2013

Tools for tomorrow

RENEWABLE ENERGY AND SMART GRIDS

The dance between the sun and planets | The next step in social | A new medicine for the smart grid | Diving into our DNA | Dispelling myths on renewable energy | Robots learn to play nice

SCHOOL OF ELECTRICAL ENGINEERING
A WORD FROM THE DEAN

BUILDING A SUSTAINABLE TOMORROW

As a growing global population seeks higher living standards, we place more strain on our environment and infrastructures. This presents a fundamental challenge for research in the School of Electrical Engineering at KTH Royal Institute of Technology. How can we contribute so that more people can live a comfortable life, while preserving the wellbeing of our planet? At the core of electrical engineering in the 21st century lies the task of reducing carbon footprints; facilitating the integration of natural energy sources – such as utilizing solar, wind and water on the grid on a bigger scale – over long distances; and making sure these resources are used efficiently. In this yearbook you can see a few examples of what we have done during the previous year to provide the world with the tools for a sustainable society.

In order to contribute to real change, sustainable attitudes have to permeate all of our activities. Our students need the right tools to become agents of change.

During the last year, we launched a new course called Global Impact of Electrical Engineering, which addresses society’s challenges. With faculty mentors, the students explore the ethical implications of research in electrical engineering and are introduced to role models from private enterprise and industry.

Also, while students are completing their bachelor’s thesis in the five-year Masters of Science degree programme, they are guided by teachers to think more responsibly about their future profession and the engineer’s role in the society. Finally, the Sustainable Engineer course is designed to help master’s students put this knowledge into practice during their specialisation.

We are immensely proud that the numbers of students in our master’s programmes are now back at the same levels as before the tuition fee was introduced. Also, during 2013, the Swedish Higher Education Authority carried out a survey of all the Master of Science in Engineering programmes in Sweden. Both our Master of Science in Electrical Engineering and the Master’s programme in Electrical Engineering were awarded the grade “high quality”. We are pleased, but we will not be satisfied until we obtain the grade of “very high quality”.

We aim to be one of the leading institutions in Europe. The annual QS World University Rankings by Subject recognised this in its 2013 rankings, which rated Electrical Engineering at KTH sixth in Europe, and 24th in the world. The school of Electrical Engineering at KTH also proudly holds the 76th place on the National Taiwan University Ranking. Clearly, the school has generated results due to its determined and long-term focus on research and education of the highest quality.

So in the coming years, our focus will continue to be on attracting top students from around the world and researchers who lay the foundation for sustainable infrastructures. It’s our job to make sure they have the tools to excel in their work.

Professor Stefan Östlund, Dean, School of Electrical Engineering.
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EMPOWERING PEOPLE ON SOCIAL NETWORKS

Social networks have changed the world. Now they need to be changed.

TEXT & PHOTO MARIE ANDROV | ILLUSTRATION ANDERS WESTERBERG

IN AN INCREASINGLY connected world, much information that was once private is now shared among anything from hundreds to millions of people. Yet, if social media use is any indication, relatively few people seem to mind: nearly one-sixth of the world’s people are active users of Facebook.

What many of them don’t seem to realise is how exposed their data is, and the extent to which it can be used by service providers and third parties, says Sarunas Girdzijauskas, Assistant Professor in Communications Networks at the KTH Royal Institute of Technology School of Electrical Engineering.

“Everybody has a Facebook or Google + account today and is very happy about it,” he says. “We think everything is free on social networks, but in a sense, we pay by giving away our “private data to be monetised by social network providers.”

One problem is centralised data management. Social networks store and manage your data – photos, videos, contact information and messages – along with data from millions of other users in huge data centres around the world.

Centralised storage makes it easier for someone to tap into your personal data. Girdzijauskas adds that these centres are also expensive to run and are environmentally unsustainable.

Another concern is ownership of information, which becomes increasingly difficult for the user to determine when the terms and conditions of these services are constantly changing. Complicating matters further is the question of whose laws apply when the user’s social network provider is registered in one country, and the data is stored in yet another.

“If a photo I posted last month becomes very famous in different social networks, it’s very likely that the social network provider owns the rights by now,” Girdzijauskas says.

So, how can we ensure the same instantaneous global spread and functionalities that we enjoy in today’s social networks, and at the same time keep our data private?

A consortium that includes seven research partners from five countries has proposed a way. They designated a team of 11 PhD students and five postdoctoral…
to develop technologies that enable decentralised online social networks. Instead of data being handed over to centralised social network providers, it can be intelligently distributed on a number of devices belonging to trusted individuals.

**Precisely how users** can know who to trust is the main issue being addressed by those working on the research project that Girdzijauskas coordinates called iSocial. This project is funded by the European research fellowship programme Marie Curie Actions.

The starting point of iSocial is to enable people to exchange data locally. Most people don’t use the full capacity of their computer’s hard drive, so the researchers are exploring how they can take advantage of this fact.

But how can I trust my friends not to peek at my data? And what if my friend’s computer is switched off? How can I then get an overview of my data? These questions are being addressed by those working on the project.

“We are building decentralised search, storage and data dissemination networks which are secure and based on trust relationships among the involved users,” Girdzijauskas says. In order to get access to your data, your friend’s computer has to be up and running. So the researchers are looking into a solution similar to peer-to-peer (P2P).

To maximise data availability, they are also considering how many replicas of data are needed to assure access when you want it. “Maybe we will not be able to guarantee the same quality of service as Facebook, for example, since uploading and downloading will depend on local conditions,” Girdzijauskas says. “But maybe that’s the price we will have to pay to protect our privacy.”

Along with the friendlier distributed storage, researchers are also developing an open source platform – for distributed machine learning that will enable pooling of global trends while keeping user data secret.

“As the total data is aggregated, your user data never leaves your device and nobody can peek at your data”
People’s privacy will be preserved by a distributed data algorithm. The pooling application is installed on the social network for the benefit of all users, including private individuals as well as companies.

For example, if someone wants to inquire about a salary range for a particular segment or group, iSocial algorithms will enable the pooling application to quickly converge to a correct prediction without any need for private user data to ever leave their machine, and without being exposed to third parties.

“As the total data is aggregated, your user data never leaves your device and nobody can peek at your data – they can only see where it comes from,” Girdzijauskas says.

**UP AND COMING** internet players have a lot to gain from this distributed model too, Girdzijauskas believes. Today there is a major barrier preventing smaller companies from entering the social network market. Only large companies that have the resources to keep big data storage centres can host your data. And smaller companies are unable to launch social media applications without making commitments to network giants such as Facebook and Google. A distributed model would – apart from empowering people – also empower small companies.

**WHETHER PEOPLE** will want to accept delays or changes in the quality of service in order to protect their privacy is up to the test in iSocial.

“The question is, do you want your data to be stored with people you know, or with someone you don’t know; and you have no idea how they are going to use your information?” Girdzijauskas asks. “We will know if users are concerned about their privacy by the end of this project.”

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**Advanced polymer features built-in adhesive**

**A NEW POLYMER THAT ALLOWS PLASTIC COMPONENTS TO BE MADE IN INNOVATIVE WAYS WINS MERCENE LABS A SPOT IN THE KTH GREENHOUSE LABS INCUBATOR**

**TEXT** Peter Larsson | **PHOTO** Håkan Lindgren

**ADVANCED POLYMER** developed by Mercene Labs enables epoxy chemistry in entirely new applications. The material earned the fledgling company the 2013 Ingemar Croon Award from the KTH Royal Institute of Technology’s Greenhouse Labs.

Mercene Labs CTO Fredrik Carlberg says the firm, dry, mouldable material offers a way to make plastic components with custom shapes and qualities, with adhesive incorporated into them.

**“YOU CAN** shape the material as you like, and then you can activate the epoxy to bond it strongly with the base layer,” he says.

**“OUR MATERIAL** enables quicker, cheaper processes in the production and bonding of components,” he says.

In addition to a cash prize of EUR 240,000, the Ingemar Croon Award wins Mercene Labs a place in the KTH Greenhouse Labs incubator laboratory.

“This is a good, innovative environment, and it gives us a good network of contacts,” Carlberg says. “And let’s not forget all the great cutting-edge labs.”
Fuel cell solution catches Obama’s attention

**During his September, 2013** visit to KTH Royal Institute of Technology, **Barack Obama** was given a demonstration of **PowerTrekk**, a fuel cell and battery charger that runs on water and salt. Fuel cell technologies promise a more sustainable transport and energy sector by an efficient direct conversion of bio- or chemical energy into electricity. An essential innovation behind the PowerTrekk charger is a novel assembly method, co-invented by **Wouter van der Wijngaart** and **Sjoerd Haasl**, of Micro and Nanosystems at the School of Electrical, which allows fuel cells to be lighter, smaller and less costly to produce, while providing a higher power output for a given size. ■

“I’m very proud that technology developed by members of our team has been recognised by the world’s most influential advocate of renewable energy,” says van der Wijngaart.

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KTH researchers Rakel Wendland Lindström and Carina Lagergren, Chemical Science and Engineering, give US President Barack Obama a demonstration of the fuel cell and battery charger PowerTrekk, that they are behind.
IEEE LOCAL WINS CHAPTER OF THE YEAR AWARD

THE SWEDISH combined Vehicular Technology, Communications and Information Theory Chapter of the IEEE won the IEEE’s Chapter of the Year Award for 2012 partly thanks to the ACCESS Distinguished Lecture Series and a national communications workshop, jointly organised by the centre. “This award is an indication that a wide range of world-class activities took place in Sweden in 2012,” says Lars Rasmussen, professor of Communications Theory at KTH Royal Institute of Technology, who heads the Information Theory Chapter in Sweden. “The local IEEE Distinguished Lecturer Programme is heavily reliant on the ACCESS Distinguished Lecture Series, for example,” he adds.

THE SMART MOBILITY LAB LOWERS CARBON EMISSIONS

During 2013 the high tech Smart Mobility lab has taken shape with a positioning system that uses 12 infrared cameras, and an autonomous model vehicles that can move in the road network, as well as motion capture system, Qualisys 3D visualization and trajectory projections on the floor. Here researcher and students develop and test smart transport solutions that may help lower carbon emissions by up to 15 per cent. Watch the video from the lab at www.ee.kth.se/yearbook

Three questions to Tomas Karlsson, the new head

Who are you?
—I’m an associate professor in Space and Plasma Physics, with a passion for people and space.

What will the group focus on under your leadership?
We are involved in several international space projects. In one in particular, we have developed instruments to measure electrical fields – associated with space weather – for the NASA mission Magnetospheric Multiscale. This is an ambitious space physics project involving four satellites to be launched in 2015. The project will help scientists understand the interaction between the sun and its surrounding planets, including Earth, by measuring the electromagnetic activity in the magnetosphere.

What are you aiming at?
I want to steer us towards solving some of the mysteries of space and its weather.
Resting on a table in an office at KTH Royal Institute of Technology, lies a case containing what appears to be a gold Christmas tree ornament. **Tomas Karlsson** gently lifts the orb and removes its protective wrapping to offer his visitor a close-up look.

**TEXT DAVID CALLAHAN | PHOTO HÅKAN LINDGREN**

For the Professor of Plasma Physics, this baseball-sized sphere is worth more than gold. It contains electric field sensor electronics that will soon fly far above the Earth, taking measurements that will help scientists understand the interaction between the sun and its surrounding planets.

Karlsson is just one of the people at KTH working on the Magnetospheric Multiscale (MMS) project, a mission led by NASA, which will use the Earth’s magnetosphere as a laboratory to study the microphysics of magnetic reconnection – a fundamental plasma-physical process that converts magnetic energy into heat and kinetic energy of charged particles.

They have dedicated the working-hour equivalent of 10 years to constructing instruments and power supplies that will enable four satellites to take ultra-high resolution measurements of the ion and electron distributions and electric and magnetic fields within cosmic plasma flows.

Magnetic reconnection occurs universally in plasmas, the electrically conducting mixes of positive and negatively charged particles that account for an estimated 99 per cent of the observable universe. **Göran Marklund**, Professor in Space Plasma Physics, explains that magnetic reconnection is responsible for driving the aurora borealis and is also believed to be behind solar flares and many other astrophysical phenomena.

The scientific investigation, called Solving Magnetospheric Acceleration, Reconnection, and Turbulence (SMART), will also contribute to solving problems on Earth related to magnetic reconnection, Marklund says.

“In connection with solar flares and space storms, the Earth’s atmosphere is hit by intense particle flows,” he says.

The MMS project aims to understand questions such as how reconnection starts and how it ceases, as well as how it accelerates particles to high energies.

“While this is basic research, in a broader context what we are doing is mapping the space environment that is closest to Earth, which is also important for technical applications such as satellites,” Marklund says.
These large currents flow down into the atmosphere, and they can induce strong currents to power grids, burning out transformers and causing other damage,” he says. “So this kind of research is a step towards understanding these effects on the environment.”

This not only affects the health of satellites, but also technical systems on Earth. “These large currents flow down into the atmosphere, and they can induce strong currents to power grids, burning out transformers and causing other damage,” he says. “So this kind of research is a step towards understanding these effects on the environment.”

Each of the four NASA satellites will carry four of the sensors created by KTH, which will extend from the spacecraft on 60m-long retractable wires, housed in titanium nitride coated spherical casing, which gives them their golden hue. A prototype of this wire boom system, which resembles a fishing reel, was engineered at KTH.

INSIDE THE BALL-SHAPED case, there is also a retractable reel, which the team has nicknamed the “yo-yo”. Around it, a short, 0.24mm wire is wound that will enable the probe to be extended even further from the end of the boom cables.

The idea is that the thinner wire helps reduce disturbance in the measurements. “There are a number of disturbances we want to avoid,” Marklund explains. “We want to be as far from the satellite body as possible because when it orbits the Earth, it leaves a wake in the plasma, just like a boat or a bus.”

In creating the instruments, the engineers also had to take into account other extreme conditions of the near-Earth space plasma environment. Karlsson says the team had to build light mechanics and components to reduce mass as much as possible, but the gear also had to
During solar storms, satellites can get killed, he says. “We needed radiation-hardened components that can operate even in the radiation regions. In addition, these were placed in boxes with a level of thickness that protects the electronics.”

With their partners at the University of New Hampshire in the US, the team tested the electrical and mechanical parts in simulations of the extreme heat and cold of sunlight and shadow in space. Then there’s the problem of making sure that moving parts operate in a vacuum. “There are requirements on surface properties – lubrications that will work in a vacuum,” Karlsson says.

While the probe is designed to operate for two years, it will likely continue operating for a long time afterwards, Marklund says. The predecessor of MMS, the ESA Cluster project, probes Earth’s magnetosphere with satellites that were designed to be in service for two years, but which have actually have been in operation for 14 years. “When you build a space mission that costs USD 1 billion and it operates longer than expected, it’s unwise to turn it off,” Marklund says.

So the scientists have high hopes for a long and fruitful investigation. Their colleague, Per-Arne Lindqvist, responsible for MMS at KTH, will work with an international team of scientists who operate the instruments, collect data and analyse the results from the MMS mission.

The launch of the four satellites is scheduled for 26 November, 2014. “We will be very active in the research that follows,” Marklund says.
A new method of speech manipulation turns down the volume on pumped up public address systems.

TEXT MARIE ANDROV AND DAVID CALLAHAN | PHOTO MARIE ANDROV
Connected boot boosts firefighter safety

New professors in 2013

SVETLANA RATYNSKAYA
Professor space and plasma physics

PER BRUNSELL
Professor fusion plasma physics

MEHRDAD GHANDHARI
Professor electric power systems

FRANK NIKLAUS
Professor micro-manufacturing

LINA BERTLING TJERNBERG
Professor Power Grid Technology

MAGNUS JANSSON
Professor Signal Processing

MARTIN NORGREN
Professor Electromagnetic Theory

Connected boot boosts firefighter safety

TECHNOLOGY DEVELOPED at KTH Royal Institute of Technology Department of Signal Processing will save more lives from fires while making the work of a firefighters safer. A small embedded computer in each of the heels of a firefighter’s shoes is combined with radio ranging equipment to enable emergency response coordinators to follow firefighters’ movements and location throughout an operation – without any infrastructure. This positioning system, known as a tactical locator system (TOR), can operate in extreme situations.

In October 2013, a team of researchers from KTH Signal Processing, the Indian Institute of Science in Bangalore and the Swedish Defence Research Agency, as well as firefighters from the Swedish Rescue Services Agency, tested the TOR in real time 25 metres below ground.

The TOR system allows for precise, simultaneous location tracking of multiple workers in the field, and the data is output to a nearby display. TOR relies on the OpenShoe project.

WATCH THE SUCCESSFUL TESTS ON VIDEO AT: www.ee.kth.se/yearbook

New professors installed at the KTH Royal Institute of Technology School of Electrical Engineering in November, 2013.
INNOVATIONS ON THE SMART GRID

Meet the new power grid. It will be smarter, more sustainable and more reliable. And the KTH Royal Institute of Technology School of Electrical Engineering is creating solutions that will make it a reality. >>
A SMART NETWORKER FOR A SMART GRID

Sweden’s top proponent of smart grid technology, Lina Bertling Tjernberg, has dedicated her career to analysing the reliability of electric power systems, mainly focusing on the grid. This is no easy task, especially given the rapid advance of technology and the changing nature of energy during the last 15 years.

FOR ALL OF the grid’s complexity, the point of having an energy system is quite simple, says Lina Bertling Tjernberg.

“In my mind it has only one purpose: to deliver electricity to customers with a certain level of quality and availability,” she says. “I work with mathematical models – what kind of measures can we develop for the reliability of the system?”

That question has occupied Bertling Tjernberg for the last 17 years. After five years as a Professor in Sustainable Electric Power Systems at Chalmers University, she has returned to the university where she earned her doctorate to become KTH Royal Institute of Technology School of Electrical Engineering’s first Professor in Power Grid Technology, or what’s commonly called Smart Grid.

It’s a fitting role for a scientist who has built a worldwide network of contacts in the area of the smart grid, and who is the Swedish government’s adviser on the subject. With renewable energy sources playing an increasingly important role in the power system, Bertling Tjernberg’s core areas of interest – high voltage direct current (HVDC) and grid reliability – pose critical questions for smart grid planners.

But Bertling Tjernberg is also a connection-maker, and her involvement with the global smart grid community is as much about her own research as bringing the best ideas together from different disciplines, with the singular goal of making the power system’s work more efficient, more sustainable and, well, smarter.

“My passion lies in finding new ideas and capturing the different kinds of knowledge, so that together we can find solutions for the smart grid and the energy system,” she says.

A GLOBAL NETWORK

As a member of CIGRE (the International Council on Large Electric Systems), Bertling Tjernberg is one of two national members of a working group to examine the reliability and impact of high voltage direct current (HVDC) on smart grid. The research will play an important role in the building of Sweden’s proposed Southern Link, to secure the southern part of the country’s electricity supply.

But CIGRE is just one of several organisations in which Bertling Tjernberg is involved. She maintains contact with a global community of smart grid engineers, scientists and policymakers through her involvement in professional groups such as the Institute of Electrical and Electronics Engineers (IEEE), where she serves as Treasurer of the IEEE Power & Energy Society and Editor of the IEEE Transactions on Smart Grid Technologies.

OVERCOMING GAPS

She sees the multi-international interactions as an important part of her role. “To me, in my role as an expert, it’s an obvious way of payback to my employer, while participating in leadership training,” she says. The IEEE leads several large- and small-scale efforts on sustainable energy, Bertling Tjernberg points out. And her volunteer work is a source of inspiration that enables her to keep her abreast of research trends.

“During my travels I read, write, listen and come up with new long-term ideas,” she says. “Meeting all these amazing people provides meaning, joy and inspiration in my working life – both with people that are my models and the new generation whom I can support and guide into the power system society.”

Her devotion to putting people in contact with each other is motivated by what she sees as a need to widen the participation...
in building energy systems of the future. Bertling Tjernberg likens the evolution of the power grid to that of the telecommunications network, explaining that the power system too is bound to see an expansion in the kinds of actors involved. “It’s crucial to get people together to meet in order to overcome gaps in technology areas, between engineers and policy makers, between generations and different cultures,” she says.

Bertling Tjernberg has helped widen the circle by organizing the IEEE’s first Innovative Smart Grid Technologies (ISGT) conference in Europe in 2010, and has since led the ISGT Europe Steering Committee. She also is an adviser for ISGT in the US and Asia. “Smart grid requires knowledge from several disciplines and to think in new ways.”

AN EXPLORER’S INSTINCT
From the beginning of her career, Bertling Tjernberg has demonstrated the instincts of an explorer – one whose fascination with complex problems is strong enough to overcome any doubts about what lies ahead. “To me as a researcher, you’re always searching,” she says.

After earning her doctorate, Bertling Tjernberg was offered a position in 2007 as research director at the Swedish National Grid (Svenska Kraftnät). Her decision was guided by a sense that something interesting lay ahead.

“When I was doing my research studies at KTH, I thought, ‘I want to become a professor’. She wanted to follow in the path of her international adviser and mentor, Ron Allan, Professor Emeritus in Electrical Energy Systems at the University of Manchester. “But then came the offer from Svenska Kraftnät, and I couldn’t resist,” she says. “If your vision is to become an expert in the electric power system, you really need to explore and understand the operation and how it works in real life.”

As she describes it, Bertling Tjernberg finds herself at another crossroads in 2014. After five years at Chalmers University, she has returned only recently to KTH. With no courses or projects at KTH yet, she travelled to Brussels in December to take stock of the most recent EU calls on transmission issues and reliability. Then she settled in at Stanford University in the US with a Smart Grid group at the Department of Civil and Environmental Engineering to prepare for a half-year sabbatical during which she is developing research ideas for the years ahead. “This is a good time to do it,” she observes.

It’s an exciting time to select new projects, Bertling Tjernberg says. In addition to HVDC, solar energy could also come up on her agenda. “We’ll see,” she says.

One of the big challenges ahead could be managing a wider array of small-scale electricity generation, enabled by more affordable wind and solar technology, she says.

“It is all about the sustainable energy system, and as engineers we want it to work efficiently. My wish is to contribute with smart methods to model and evaluate the reliability of the power grid,” she says.

“We have a lot of work to do because the power grid and the energy system will not look the same as they do today.” ■

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CUTTING POWER LOSS ON SMART GRIDS

As society’s reliance on renewable energy increases, researchers at KTH Royal Institute of Technology are playing a critical role in optimising power grids to meet the challenge.

TEXT DAVID CALLAHAN & PETER LARSSON | PHOTO JANNE DANIELSSON

The power grid of the future will draw a great amount of energy from large off-shore wind farms – a source of power that is as variable as, well, the wind. Furthermore, because of their distance from land, the wind farms generate will be fed into the grid via direct current (DC) cables.

Grids built in the 1950s rely on current-source converters (CSCs), which are adapted for point-to-point connections.

Now, as the grid incorporates more DC transmission, multilevel voltage-source converters (VSCs) are emerging as a new breed of power converters.

However, power losses are a typical flaw with the new technology.

“When DC is turned into AC, it’s chopped up into pieces, creating a square wave,” Nee says. “But what you want instead is a sine wave and to create this, the multilevel power converter contains a row of multi-circuit converters that transform the current in several stages – in other words, creating many small square waves.”

Nee and the other KTH researchers have reviewed and refined this process, partly by using thyristors instead of transistors in the multilevel converter invented by Professor Rainer Marquardt from the Universität der Bundeswehr München in Germany. The result is a reduction in power loss during conversion, from 1.7 per cent to 0.7 per cent.

To put that figure into context, fellow researcher Staffan Norrga, Associate Professor at the Department of Electrical Energy Conversion, offers an explanation.

“There are about 150 gigawatt-sized high-voltage DC links in the world today, about 5GW of which are made up of VSC-based converters,” he says. “The loss reduction we’re talking about here – from 1.7 per cent to 0.7 per cent – means a 200,000 tonne reduction of CO2 emissions per year for these 5GW based on a reasonable estimate of power usage.”

TEAM LED BY Hans-Peter Nee, Professor of Electrical Energy Conversion at KTH, is working on technology that will help optimise the grid for variable energy and high-voltage DC transmission, resulting in fewer energy losses and reductions in carbon emissions of up to 200,000 metric tonnes per year.

“The loss reduction ... means a 200,000 tonne reduction of CO2 emissions per year.”
The Sahara Desert could supply solar power to countries as far away as Sweden, if the advances in power grid technology under development at the KTH School of Electrical Engineering are put into practice.

If renewable energy sources are to meet society’s electricity needs, smart grids will be required to have the flexibility to deal with fluctuations in power production. They must also be capable of carrying electricity much further.

Göran Engdahl, Professor of Electrotechnical Design and researcher at SweGRIDS, says that direct current is much better suited to travelling long distances than alternating current. The problem is that its circuit is much harder to break.

But working in collaboration with ABB to develop a high-voltage direct current (HVDC) circuit breaker, Engdahl’s research team has contributed to the development of a circuit breaker that will make the job much easier.

In order to break a direct current, the contacts must be separated extremely fast, which happens in the new switching device, Engdahl says. The problem of transporting energy over long distances and in large quantities with the help of HVDC is thereby solved in principle.

Engdahl says that in a smart electricity grid, it must be easy to redirect energy, depending on supply and demand, variation and local production. “It must also be possible to close off parts of the grid for maintenance, without interrupting supply to consumers.

“Breaking the circuit is a hard nut to crack, and it is exciting to be able to contribute to solving this problem.”

“In order to break a direct current, the contacts must be separated extremely fast, which happens in the new switching device”
MYTH BUSTER LOOKS TO AN ALL-RENEWABLE FUTURE

COULD SWEDEN FULFILL ALL ITS POWER NEEDS WITH RENEWABLE ENERGY? LENNART SÖDER, PROFESSOR ELECTRIC POWER SYSTEMS, SAYS IT’S ABSOLUTELY POSSIBLE AS HE GOES ABOUT DISPELLING NEGATIVE MYTHS ABOUT THE POTENTIAL OF SOLAR, WIND AND WATER POWER.

“SOMETIMES PEOPLE ASK” me if there are power system problems with renewable energy sources. Well, we solve problems at KTH,” says Söder, Professor of Electric Power Systems at KTH Royal Institute of Technology. His investigation into the possibilities and challenges of Sweden using 100 per cent renewable electricity sources has dispelled a number of lingering myths.

As one of the researchers within the North European Power Perspectives project, Söder has been busy answering the sceptics, proposing that Sweden could use solar and wind power for 40 per cent of its energy by 2030, with the balance provided by hydropower, biomass and gas turbines. He has presented his analysis in meetings with the Swedish national grid and the Swedish Energy Agency and has been updating it continuously in response to questions from the groups.
“You have to be very careful with how people define limits, challenges and problems. There are challenges with everything,” he says. “We are concentrating on the scientific challenges.”

**Isn’t there a limit to how much wind power you can generate?**

“There’s no physical limit to wind power from the power system point of view. But you need a huge amount of storage if 100 per cent of all energy comes from wind power – which, by the way, is not relevant for Sweden. It’s technically possible. So, it depends on how you define ‘limits’.

**Some people say** they don’t like wind power. And they say it doesn’t work. It’s ugly, noisy, and it affects their property values. That’s their opinion. If they think it causes problems for them, then I respect that. But don’t tell me it doesn’t work.

“People argue for one thing but in reality they are arguing for something else, so there should be some kind of honesty. And on many sides there are people who don’t understand how this works.”

**But doesn’t the variability of wind and solar power make renewable energy too unpredictable to meet the needs of the customers?**

“Wind and solar power turn out to be more stable than most people realise. What’s interesting is with a country as large and as spread out as Sweden, you have wind turbines in a lot of different places. The variation in wind power from hour to hour is relatively small, up to about 10 per cent of the installed capacity. It could be that the wind increases in Skåne while it goes down in Norrland; but by exchanging the power between these areas, the total rate of changes decreases. And this shows the importance of having a good transmission system.”

**A lot of people say it’s too expensive to build out the reserve generation you need to deal with spikes in consumption.**

“The cost of meeting the need of maximum consumption at low wind and solar activity in a system where all Swedish nuclear power is replaced with wind and solar power can be estimated to a level of SEK 0.01/kWh. You already pay about SEK 1.30/kWh on your electric bill, so this cost can hardly be seen as a show stopper. When discussing the future, you also have to consider what the alternative is to greater amounts of solar and wind power. By comparison, in the UK they’ve estimated the cost of building a new nuclear power plant at what amounts to SEK 1/kWh, which is much more expensive than the current cost of wind power.

“So there are several possibilities for how to design the future power system. It is important to have a serious discussion based on facts concerning technical and economic consequences and challenges of different designs. And there is still a great need for research to obtain a better understanding of the challenges and consequences of different possible solutions such as electric vehicles, storage, smart grids and different market designs.”
LIGHTNING HARNESSED TO PROTECT GRID

Doctoral student Roya Nikjoo has developed a »preventative medicine” that signals when power components need to be replaced – stopped from harming nearby equipment.

TEXT DAVID CALLAHAN AND MARIE ANDROV | PHOTO HÅKAN LINDGREN
Energy Storage (SweGRIDS), has developed a system that uses natural transients to measure the wear and tear on power components. “We can use these high voltages to obtain more information about the condition of components like transformers and bushings than through offline inspections,” she says. “It gives us a more systematic way of tracking the trends in how components’ conditions are affected by high voltages.”

The technique she developed can be thought of as “preventive medicine”. Components can then be replaced or fixed before they themselves cause damage to neighbouring equipment.

The work has earned Nikjoo honours from SweGRIDS, as well as the Young Researcher Award at the 18th International Symposium on High Voltage Engineering, ISH, 2013, Seoul, Korea, for her paper, “Insulation Condition Diagnostics of Oil-impregnated Paper by Utilizing Power System Transients”. She won a similar award in Vienna in 2012.

Measurements Begin As signals created when lightning or power switches break an electrical circuit, interrupting the current or diverting it from one conductor to another. Those signals are used as stimuli to obtain the response from power components, Nikjoo explains.

Starting her project in 2011, Nikjoo equipped power components in the lab with sensors to measure the current of lightning or switching impulses with different frequencies as it goes through the component.

The output produces a graphic representation of the system, much the same way as ultrasound produces an image of a fetus. “It’s like getting the fingerprint, of the component,” Nikjoo says. “As that fingerprint changes, I can use it to identify the well-being of the component, and know if something is wrong.”

In recent months Nikjoo has been performing tests with higher voltages that are more akin to what occurs in the field. She also has been investigating all the parameters that can affect the accuracy of the results, such as the cables’ coupling, in the measurement circuit.

The method will save power grid operators money in equipment replacements and maintenance, while keeping customers powered up.

“This can make electricity more reliable in a smart grid. Customers won’t need to worry about blackouts or losing money due to a shutdown.”

FOR GOOD REASON, when power switches or lightning create high voltage currents, power companies view it as a problem. These so-called natural transients have the power to destroy components and cause disturbances along the transmission line.

But Roya Nikjoo went looking for the positive side of natural transients, and she found it. The KTH Electrical Engineering doctoral student at the Swedish Centre for Smart Grids and
Researchers from the KTH School of Electrical Engineering have developed a user-friendly app that enables iPhone and iPad users to see for themselves what’s happening in the power grid.

Despite people’s heavy reliance on electricity and its unquestionable power, for most it remains quite a mystery. This is partly because electricity is invisible. Now a potential smart grid accessory, the STRONgrid iPad Visualization App (there’s one for iPhones and desktop computers too), could enable anyone – not just power company technicians – to check for outages in the grid.

The STRONgrid prototype app uses data collected by phasor measurement units (PMUs) that are deployed in the electricity network linking Norway, Denmark, Sweden and Finland. Luigi Vanfretti, associate professor at the Smart Transmission Systems Laboratory (SmarTS Lab) of the Department of Electric Power Systems, says the app shows when outages are occurring.

“It moves the ability to visualise what is happening in the network out of the control room,” Vanfretti says. The app could be further developed for monitoring the overall health of the grid.

Also included in the STRONgrid project are Maxime Baudette and Muhammad Shoaib Almas, researchers at the SmartTS Lab, and Norway’s power grid operator, Statnett. It is funded by Nordic Energy Research.

From the left: Luigi Vanfretti, associate professor in smart grids, doctoral students Maxime Baudette and Muhammad Shoaib Almas also working in the SmartTS Lab at KTH.
TEAMWORK MAKES ROBOTS BETTER HELPERS

KTH researchers are helping robots learn to cooperate, a difficult but potentially revolutionary challenge. »

TEXT DAVID CALLAHAN | PHOTO HÅKAN LINDGREN
A CHILD-SIZED ROBOT shuffles towards a ball on the floor of the Computer Vision and Active Perception Lab at KTH Royal Institute of Technology, as a team of student researchers watches intently.


To an outsider, the demonstration might appear to be no more than an exercise in basic robotic abilities, but the activity is actually part of an ambitious project to make robots co-operate on complex missions using body language.

Funded by the EU’s Seventh Framework Programme for Research, RECONFIG (Cognitive, Decentralized Coordination of Heterogeneous Multi-Robot Systems via Reconfigurable Task Planning) began early in 2013 and runs until 2016, with project partners at Aalto University in Finland, the National Technical University of Athens in Greece, and the École Centrale Paris in France.

In the not so distant future, robotics will play a major role in service-oriented tasks of everyday life – at home, in the classroom and at work – and robotic vacuum cleaners have already made their way into our homes. Sometimes, however, a single robot is not sufficiently capable of carrying out a certain task, such as moving heavy objects.

Dimos Dimarogonas, Assistant Professor in Automatic Control and coordinator of the project, says that the basic aim is to get one robot to understand when another robot needs its help and to change its plans accordingly.

“By studying each other’s body language, our robots will learn to interpret information and act on it,” Dimarogonas says. “If they cannot accomplish their individual plans, once they have met and exchanged plans, they can reconfigure to pursue a mutually satisfactory goal.” The aim of RECONFIG is to decentralise the coordination of robot teamwork, in which each robot identifies its own tasks. The work underway in the robot lab has so far been focused on individual robots, or agents. However, Dimarogonas says they’re working towards multiple robot systems.

“We are building from the ground up,” he says. “We need to make sure the individual systems
are robust enough that when we move to the multiple agent platform, they will work there as well.”

**Getting Robots To** co-operate is difficult because each one has its own view of the world. They categorise the same object differently, depending on their perceptual viewpoint – somewhat like humans. But if humans have problems with common perception, how will robots manage? This is what the research partners are trying to address.

The researchers are trying to reach agreement on how the robots should perceive sensor-based information, such as seeing or grasping an object.

By combining reconfigurable task planning with implicit sensing-based communication (embedded cognition-coupled communication) and explicit body language, such as pointing at an object, the robots will be able to re-evaluate their pre-programmed plans based on common perceptual agreement. They will also be able to update both these plans and corresponding trajectories based on their pre-programmed tasks.

“Let’s say that a team of robots is pre-programmed to find and carry all the chairs in a room,” Dimarogonas says. “One of them identifies a new chair in real-time. It will then be able to decide whether to carry the chair itself or inform another robot to change its plan to take care of the new chair.”

**If Successful,** the projects can set the standard for real-time robot co-operation for in-house domestic service activities, or even for working as assistants in hospitals or schools, Dimarogonas says. “The School of Electrical Engineering is really excited about this because lower and higher educational institutions are among the stakeholders we have targeted for this project.

“There’s a lot of work to be done, but we could see robot teams like this working in schools relatively soon.”

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**Professor wins award for work in auroral physics**

**GÖRAN T. MARKLUND,** Professor of Space and Plasma Physics at KTH Royal Institute of Technology, has received the European Geosciences Union’s Hannes Alfvén Medal, named in honour of the Nobel laureate. The Hannes Alfvén Medal is awarded annually to researchers for outstanding achievements and discoveries in the field of Planetary and Solar System Sciences and Solar-Terrestrial Sciences. Of 80 nominated researchers around the world, the 2013 medal was awarded to Marklund with the citation:

“The 2013 Hannes Alfvén Medal is awarded to Göran Marklund for his outstanding contributions in auroral physics, especially his discovery of downward directed magnetic-field aligned electric fields – an essential feature of the auroral circuit – and their association with black aurora.”
IEEE honours three from EE

Researchers Sailing He, Håkan Hjalmarsson, and Karl Henrik Johansson from the KTH School of Electrical Engineering were among 298 scientists worldwide who were appointed Fellows in 2013 by the Institute of Electrical and Electronics Engineers (IEEE). This distinction, the IEEE’s highest level of membership, is reserved for those who have achieved lasting and outstanding results in the institute’s fields of interest.

Professor Hjalmarsson, from the Department of Electromagnetic Engineering, was recognised for his contribution to sub-wavelength photonics, involving novel designs and structures for photonic integrated circuits, new methods and structures for artificial photonic materials, and nanophotonics for bioimaging and sensing.

“I became a Fellow of the Optical Society of America (OSA) and the International Society for Optical Engineering (SPIE) years ago. I feel honoured to receive the recognition from a larger society – IEEE – which also covers other areas of my research topics, such as antennas and microwave, besides photonics,” he says.

Professors Hjalmarsson and Johansson are both from the Department of Automatic Control.

Hjalmarsson’s research focuses on controller design, such as in the European Union-project Autoprofit (Advanced Autonomous Model-Based Operation of Industrial Process Systems). “The aim is to make model-predictive control of processes more efficient,” Hjalmarsson says.

Johansson was recognised for his contributions in control of hybrid systems and dynamic networks, especially how to use communications networks to control systems and resources more efficiently.

“This appointment is an encouraging confirmation that my research has been considered innovative and important, and that my group is at the research frontier,” Johansson says. ■

Text: Marie Androv

KTH School of Electrical Engineering 2013
With the spread of MOOCs, some universities run the risk of becoming “typewriters in an era of iPads”.

Realising the potential of online education

Will the university survive global online courses? That provocative question was asked in a seminar on massive open online courses (MOOC), organised by Gunnar Karlsson at the KTH School of Electrical Engineering and Sverker Janson at SICS together with three speakers from two other Swedish universities. The seminar attracted more than 350 people to KTH in May 2013.

The group’s concern was first raised in 2011, when Stanford University attracted 160,000 students from 190 countries to enrol in a single online course.

“This was when the real internet revolution began for universities,” the seminar’s organisers and speakers wrote in an op-ed article in Svenska Dagbladet, published on 19 May, 2013. The authors wrote that the internet has driven the restructuring – and even closing down – of businesses in numerous industries, and that universities could be next.

With their huge lecture halls, universities like KTH and the Faculty of Engineering at Lund University (LTH) could become “typewriters in a world of iPads” in a couple of years, said Per Ödling of LTH. Sanna Wolk and David Black-Schaffer from Uppsala University focused on the opportunities, presenting tools and raising legal issues in making MOOCs a reality.

The aim of the seminar was to engage universities in meeting the threats and realising the possibilities of online education.

TEXT MARIE ANDROV

Watch the short interviews and filmed seminars at: www.ee.kth.se/yearbook

KTH’S EQUALITY AWARD GOES TO EE’S HR MANAGER:

“It’s everybody’s responsibility to work against discrimination”

THIS YEAR’S winner of the KTH Royal Institute of Technology’s Equality Award, Irina Radulescu, Human Resources Manager at the School of Electrical Engineering, is deeply engaged in KTH’s network for female professors and docents, where she is responsible for carrying through the network’s projects. According to the award committee, Radulescu also “elegantly” integrates gender equality, diversity and equal treatment in her daily work.
Mentoring brings "big picture" into focus

Gathered around a table, a group of students begin to talk about their teachers as part of a class meant to bridge the gap between teachers and students. They trade their assessments with frank honesty.

TEXT DAVID CALLAHAN | PHOTO JANNE DANIELSSON

“HE’S REALLY, REALLY good, very inspiring and he seems to enjoy teaching,” a young man says about one teacher, and his companions nod in agreement. “Yes, really good,” says another.

“It seems like others teach just because they have to,” one student observes.

It could be a scene out of any dormitory lounge or campus café, but it’s not.

“Is that how it works? that being able to do research is their motivation to teach?” a student asks, turning around to someone sitting at the end of the table.

It’s a teacher.

The conversation here is actually being moderated by a faculty mentor, Jan Scheffel, who concedes that there are doctoral students who would prefer not to teach, even though doing so is one of the ways they can meet their requirements.

“The first year students need to meet good, pedagogical teachers,” Scheffel tells them. “The risk of dropouts is high in the first year – you really have to get through to students from the beginning.”

This is the second time in the autumn term that the seven students have convened for their two-hour mentoring session with Scheffel.

It’s part of Global Impact of Electrical Engineering, a new course that students at the KTH Royal Institute of Technology School of Electrical Engineering are enrolled in for three years until they complete their bachelor’s degree. While half of the sessions are devoted to discussions about how electrical engineering addresses society’s challenges, the other half is more about the challenges the students face in their course work.

The aims of the class can also be seen as two-fold: to give students the “big picture” about the role of electrical engineering; and to bridge the communication gap between students and faculty, says James Gross, the project leader behind the new course.

Gross points out that problems with students’ study plans often do not become apparent until it’s too late to do anything about it. So, the Global Impact mentors like Scheffel get right into the discussions with students early on to help straighten things out and to facilitate interaction with students who might be able to help each other.

“We get very late feedback if the study plan is not designed well or if we put certain courses too late into a study plan so that they can’t grasp the content of other courses,” Gross says. “We wanted to establish a course where the faculty gets more in contact with the students to mentor them, to guide them, but also to get feedback early on.”

Scheffel says the close interaction with the students is intentional, and there’s no hiding from...
the teacher. “In these sessions, they all must speak in order to get credit,” he says. “The idea is to be visible, to be seen and to feel they have a place here. When they feel I’m learning their name and who they are, that produces a stronger tie.”

Then there are the Global Impact lectures. Twice a term, speakers are invited to talk about societal challenges for which electrical engineering will have to provide solutions in the future. One aspect of these presentations is to feature role models, who include people from the KTH faculty, as well as engineers who are employed with companies or who are entrepreneurs.

“We had the impression that we are educating a bit too narrowly in the specific fields,” Gross says. “The students are well educated about certain theoretical fields of electrical engineering, but they don't see the big picture.”

The students immediately notice a difference. “This course is very different from my other courses,” says Ulrika Karlson, a first year student. “The other courses contain a lot of theory; they are all about logical thinking and problem solving. But here you have a topic to write an essay about and discuss a problem that doesn’t have an exact answer.

“You have to reflect, weigh the advantages against the disadvantages and draw conclusions. You get perspectives on what the training involves.”

Ulrika Karlson and six classmates at the second mentoring session in the course Global Impact of Electrical Engineering in the first year of the Master's of Science degree programme in Electrical Engineering.
AUTOMATIC CONTROL METHOD TRACES GENETIC LINK TO DISEASE

More than a decade has elapsed since the map of the human genome was completed, yet a mystery still lingers: how exactly does the DNA sequence make one’s hair a certain colour, or predispose someone to brain cancer?

TEXT DAVID CALLAHAN AND MARIE ANDROV | PHOTO HÅKAN LINDGREN

THE ANSWER could be found in a statistical method developed by Torbjörn Nordling, a researcher at the KTH Royal Institute of Technology School of Electrical Engineering, to trace the link between hereditary information and the dynamic cellular processes that lead to disease. Nordling, who recently earned his doctoral degree in Automatic Control, has been recruited by Uppsala University to put his method into practice in cancer biology, in particular the modelling of glioblastoma, the most common brain tumour among adults.

WHILE THE genetic information encoded in the human genome remains virtually static in the cell, the phenotype – which describes observable characteristics such as appearance or medical conditions – is a consequence of a dynamic process, or a control system, in which genes interact with one another. With Nordling’s method, medical researchers could gain a valuable overview of these processes.

“Although we are sure about the genotype, we do not know how the phenotype arises,” Nordling says. “This is because the genes switch on and off as needed, depending on the environment.”

For example, a yeast cell growing in glucose will need certain enzymes turned on, unlike a yeast cell growing in another type of sugar, he says.

“THIS CONTROL is fully automatic and is a dynamic process that is governed by the environmental cues and the needs of the cell,” he says.

Nordling’s proposal is the first method that statistically ensures that an interaction actually exists between genes in this intracellular control system.

The researcher struck on his idea simply by turning the problem on its head, and asking: What links can we show to exist based on the data available to us today?

By taking into account the limitations of the data, Nordling can show that a link is necessary to explain the data and ultimately must be included in the system, under mild assumptions.

The method has been successfully applied on published data from IRMA, a synthetic gene control network, which researchers built inside an actual yeast cell. By interfering with the five genes in the cell, Nordling has seen how these are affected. What’s most surprising about his results is that a previously unknown interaction is necessary to explain the data.

“Several methods have been used and all produced networks that were a little different and that vary from the expected network, even though they use the same data. No previous theories have been able to prove that any of these links actually exist. I can prove mathematically that the link must be there, under mild assumptions.”
FACTS AND FIGURES

The KTH School of Electrical Engineering is growing fast, both in staff and in revenue. During the last few years, the school’s EU funding has risen substantially. In seven years the staff has increased by nearly 60 per cent, to 441 full-time employments in 2013, from 284 in 2007. Teaching faculty and doctoral students account for the biggest growth.

It has also been a successful year for EE’s educational programmes. Applications per place in our programmes have increased significantly. At the same time, the programmes performed well in a major national evaluation.
EXTERNAL FUNDING – EU REMAINS AT THE TOP

During the last few years, the KTH Royal Institute of Technology School of Engineering’s EU funding has risen substantially, thanks to the many EU projects in which our researchers are involved – 111 in 2013. Our EU funding increased by 46 per cent in 2012 alone. The levels of EU funding have stabilised in 2013, and now constitute 31 per cent (SEK 62 million) of our total external funding (SEK 204 million 2013). The School of Electrical Engineering has the highest percentage of EU funding within KTH as a whole, with 23 per cent of the total (SEK 281 million 2013).

While EU funding stabilised in 2013, industry and government funding increased sharply, by nearly 50 per cent and 25 per cent, respectively. This is due to industry and governmental funding from partners ABB, Fortum, Vattenfall, the Swedish Energy Agency and Vinnova, among others, for joint research in the Swedish Centre for Smart Grid and Energy Storage (SweGRIDS). The increase in government funding is also owed to the Swedish Foundation for Strategic Research’s long-term investment in several future research leaders at the school.
RESULTS:
HIGHER INCOMES, MORE INVESTMENTS

The KTH School of Electrical Engineering’s income has increased substantially during the past four years, partly thanks to a rise in EU funding, but also as a consequence of the Swedish government’s investment in strategic research areas. This resulted in additional funds of SEK 27.52 million in 2013 (SEK 21.5 million in 2012) for teaching faculty and research in the areas of energy, ICT and transportation. Of these funds, SEK 5 million goes to partners and for the co-ordination responsibility for the Strategic Research Area “The Next Generation Information and Communications Technology” (SRA ICT TNG). Subsequently, these investments have led to an increase in operating costs.

In order to enhance learning and research outcomes even further, we have strengthened the school’s lab environment with three new facilities during 2012–2013. We invested SEK 3.2 million in three new labs: Smart mobility, 3D printing and the ACCESS communication lab.

RESULTS AND GOVERNMENT CAPITAL 2007–2013 (SEK MILLIONS)

INCOME 2010–2013 (SEK MILLIONS)
STAFF: EXCEPTIONAL GROWTH AND A STRONGER FACULTY

Since the establishment of the school, the staff at the KTH Royal Institute of Technology School of Engineering has grown exceptionally. In seven years the staff has increased by nearly 60 per cent, to 441 full-time employments in 2013, from 284 in 2007.

The largest staff growth was in teaching faculty and doctoral students during the period 2007 to 2013. Over the last seven years teaching faculty has doubled (50 per cent) and the number of doctoral students has increased by 60 per cent. This was due, in part, to greater demand for our research in general, which has attracted more external funding to the school.

Other factors were the increase during 2010–2014 in the government’s investment in strategic research areas and grants from the European Research Council to several researchers at the school. This has enabled us to recruit highly talented teachers and faculty, who in turn have been able to recruit more doctoral students.

As a result, the new faculty could recruit post docs and researchers, which is why research associates increased from 65 in 2012 to 78 in 2013. Meanwhile, there were a few retirements among the teaching faculty during 2013, which explains the decrease in this category during the period.

Growth in Teaching Faculty 2007—2013

- Teaching Faculty
- Research Associate

Faculty includes professors, associate professors, assistant professors. Researchers comprise senior researchers, researchers and post docs (30, out of which 25 are male, and five are female).

Teaching Faculty includes professors, associate professors, assistant professors. Research associates comprise senior researchers, researchers and post docs.

Number of Full-Time Staff

- Faculty and researchers
- Doctoral students
- Technical staff

Faculty includes professors, associate professors, assistant professors. Researchers comprise senior researchers, researchers and post docs (30, out of which 25 are male, and five are female).
BREAKDOWN OF FULL-TIME STAFF

- Technical and administrative staff: 53
- Faculty and researchers: 147
- Doctoral students: 242
- Researchers/research engineers: 242
- Postdoctoral students: 50
- Professors: 27
- Administrators: 28
- Associate professors: 10
- Assistant professors: 11
- Technicians: 30
- Postdoctoral students (including 86 doctoral students funded by grants and corporate support): 30
- Professors: 14
- Examination facilitators: 14
- Total: 441

MORE FEMALE DOCTORAL STUDENTS

Along with the increase in new faculty, the number of doctoral students has also steadily risen, by 60 per cent since 2007 (12.5 per cent increase 2013), with the increase in female students particularly noticeable over the past three years. Of 61 newly-admitted doctoral students in 2013, 21 per cent (13) are women, compared to 26 per cent in 2012 (14 of 54 admitted students) and 19 per cent in 2011 (6 of 32 admitted students).
HIGH QUALITY PROGRAMMES AND INCREASING APPLICANTS

It has been a successful year for programmes at the KTH Royal Institute of Technology School of Electrical Engineering. The applications per place in both the international master’s programme and the Master’s of Science degree programme in Electrical Engineering have increased significantly. At the same time, the programmes performed well in a major national evaluation.

**Courses and Programmes Offered by the School**

The School of Electrical Engineering educates engineers and master’s students in electrical engineering. We offer one Master’s of Science degree programme in Electrical Engineering and five international master’s programmes. Students in the Master’s of Science degree programme in Electrical Engineering study a five-year programme based on a 3+2 system, where the first three years consist of a bachelor’s programme and the last two years consist of a master’s programme.

In addition to the graduate engineering programmes and the five master’s programmes, the School of Electrical Engineering is involved in an Erasmus Mundus programme and two European Institute of Innovation and Technology (EIT) programmes.

**More Applicants**

Historically, the Master’s of Science degree programme in Electrical Engineering has had a very large number of applicants, but in the last seven to eight years, the program has had around 70 first-hand applicants for 40–65 places offered on the programme. In 2013, this figure rose to 110 applicants (11 of whom were women), an increase of nearly 60 per cent over the year before. It remains to be seen whether this is a coincidence or evidence of increased interest in the programme. The goal of the programme is to eventually bring in 90 students and have a minimum of two applicants per place. Today, as previously, the programme has found it difficult to attract women, which is a trend we need to reverse. The initial target is that by 2014 some 20 per cent of applicants to the programme will be women.

In 2013, the Swedish Higher Education Authority (UKÄ) evaluated the Master’s of Science degree programme in Electrical Engineering and master’s programmes in electrical engineering. Both programmes were judged to be high quality.
“Naturally we are happy,” says Joakim Lilliesköld, Director of Undergraduate Education. “We work both intensely and continuously on the programme content to increase student completion and meet the demands of the labour market. This shows that the work has had a good effect. However, we will continue to develop the programmes and degree projects further. We will not be satisfied until we get the judgement ‘very high quality’.”

The evaluation was carried out by external experts, including subject matter experts, students and working life representatives. The basis of their assessments included the students’ degree projects, the seat of learning’s self-evaluation, as well as group interviews with the students.

In recent years, one of the hottest issues concerning education in Sweden has been the introduction of tuition fees for non-European students who do not participate in any exchange agreements. Tuition fees were introduced in 2011 and the School of Electrical Engineering suffered a decline in applicants. But the school has recovered faster than expected. In just two years, virtually as many international beginners were registered to the master’s programme as before, even though the number of applicants fell. The strong recovery and continued positive trend looks set to continue in the coming years.

**EXCHANGE AGREEMENTS IN A STATE OF FLUX**

Exhaustive work has been carried out to review student exchange agreements, and during the year many agreements with our partner universities have been extended. The active work with prominent universities in Spain and France continues. Spanish universities have undergone a major education reform, where the structure of the engineering education has changed and is now divided into graduate and master’s levels. All double diploma agreements with Spanish universities will be rewritten in order to retain the unique collaboration agreements at the school.

During the year we received nearly 150 exchange students, which is slightly more than the year before. Most of these came from France, China, Germany, Switzerland, Spain and Portugal. We have also been able to offer 30 students so-called double diploma places, where they get two Master of Science degrees – from their home university and from KTH. The majority of these students come from L’Ecole Supérieure d’Électricité (Supélec), France and Universidad Politécnica de Madrid, Spain (a complete list of partner universities follows below).

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**DOUBLE-DEGREE COOPERATION AGREEMENTS**

- École Centrale de Lille
- École Centrale Paris
- École Polytechnique
- Grenoble INP
- Keio University
- Politecnico di Milano
- Politecnico di Torino
- RWTH Aachen University
- Supélec
- Technische Universität Darmstadt
- Tohoku University
- Universitat Politècnica de Catalunya, BarcelonaTech
- Universidad Politécnica de Madrid

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EXECUTIVE COMMITTEE PARTICIPANTS

8) Stefan Östlund
Dean and Chair

6) Joakim Lilliesköld
Director of Undergraduate Education

1) Mikael Skoglund
Vice Dean

3) Lise-Lotte Wahlberg
Head of Administration

7) Agneta Rune
Head of Finance

HEAD OF DEPARTMENTS

Bo Wahlberg
Automatic Control
(not pictured)

Hans-Peter Nee
Electrical Energy Conversion (not pictured)

Göran Stemme
Micro and Nanosystems (not pictured)

10) Gunnar Karlsson
Communication Networks

2) Rajeev Thottappillil
Electromagnetic Engineering

4) Peter Händel
Signal Processing

5) Tomas Karlsson
Space and Plasma Physics

11) Pontus Johnson
Industrial Information and Control Systems

1) Mikael Skoglund
Communication Theory

9) Lennart Söder
Electric Power Systems

Håkan Hjalmarsson
Director of Graduate Education (not pictured)
STRATEGIC ADVISORY COUNCIL

7) Stefan Östlund  
Dean

4) Rajeev Thottappillil  
Teacher

15) Sofia Bergström  
Representative graduate studies

17) Carl-Michael Zetterling  
KTH ICT

12) Sofia Bergström,  
President of the Electrical Engineering Section of the Student Union

3) Viktoria Fodor  
Teacher

13) Håkan Ferm  
Administrative personnel

Sara Mazer  
Head of Research, Ericsson AB  
(Not pictured)

16) Joakim Lilliesköld  
Director of Undergraduate studies

11) Nickolay Ivchenko  
Teacher

2) Richard Scharff  
Representative doctoral studies

6) Magnus Olofsson  
CEO Elforsk

14) Sophia Hober,  
Dean of Faculty – KTH’s representative

10) Armin Weckman  
Vice Representative doctoral studies

8) Mikael Skoglund  
Vice Dean

9) Göran Stemme  
Teacher

5) Ludvig Åkerman  
Representative graduate studies

14) Sofia Bergström,  
President of the electrical engineering section of the student union
With 123 master’s theses, 32 doctoral theses and 14 licentiate thesis in 11 areas, from communication theory and networks to electrical energy conversion and space and plasma physics, the KTH Royal Institute of Technology School of Electrical Engineering is committed to pushing the limits of human knowledge and maintaining its position as a world-class educational institution.
DOCTORAL THERSES

Automatic Control

Nordling, T., Robust inference of gene regulatory networks

Communication Networks

Wang, L., Cooperative and Cognitive Communication in Wireless Networks

Communication Theory

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