Preventing power gridlock

Professor Martin Maier leads a strategic project to investigate the implementation of fibre-wireless networks for efficient, integrated power grids. In an interesting conversation, he summarises the context and overarching aims of his research

Could you expand upon your project's aim of developing advanced fibre-wireless (FiWi) broadband access network solutions supplemented by fibre optic and wireless sensors? Why are you looking to learn lessons from the development of the internet?

Our Natural Sciences and Engineering Research Council of Canada (NSERC) strategic project aims at solving the problems and addressing the challenges arising from integrating the three different sectors of communications, energy and transport. More specifically, the resultant FiWi access sensor networks and proposed communications paradigms will enable the support and control of decentralised renewable energy sources, eMobility and future power grid technologies.

The research activities also explore different pay-as-you-grow migration paths to implement the proposed smart grid communications infrastructure and study business models that differ in terms of network ownership, network operation and service provisioning in order to foster competition among network and service providers, and thus drastically reduce costs. We are particularly interested in better understanding the analogies between the smart grid and the internet, given that the former is often referred to as 'a system of systems' while the latter is defined as 'a network of networks'.

What are the roles of Professors Geza Joos from McGill University and Hussein Mouftah based at the University of Ottawa in the project? How are your collective skills utilised?

Professor Joos is an internationally recognised expert in smart power grids with a particular focus on the integration of distributed generation, mostly based on renewable energy, into power distribution networks. Professor Mouftah is a worldwide leading expert in the area of optical and wireless networks, including wireless heterogeneous sensor networks.

To tackle the involved challenges of interdisciplinary smart grid research from both power and communications perspectives, leveraging the complementary skills of all three collaborators is of paramount importance in order to come up with holistic solutions.

What does the term Third Industrial Revolution (TIR), coined by Jeremy Rifkin, mean and could you offer examples of how it has been implemented in early-adopting countries such as Germany and France?

TIR goes well beyond current austerity measures and has been officially endorsed by the European Commission as an economic growth roadmap toward a competitive low carbon society by 2050. It has been receiving an increasing amount of attention by other key players, eg. the Government of China most recently. Early-adopting examples include Germany's E-Mobility project involving BMW, Daimler, Volkswagen and other key players, as well as France's first positive-energy Green Office project developed by Bouygues at competitive prices.

How does the vision of your think tank Lee Chi Networks differ from that of Jeremy Rifkin?

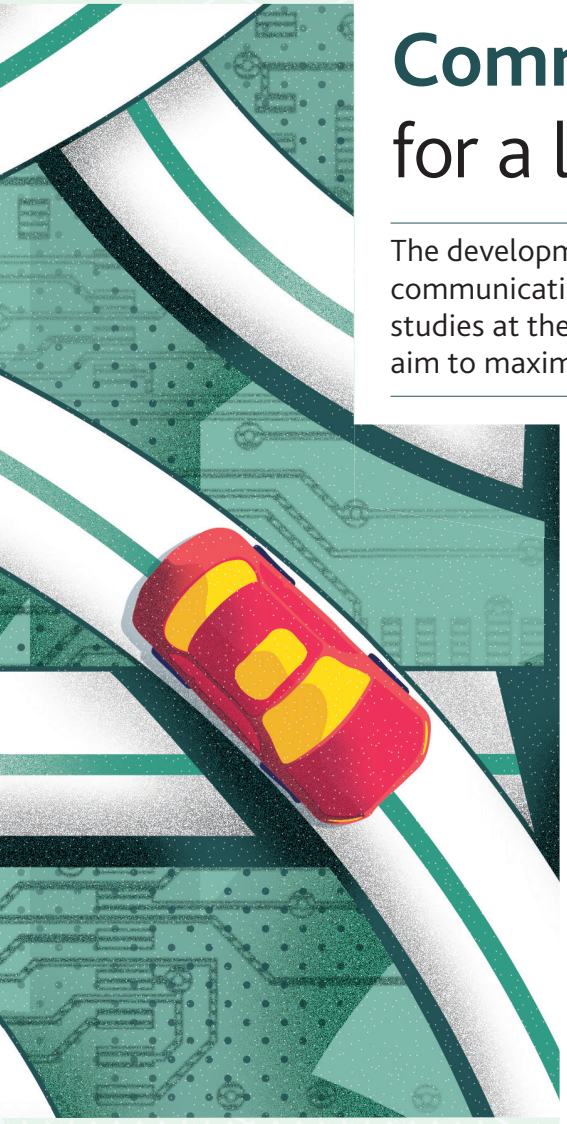
Lee Chi Networks' starting point is a recent framework for strategic thinking about the future by identifying critical trends, potential discontinuities, disruptive technologies and their implications that will shape the world in 2030. It is our belief that FiWi will play a key role in the convergence of the internet, energy and transport.

The future of a sustainable low carbon society based on a highly dependable smart grid communications infrastructure faces major hurdles relating mainly to business. What are the reasons for this bottleneck?

At present, there exists a plethora of communications technologies for the first/last mile to connect home gateways/smart meters to the smart grid, all of them trying to play a role in the smart grid market. Each of these communications technologies exhibits specific merits and drawbacks for various smart grid applications. Similarly, a huge body of advanced techniques exist to render converged FiWi broadband access networks dependable. These technologies and techniques are readily available and can be used to realise smart

Communications for a low carbon society

The development of more efficient energy usage requires advanced communications networks to monitor energy supply and demand. Innovative studies at the **Institut national de la recherche scientifique** in Montreal, Canada, aim to maximise the capacity of next-generation power distribution networks



grids and thereby enable emerging smart cities. Thus, the bottleneck is not technology, but rather a lack of regulation and innovative multitier business models for the installation of smart grid communications infrastructures based on a small number of future-proof communications technologies of choice.

Most of your project's budget has been devoted to supporting new students, including undergraduates. Why do you regard young researchers as being essential to achieving the project's objectives?

The education of the next generation of researchers and engineers is at the heart of NSERC strategic projects in general, which address mid- to long-term research topics of increasing importance within the next five to 10 years. The involvement of both undergraduate and graduate students in our aforementioned strategic project prepares them for emerging markets and future research opportunities. Upon graduation they are expected to have a competitive edge over other students, which will help them in their job search and novel research endeavours.

IT IS ESTIMATED that there will be a 75 per cent rise in power usage between 2010 and 2020, creating additional strain on diminishing fossil fuel reserves and further increasing greenhouse gas emissions. To reduce the resultant toxic environmental impact, there is expected to be growth in 'green' initiatives. This would include the use of plug-in electric vehicles (PEVs), leading to a surge in local electricity demand; and increased distributed energy resources (DERs), whereby homes generate their own electricity (known as microgeneration) using renewable energy sources, creating extra electricity supply in certain neighbourhoods.

Current electricity grids are not capable of supporting future fluctuating supply and demand. Hence, newer technologies are evolving to supplement traditional power grids, allowing energy to be used more efficiently. Smaller scale, local grids similar to centralised power grids, but more self-sustainable and self-regulating, smart microgrid technologies aim to facilitate this greener energy future. Such technologies could act in concert with centralised power grids and provide a power reserve in case of high electricity demand, reducing the national electricity demand during peak periods and the occurrence of blackouts.

FIBRE-WIRELESS NETWORKS

Professor Martin Maier and his research group from the Institut national de la recherche scientifique (INRS) in Montreal, Canada, are hoping their invesitgations will enable them to realise innovative green communications paradigms with the intent of ushering in a future of eMobility and smart microgrids. Previous studies of green communication networks focused solely on reducing the energy consumption and greenhouse gas emissions emanating from the networks themselves, but Maier believes such an approach is far from ideal: "The achievable reduction of greenhouse gas emissions is inherently negligible in comparison with other economic sectors, most notably energy and transport".

Instead, Maier has proposed the development of a system that allows cross-communication between all of these sectors. In Maier's own words: "The emergent cyberphysical systems, of which smart power microgrids and eMobility are important examples, hold great promise to usher in a more sustainable low carbon society".

SENSING CHANGE

Central to the proposed system is the creation of sustainable and holistic fibre-wireless (FiWi) broadband access network solutions enhanced with advanced fibre optic and wireless sensors. Realising FiWi – a term coined by Maier's group – networks relies on the development of next-generation passive optical networks (NG-PONs) and wireless local area networks (WLANs). Compared to traditional PONs, NG-PONs have increased capacity and range, as well as number of wavelength channels and optical network units (which convert optical signals to electronic ones, for example in users' homes). WLANs are ideal due to their properties of being data-centric and high-throughput. But key challenges remain: "Despite their obvious benefits, a number of open research questions exist to unify coverage-centric 4G LTE-A networks and capacity-centric FiWi broadband access networks based on simple, low-cost data-centric Ethernet technologies," highlights Maier.

In the envisioned scheme, fibre-optic sensors for temperature, voltage, current and sound would be placed in neighbourhood area networks and wireless sensor networks placed in each home for monitoring and communicating energy needs in a particular neighbourhood. This FiWi-enabled microgrid setup would detect changes in energy supply and demand, reducing the overall amount of energy required and thus lowering the carbon footprint of the area.

NETWORK OF PARTNERSHIP

The National Science and Engineering Research Council of Canada (NSERC) funds Maier's three-year strategic project 'Fiber-wireless access sensor networks and new communications paradigms for a future low carbon society of e-mobility and smart microgrids', which aims at realising FiWi's promise. The project has support in the form of technologies and employees of the industrial organisations Hydro-Québec and MPB communications, among others. These partnerships provide opportunities for creating important links with industry and enable the implementation of results generated from the work.

FIBER-WIRELESS ACCESS SENSOR NETWORKS AND NEW COMMUNICATIONS PARADIGMS FOR A FUTURE LOW CARBON SOCIETY OF E-MOBILITY AND SMART MICROGRIDS

OBJECTIVE

To unleash the full potential of next-generation power distribution networks through the development of advanced fibre-wireless (FiWi) broadband access network solutions supplemented by fibre-optic and wireless sensors.

KEY PARTNERS AND COLLABORATORS

Professor Geza Joos, McGill University • **Professor Hussein Mouftah**, University of Ottawa • **Louis Lamarche**, Hydro-Québec – Institut de recherche (IREQ) • **Emile Haddad**, MPB Communications Inc.

FUNDING

Natural Sciences and Engineering Research Council of Canada (NSERC)

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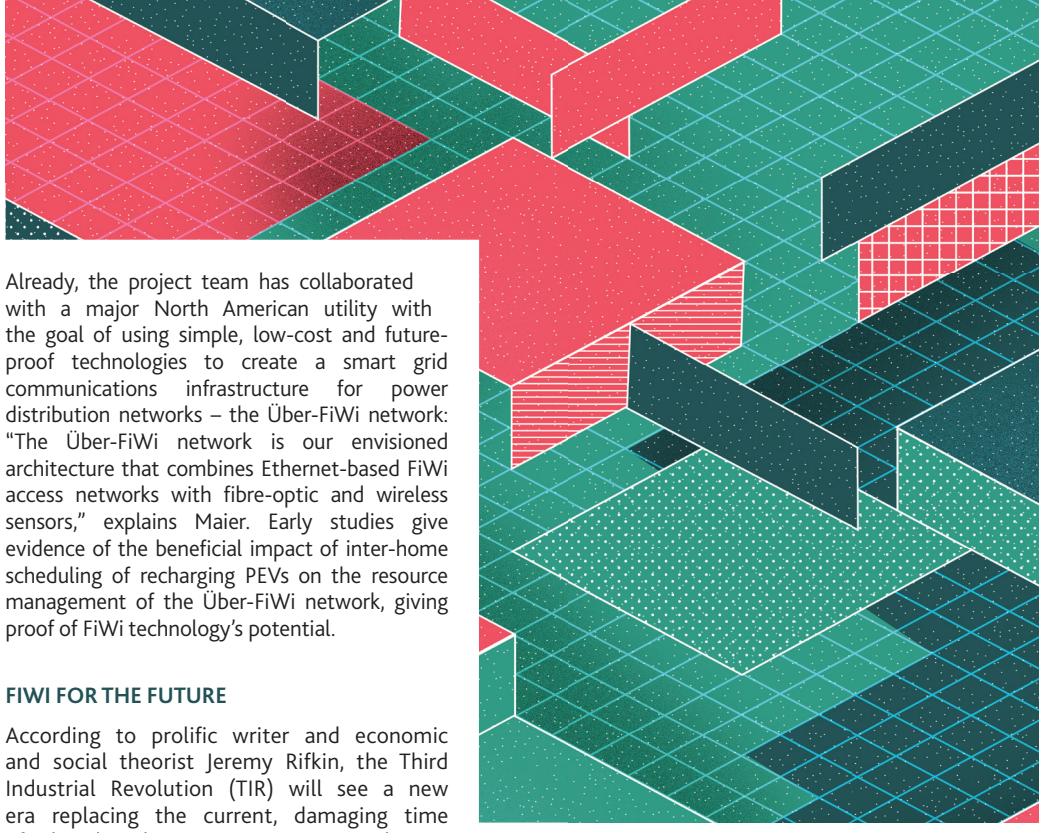
MARTIN MAIER is Full Professor at INRS, Montreal, Canada. He joined INRS as Associate Professor in May 2005, after having received MSc and PhD degrees both with distinctions (summa cum laude) in Electrical Engineering from the Technical University Berlin, Germany, in 1998 and 2003, respectively, as well as completing several postdoctoral positions. He has served as a reviewer for numerous major journals and conferences, book proposals and research grant applications, and has been appointed as an independent expert by the European Commission. Alongside these achievements, he is Founder and Creative Director of the Optical Zeitgeist Laboratory and Founder of the think tank Lee Chi Networks.



Already, the project team has collaborated with a major North American utility with the goal of using simple, low-cost and future-proof technologies to create a smart grid communications infrastructure for power distribution networks – the Über-FiWi network: "The Über-FiWi network is our envisioned architecture that combines Ethernet-based FiWi access networks with fibre-optic and wireless sensors," explains Maier. Early studies give evidence of the beneficial impact of inter-home scheduling of recharging PEVs on the resource management of the Über-FiWi network, giving proof of FiWi technology's potential.

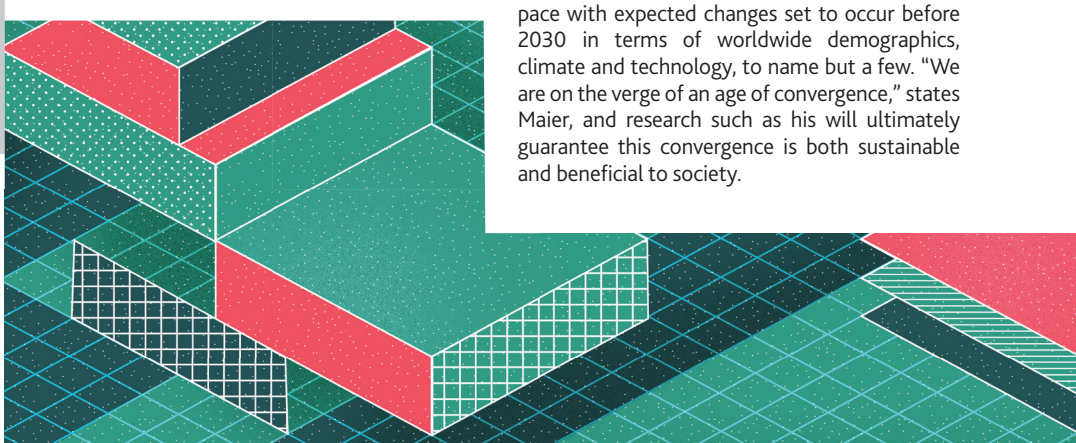
FIWI FOR THE FUTURE

According to prolific writer and economic and social theorist Jeremy Rifkin, the Third Industrial Revolution (TIR) will see a new era replacing the current, damaging time of oil and coal to create a greener and more sustainable world where energy is produced renewably in homes, streets and workplaces, and shared similarly to how data are shared on the internet. The TIR will be built on five pillars: renewable energies, positive-energy buildings, energy storage technologies, electric vehicles and the energy internet. The final pillar – the energy internet – will bring in Maier's research on FiWi networks and smart microgrids, thus representing a key component of the infrastructure of the TIR economy.

Maier has set up the cross-disciplinary think tank Lee Chi Networks that complements Rifkin's vision and helps set out and prepare for future global challenges: "Lee Chi Networks aims at unleashing the full potential of bimodal FiWi access networks to reduce the complexity of future converged communications networks," he outlines. "Unlike Rifkin, our vision is not limited to the convergence of the internet, energy and transport, but also takes into account future key technologies, eg. domestic robots, and explores ways of integrating them with FiWi from a technological rather than economic angle."

The Organisation for Economic Co-operation and Development (OECD), which supports projects that will improve international economic and social wellbeing, believes that broadband access networks, such as Maier's FiWi networks, potentiate new businesses, products, inventions and improved goods and services. Such technology may fundamentally change how and where economic activity operates. For example: "The dematerialisation of products (eg. digital photos, books, etc.) but also the rematerialisation of digital possessions via 3D printing will become increasingly popular," suggests Maier. This method of 'rematerialisation' will enable further efficiency of product production due to reduction of wastage, energy and therefore cost; because 3D printing is an additive manufacturing process as opposed to a traditional subtractive one (where the product is cut out of the raw material, leaving a lot of wastage). A shift to additive manufacturing is a perfect example of the benefits of material goods production via networked energy and communications systems.

Lee Chi Networks investigates unforeseen applications and services as well as creating minimalist guidelines for the design of novel networking concepts and enabling technologies in association with the Optical Zeitgeist Laboratory. By testing out novel technologies and services, Maier aims to ensure that developments keep pace with expected changes set to occur before 2030 in terms of worldwide demographics, climate and technology, to name but a few. "We are on the verge of an age of convergence," states Maier, and research such as his will ultimately guarantee this convergence is both sustainable and beneficial to society.



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