



Anarchy in the Power Grid

TakeAIM 2019 Runner-Up:

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The use of renewable sources of power in the UK has soared from 2.6% to 33% between 2000 and 2019, driven by the increasingly urgent need to mitigate pollution and climate change. This trend is set continue in line with government initiatives and subsidies.

This rapid shift in the nature of electricity production is causing an overhaul in the structure and dynamics of power grids. Traditional sources of energy - large, centrally located fossil-fuel power plants - are being superseded by much smaller, intermittent sources distributed throughout the grid. Increasingly, households are no longer simply passive consumers of power, but active participants in power production, equipped with photovoltaics, wind generators, batteries, smart meters and the ability to supply surplus energy to other households.

Our research shows how this more dynamic, responsive and distributed structure impacts the grid's efficiency and it's resilience to catastrophic failures such as blackouts. We use the Price of Anarchy, a game-theoretic measure of the inefficiency caused by selfish behaviour, to gauge the inherent redundancy in distributed grids. Computational models, incorporating the nonlinear dynamics of power flow in complex networks, reveal precisely how efficiency and resilience depend on the proportions of producers and consumers of power within power grids.

Working with real world power grid networks, and minute-by-minute power consumption data from UK households, the models aim to inform network controllers how to exploit the distributed nature of the grid to boost resilience and efficiency, helping ensure stable and affordable clean energy for consumers.

The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2019 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to undergraduate and postgraduate students working in the mathematical sciences. First prize was £1,000 of Apple or Amazon vouchers, with second prize winners receiving £200 and 8 runners-up receiving £25 in their choice vouchers.

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