UNIVERSITY OF CALGARY

SCHULICH
School of Engineering

Electrical and Computer Engineering

Research at the Schulich School of Engineering



The electrical and computer engineering department at the Schulich School of Engineering is highly regarded internationally for its leadership in biomedical engineering, radio systems, software engineering, micro- and nano-scale systems, and power and energy research.

With a focus on applications in health care, and energy and the environment, research is led by 42 full-time faculty members, including five chairholders, who work with 260 graduate students and a student body of 600 undergraduate students. Faculty members are leaders in multidisciplinary projects, education and research societies and organizations.

RESEARCH FACILITIES

Biomedical Engineering

Biosystems Research and Application Group (BRAG)
Biomedical Signal and Image Analysis Laboratory
Biometric Systems Research Laboratory
Biometric Technologies Laboratory
CARP Biosystems Modeling Laboratory
Low-Frequency Instrumentation Laboratory

Information and Communication Technology: Radio Systems

Intelligent RF Radio Technology Laboratory (iRadio Lab)
Wireless/Optical Fiber Communications Research Laboratory
Wireless Networking Research Laboratory
Radio Frequency/ Microwave Research Laboratory
RF Radio Technology Printed Circuits Laboratory
Anechoic Research Laboratory
Digital Signal Processing Research Laboratory
Multimedia Signal Processing Research Laboratory
Sensor Network Research Laboratory
Embedded System Research Laboratory

Information and Communication Technology: Software Engineering

Software Quality Engineering Research Laboratory
Theoretical and Empirical Software Engineering Research Centre
Intelligent Software Systems Research Laboratory
Visualization Research Laboratory
Laboratory for Software Engineering Decision Support
Human-Computer Interaction Research Laboratory

Micro/Nano Systems

Advanced Technology Information Processing Systems (ATIPS)
Analog Electronics Research Laboratory
Intelligent Sensors, Integrated Systems (ISIS) Laboratory
Fully Integrated Systems and Hardware Laboratory
Intelligent Video Systems Research Laboratory
Advanced Micronanosystems Integration Facility (AMIF)
Secure System-on-Chip (SOC) Laboratory
Radio Frequency Integrated Circuits (RFIC) Laboratory

Energy Systems

Power Research Laboratory
Power Electronics Research Laboratory
Solid State Lighting and Human Development Research Laboratory
Dynamics Power Research Laboratory
Robotics Research Laboratory
System Identification Research Laboratory

BIOMEDICAL ENGINEERING

The results of the research performed in this department are assisting medical researchers, physicians, radiologists and surgeons. Collaborative research projects and partnerships with industries and medical specialists are aimed at significant advances in the effectiveness and delivery of health care.

RESEARCH PROJECTS INCLUDE:

- Development of “lab-on-a-chip” devices for testing, analyzing and diagnosing fluids on compact devices in a medical laboratory or at the point of care.
- Development of intelligent and miniaturized instruments that may be swallowed or implanted to image, detect and treat abnormalities in the digestive system.
- Wireless devices with information and communications technologies to monitor patients in hospitals.
- Radio-frequency imaging devices and digital image processing techniques for the detection of breast cancer.
- Computer models of the electrical activity of the heart to understand cardiac disorders and improve the chance of success of defibrillation.
- Novel devices and methods to measure and model the electrical activity of the gastrointestinal tract to understand and treat motility disorders, and to improve the utility of electrogastrography.
- Digital signal processing techniques for noninvasive diagnosis of knee-joint pathology, to study motor control pathways, and for brain-computer interfaces.
- Biometrics for surveillance and security.
- Methods to compensate for susceptibility artifacts in magnetic resonance imaging.
- Imaging systems and techniques to study stroke.
- Design of microchips capable of detecting nuclear magnetic resonance in small samples of liquids or gases.
- Techniques for detection, imaging, analysis, monitoring, repair, augmentation and replacement of biofunctions.
- Interfacing neurons to silicon chips.
- Design of an implantable blood glucose monitor.
- Methods for computer-aided diagnosis, surgery and therapy.

SOFTWARE ENGINEERING

The primary research focus of the Software Engineering Research Group (SERG) at the University of Calgary is on developing and evaluating methods, techniques and tools for the creation and maintenance of intelligent computing systems.

The group has active collaborations with academic partners at local, national and international levels. Research projects also involve collaborations with organizations locally (such as the City of Calgary, Enbridge and Chartwells) and internationally (such as Google, IBM, Hewlett Packard, Siemens and Microsoft).

RESEARCH PROJECTS INCLUDE:

Innovative Software Products

- Development and evaluation of industrial software products using intelligent technologies (such as neuron-fuzzy nets, cognitive informatics, agent-based technologies, genetic algorithms, knowledge management and semantic integration).

Requirements Engineering

- Techniques to capture, validate and gain a complete understanding and management of software requirements, both initially, and at all subsequent stages of a system life cycle. We study the following areas from a practical viewpoint: managing the gaps between requirement engineering and software design/architecture; elicitation, analysis, validation and management of non-functional requirements.

Testing and Quality Engineering

- Development and evaluation of methods, techniques and tools that help improve the quality of intelligent computing systems. “Quality” refers to product characteristics such as correctness, performance, availability, reliability, safety, usability, maintainability, etc.

Software Process Engineering

- Methods, techniques and tools for the assessment, evaluation, and improvement of software development processes. This area includes the development and application of intelligent decision-support systems and the application of software process simulation.

Empirical Evaluation of Products, Techniques and Processes

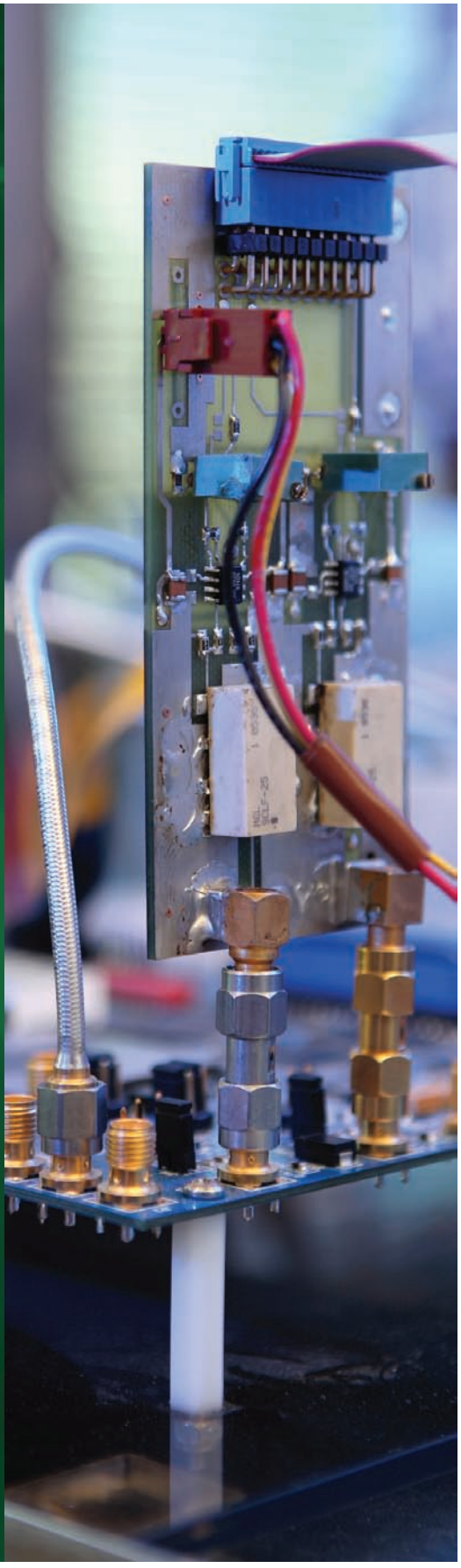
- Development and application of empirical methods, techniques and tools for the evaluation of software development products, techniques and processes in industrial environments.

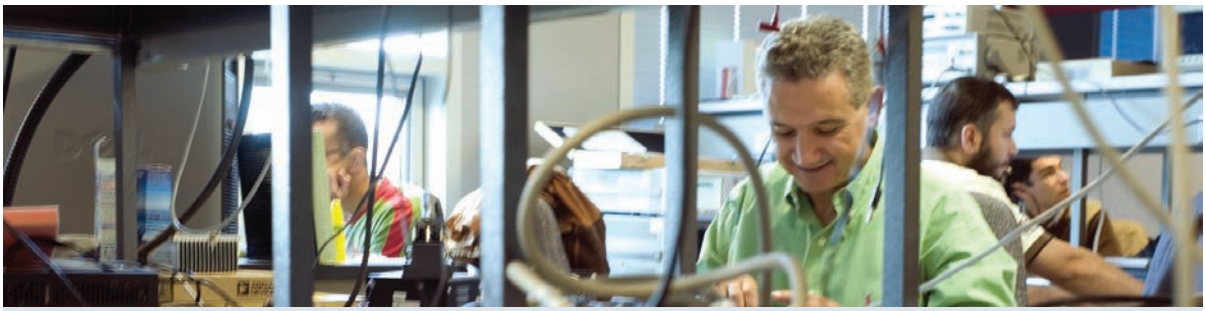
RADIO SYSTEMS

Information and communication technology (ICT) radio systems research in the department of electrical and computer engineering in the Schulich School of Engineering is advancing the core understanding and application of wireless radio and/or sensor networks that are embedded in the everyday environment, and which provide increased awareness, monitoring and control of our surroundings.

The expertise and approach often lead to real hardware prototypes, helping to bridge the gap between fundamental research and commercialization, especially with a more “green” approach to radio systems. Within Calgary, there is a strong wireless industry to act as a receptor for graduating students and for research ideas.

The department’s research and postgraduate training activities in ICT are organized into four groups working in cross-related areas.





RESEARCH AREAS:

Applied Electromagnetics and Antenna Systems

- Electromagnetic theory.
- Fast and accelerated computational electromagnetic analysis and design techniques of 3D structures.
- The design of phase array and smart antenna systems for wireless and satellite communications.
- Advanced antenna systems for positioning and location applications.
- Antennas and energy applicators for medical diagnostics, cancer detection and thermotherapy.
- Antennas for automotive and ground radar penetrating applications.

Communications, Networks and Sensors

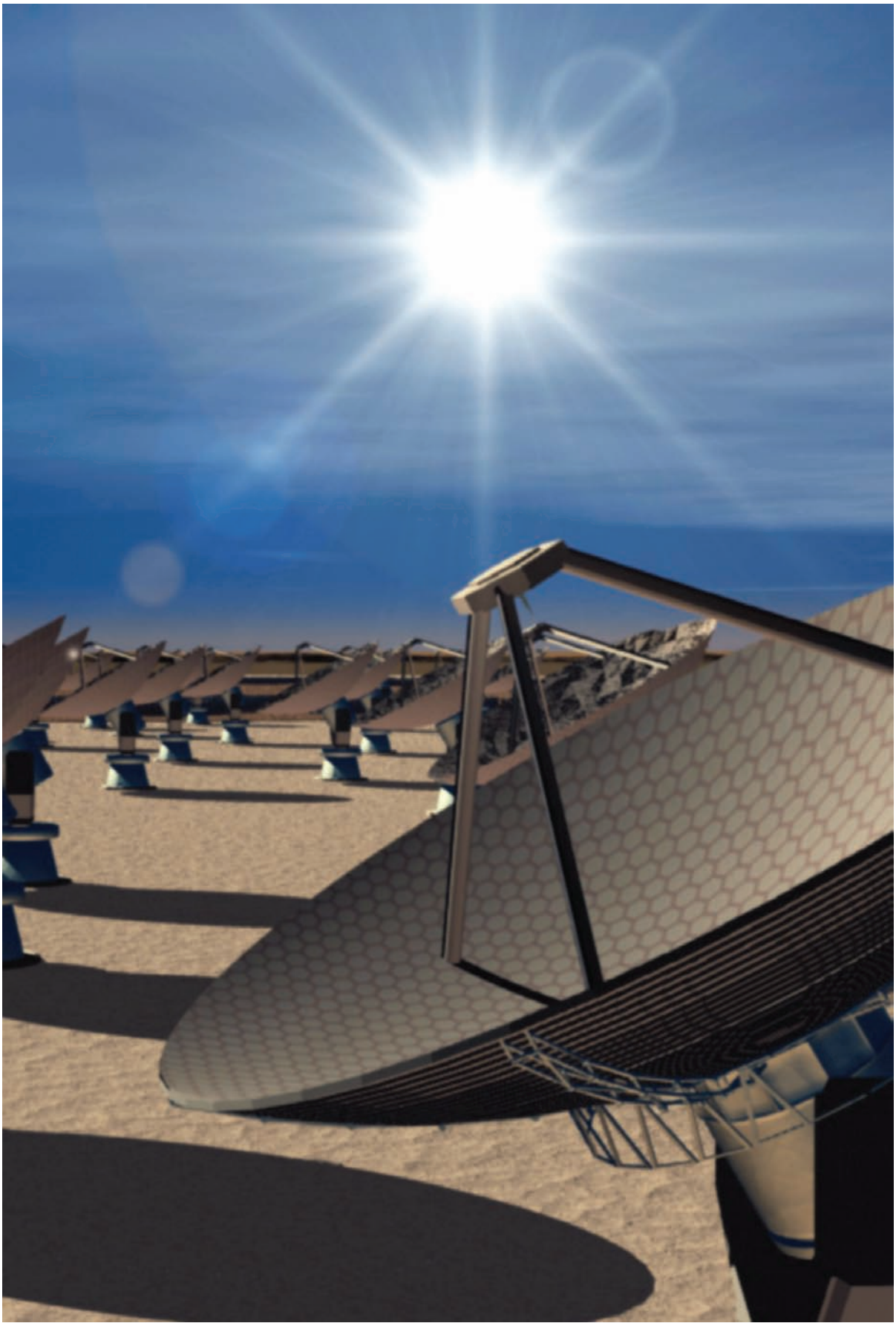
- Communications theory.
- Combined/adaptive modulation and coding techniques.
- Propagation measurements, channel modeling and blind equalization techniques.
- Multiple-access and multi-user detection/estimation techniques.
- Radio location, interference detection, cancellation and link quality estimation.

Signal Processing and Applications

- Fundamental research in estimation, detection, sampling and quantization theory, as well as multidimensional system theory.
- Signal processing theory and the development of advanced and new algorithms and their implementation.
- Adaptive signal processing techniques and their implementation.
- 3D and multimode image processing, coding, compression, image enhancement and fusion.
- Synthesis of high-level, real-time digital signal processors.

Microwave Engineering and Radio Systems

- Intelligent multimode, software-defined and high-performance radio systems for emerging wireless and satellite communications operating up to millimetre-wave frequencies.
- Advanced RF front-end design, agile transceiver design.
- Software defined radio (SDR).
- Power amplifiers.
- Linearization, equalization and impairment compensation using digital signal processing techniques.
- Embedded electronics.
- Design of highly power efficient and very low energy consuming (“green”) electronics for future radio systems, as well as for multi-antenna and MIMO applications relevant to the modeling of semiconductor devices.
- Behaviour modeling of communication systems.
- Development of new and advanced RF/microwave instrumentation and measurement techniques to support research.



MICRO/NANOTECHNOLOGY SYSTEMS

The micro/nanotechnology research group has a well-established record in designing and building biomedical devices, sensor devices and networks, and micro/nano integration and packaging (known as convergence). Research is supported by a substantial fabrication facility, an established imaging lab, and a strong track record of collaborative ties to other disciplines and organizations.

EXPERTISE LIES IN:

Nano-Magnetoelectronics (also known as Spintronics)

- Materials in which electrons can be "flipped" in place to represent different logic values, rather than transporting them from one part of a semiconductor to another. This work has application to ultra-high-speed computers.

Microelectro-Mechanical-Systems (MEMS)

- Semiconductor technologies manipulated to perform mechanical functions as well as electronic, especially in the application of MEMS to electromagnetic and biomedical applications. Successes include the design of electrostatic micro-motors, nuclear force microscopy, tunable electronic components and high-quality on-chip magnetic elements.

Microfluidics

- Electronic control of liquid samples over specially engineered surfaces. This work allows for the analysis (flow cytometry) and manipulation of bio-materials for a number of chemical applications, most notably for medical purposes.

Electronics

- Advanced circuitry for communications and computing using nanoscale semiconductor transistor technology. Work includes amplifier design for the square-kilometer array telescope, high-speed wireless communications systems, and integrated circuits for filtering and control.

Sensors

- Optical sensors (cameras), building active pixel displays and realizing high dynamic range imagers using advanced silicon technologies. This work spans integrated circuit design and design of semiconductor photodetectors.

"Green" Communications Systems

- Advanced electronics using exotic semiconductor materials and design techniques for multi-antenna systems, very low energy ("green") power circuits and millimeter wave communicators.

Digital Systems

- Automatic design of nano-scale digital computers including layout and verification of VLSI hardware as well as logic design techniques for Bayesian nanosystems.

POWER AND ENERGY RESEARCH

Located in the heart of Canada's energy powerhouse, the Schulich School of Engineering plays a crucial role in supporting research in energy developments. The electrical power and energy group has wide-ranging expertise ranging. The group is also training future engineers to become the future leaders of the Canadian electrical energy section.

RESEARCH AREAS:

Electric Energy Markets

- Optimal operation, planning and management of deregulated electric energy markets.

Adaptive Control and Artificial Intelligence Applications in Power System Control and Protection

- Application of adaptive control, fuzzy logic and artificial neural networks in the control and protection of power systems.

System Identification

- Creation and validation of mathematical models of power system components, such as generators and loads, based on measurements of their inputs and outputs.

Renewable Energy and Solid State Lighting

- Renewable energy and solid state lighting, with applications in developing nations. This research is often done in cooperation with the Light Up the World foundation.

Optimal Operation and Modeling of Power Systems with Stability Constraints

- Tools that enhance the operation and modeling of electrical power systems, so that the probability of experiencing large-scale power failure events are minimized while maximizing the amount of load that can be serviced.

Wind and Solar Power in Electrical Power Grids

- Large integration of wind-powered generation in electrical grids.

Power Converters for Wind and Solar Power

- New ways to design power inverters for these renewable sources, including the use of parallel inverter topologies, cascaded H-bridge inverters, and sparse matrix structures.

Wind Power and Carbon Management

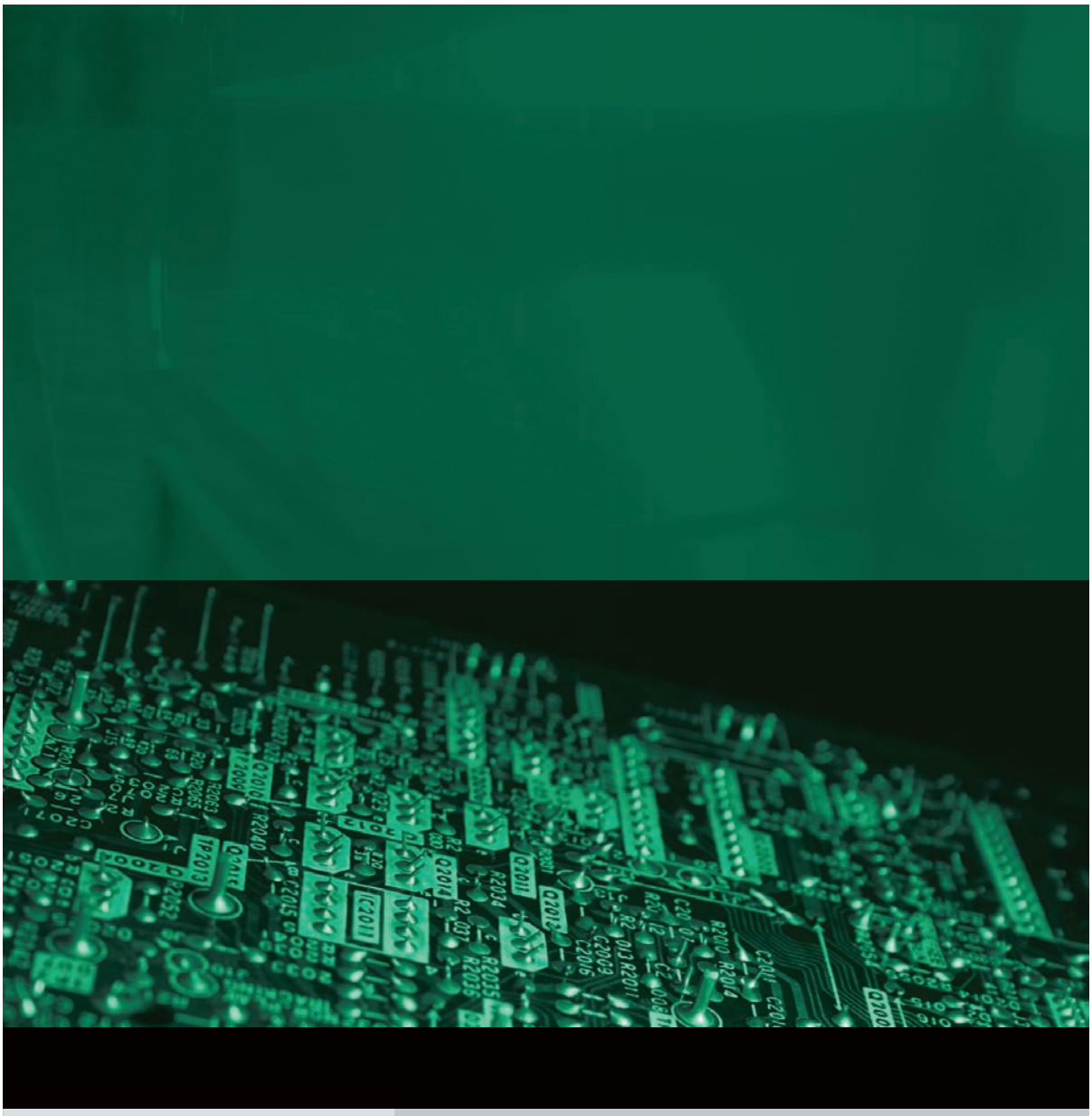
- True carbon management benefits of wind power, the operating cost added to real power systems when significant amount of wind power is integrated, and the uncertainties of the above.

Impacts on Electricity Market Prices

- Analysis of delivered cost of electricity is dependent on technology type, fuel cost and access to transmission facilities. Realistic models of power systems with different levels of wind generation penetration are being developed and simulated.

System Operation and Planning

- Models are being developed, that integrate and compare existing policy with recommended changes that follow from this analysis, to advance and enhance transmission system planning tools.



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