



Optimisation in electrical power networks

TakeAIM Winner 2014:
Eoin Devane

Institution:
University of Cambridge
DAMTP
Centre for Mathematical
Sciences, Wilberforce Road,
Cambridge CB3 0WA

In our technological world, demand for electrical power is greater than ever before. At the same time, power network structures are becoming more complex, through the increasing variety of energy sources and loads, the proliferation of distributed generation, and the advent of the smart grid. Within this rapidly developing setting, understanding the underlying mathematical problems is vital to the successful operation of our power grid.

One interesting problem is to determine the Optimal Power Flow (OPF) in a network. The OPF describes the generation schedules and voltage levels that minimise the total cost of power generation while satisfying the required power loads and physical operation constraints. Since today's power networks are often organised in a decentralised structure, with rival operators controlling disjoint components of the network, it is desirable to be able to solve the OPF problem in a distributed manner whereby these competitors are not required to share crucial internal operational details. Within my research I have investigated how distributed optimisation schemes may be modified to yield a solution to this problem that can be obtained efficiently, minimises the necessary information exchange, and offers guaranteed convergence to optimality.

Such distributed approaches could be important in future power grids both for producers to operate profitably and for consumers to receive the electricity they require. Furthermore, the schemes considered are based upon dynamically updated price variables for the electricity transfer between regions, raising the possibility of incorporating them within market mechanisms to allow for optimal system operation within a competitive marketplace.

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The use of mathematics has profound consequences in all walks of life, but the opportunities that it opens up often go unrecognised or underexploited. The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the fourth annual TakeAIM competition in 2014 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to all undergraduate and postgraduate students working in the mathematical sciences. The author of the best entry received £1,000 of Apple vouchers as his prize, with £500 of Apple vouchers being awarded to authors of the four entries that tied for second place.