitivity Studies of PV Inverter Contribution to Faults						♦				
Small Wind & Energy Storage Islanding (Microgrid) Pilot						♦				
MSA Exit Test								♦		
Efficiency Improvement							♦	♦		
Storm Hardening Strategy								♦		
Reliability Enhancement & Strategic Plan							♦	♦		
Substation Misoperation Investigation							♦	♦		
Transmission Life Extension & Modernization Assessment	♦							♦		
Aging Distribution Infrastructure Mitigation Plan		♦							♦	
Aging Infrastructure Assessment							♦		♦	
Downtown Secondary Network Study							♦		♦	
Extreme Weather Preparedness, Hardening and Best Practices									♦	
Strategic Delivery System Roadmap									♦	
Substation & Feeder Planning Improvement							♦		♦	
Sufficiency Review/RSAW Support									♦	
CIP Mock Audit & Preparation										♦
Compliance Program Staffing Review										♦
SGIG PMU Cyber Security										♦
NERC Compliance Guidance	♦							♦		♦

Selected Project Experience Applications	Transmission	Distribution	Protection	Automation	Enterprise	Sustainable	Telecomms	Asset Ops	Asset	Regulatory
Harmonics Analysis and Mitigation and Filters Design	♦	♦						♦		
Power Quality and Flicker Analysis and Mitigation	♦	♦						♦		
Insulation Coordination, TRV, Fast and Very Fast Transient Studies	♦	♦						♦		
TOV and Switching Studies	♦	♦						♦		
Smart Renewable Energy Inverters: Energy Management	♦	♦						♦		