National Energy Technology Laboratory – Regional University Alliance (NETL-RUA)

Grid Technologies Collaborative (GTC)

Gregory Reed, PhD – University of Pittsburgh – GTC Lead
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GTC Overview

- **The Grid Technologies Collaborative (GTC) is an integrated industry-university-government research and development group that advances the state-of-the-art in transmission and distribution system level power electronics technologies.**

- **Participants in the collaborative include industry partners and researchers from the U.S. Dept. of Energy's National Energy Technology Laboratory Regional University Alliance (NETL-RUA) Institutions and the University Energy Partnership (UEP).**

- **The GTC executes a comprehensive program of fundamental research; technology development, simulation and modeling, testing, and commercialization; and professional training for the advanced grid technologies sector.**

GTC History, and Status

- **Originated from NETL Strategic Growth Area (SGA) initiatives workshop – May 2011**

- **Selected as one of two SGA's for NETL support in 2012**

- **Formally established with seed funding in August 2012**

- **Group consists of 23 faculty and graduate student researchers from the five RUA universities and personnel from NETL, URS, and UEP**

- **Initial R&D project effort underway entitled:**

  - **The Next Generation Power Converter:**

    Applications for Enhanced T&D Grid Performance and Energy Resource Integration

  - **Benefits and outcomes: creating opportunities for faculty and graduate student researchers; expanding the capabilities and breadth of NETL's research portfolio; engaging industry in technology development and regional growth**

NETL-RUA GTC Leadership Team

- **GTC Lead:**
  Gregory Reed, University of Pittsburgh

- **Program Development**
  Wayne Honath, University Energy Partnership

- **Steering Committee**
  Steven Bossart, DOE NETL

  Keith Dodrill, DOE NETL

  Gabriela Hug, Carnegie Mellon University

  Gregory Dobbs, Penn State University

  Dushan Boroyevich, Virginia Tech

  Parviz Famouri, West Virginia University

  Janet Nelson, URS Corporation

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GTC Mission Statement

- **The GTC Mission is to become a world leader in the development, demonstration and applications of "Grid-Scale Power Electronics Devices and Systems"**

    – Advanced power electronics technologies are at the core of improved grid performance and enhanced reliability – e.g.: FACTS, HVDC, MVDC, Hybrid AC/DC topologies.

    – Power electronics technologies are highly integrated, engineered systems that incorporate advanced devices, components, and equipment; control architecture; and engineering design to facilitate the optimal delivery of electrical energy from generation resources to end-users.
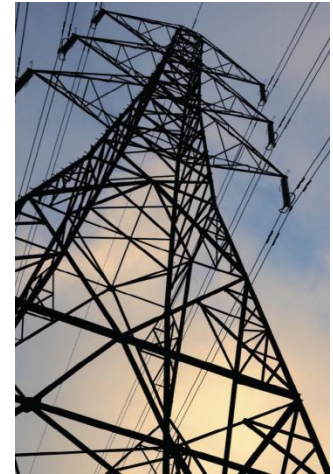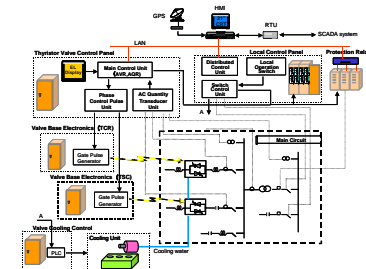
GTC Vision

- **The GTC Vision is the realization of an advanced electricity transmission and distribution network that:**

  – Is efficient, reliable, and resilient to disruptions and other contingency events on the power grid

  – Integrates clean energy generation resources, energy storage capacity, and alternate operational concepts

  – Delivers the most suitable forms of electricity in the most economic manner to end-users and enables greater levels of consumer participation

GTC Fundamental Activities

- **The GTC engages in three fundamental activities:**

  1) Developing new grid-scale power electronics devices for emerging AC and DC electrical infrastructure, supporting systems and algorithms, and demonstrating their technical and economic value proposition.

  2) Educating the next generation of power electronics and power systems engineers through advanced curricula at member universities and training programs for existing professionals.

  3) Partnering with industry and the public sector to advance the state-of-the-art of technology and demonstrate the benefits of advanced power electronics through collaborative research and development, seminars, and workshops.

- **The core R&D focus areas of the GTC include:**

  – Modeling, simulation, and analysis

  – Power semiconductors and materials development

  – Circuit and device design, integration, and topologies

  – Advanced control, systems interface, and protection

  – Testing and turnkey systems integration

  – Deployment and operations

The Next Generation Power Converter: Applications for Enhanced T&D Grid Performance and Resource Integration

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Next Generation Power Converter: Collaborative Planning Overview

- The R&D Project grew out of a series of meetings beginning March 2012

- Synergistic approach to a joint R&D project

- Strong team interactions and collaboration began with the first meeting

- Each member university has a defined lead role responsibility for scope of work and associated deliverables

- Each task within the scopes of work has identified input and support roles from each member university, NETL, UEP, and URS

- The project takes advantage of low developments costs through a primary task set of simulation and modeling, utilizing industry-standard tools

- Added 23 faculty, grad students & post-docs to research team in August
  - Immediately began direct collaboration
  - This important outcome establishes and reinforces the cooperative basis of the Regional University Alliance concept

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Next Generation Power Converter: R&D Program Overview

- Utility T&D scale advanced power electronics converter design and development for FACTS and DC based applications

- A key interface to power grid modernization and advancement

- Efficient, bidirectional connection and control interfaces

- Initial applications at utility-scale distribution level

- Control concepts and interfaces extended to transmission system level and applications

- Initial focus areas:
    - Renewable energy integration
    - Energy storage interconnection
    - Traditional and emerging AC and DC loads
    - Hybrid AC/DC System Architectures

Next Generation Power Converter: R&D Project Summary

- Develop and validate steady-state and dynamic models of system interactions at the converter-grid interface

- Develop power electronics based converter model

- Structure for utility scale high power applications at transmission and distribution levels

- Develop system simulation models based on standard IEEE test bus cases initially, with extensions adapted to specific application developments (i.e., renewable energy integration, storage, constant-power loads, etc.)
    – IEEE Standard WECC 9-Bus Transmission Test Case System One-Line
    – IEEE Standard 13-Bus Distribution Feed Test Case System One-Line

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Next Generation Power Converter: Initial System Applications

- Enhanced transmission and distribution grid performance

- Advanced control methodologies

- Interface and communications protocols

- Integration of various energy resources, energy storage, and AC/DC load entities (standard equipment/component models and some specific user-based models to be developed, in conjunction with the new converter topology model)

- Power system steady-state operation scenarios and dynamic stability analysis

- Power system security, and reliability enhancement

Next Generation Power Converter: 2012/2013 Project Deliverables and Contributions

- Develop model of integrated distribution feeder system and transmission grid network (IEEE test bus cases) with sufficient complexity to perform detailed simulations and studies to demonstrate benefits of the new converter design, as related to transmission and distribution grid performance and applications
- Perform detailed modeling and analysis, including integration of renewable sources, utility scale storage, and accommodation of traditional and emerging AC and DC loads; and hybrid AC/DC system architectures
- Conduct simulation and analysis of system interaction at interfaces and connection points for various types of technology integration
- Analyze performance and efficiency enhancements for distr. voltage applications
- Investigate manufacturing costs for prototype and limited/larger production needs
- Design smart controls based on system & component modeling
- Develop communications and interface architectures
- Establish hierarchical control methodology w/ predictive and adaptive algorithms
- Model (from new developments) advanced converter materials and devices
- Identify initial demonstration sites for utility scale applications
- Build initial proto-type of design concept and bench-scale device/system

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Next Generation Power Converter: Lead Roles for Scopes of Work

Scope of Work Leads by RUA Institution

- **University of Pittsburgh:** System Level Modeling

- **Virginia Tech:** Converter Topology Design

- **Carnegie Mellon:** Smart Control Methodology

- **West Virginia:** Interface & Communication Protocols

- **Penn State:** Demonstration Site Plan & Development

- **NETL:** Program Support for AVESTAR Integration

- **URS Corp.:** Systems/Applications Engineering Support

- **UEP:** Program Development, Industry Outreach, Project Support

Each GTC member institution supports and collaborates with the area leads on all scopes of work, creating strong interactions and teamwork

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Ongoing GTC Research Team Activities

- GTC participation in NETL meeting with DOE Office of Electricity Delivery and Energy Reliability, Oct. 25, 2012, Washington DC

- Pitt's 7th Annual Electric Power Industry Conf. – Nov. 12-13, 2012
    - GTC Workshop session, graduate student poster sessions, and NETL panelists and workshop moderators

- GTC National Conference - March 26, 2013, Arlington, VA
    - Hosting key legislative, government and industry representatives as audience and speakers

- Continue to build on integration of graduate students & post-docs into the research team, encouraging and developing collaboration

- Increase inter-University activities leading to joint conference presentations and publications in technical journals

- Position GTC as participant in 2013 Electricity Systems Hub proposal and other major funding opportunities

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