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Explainer: how does the electricity grid work?

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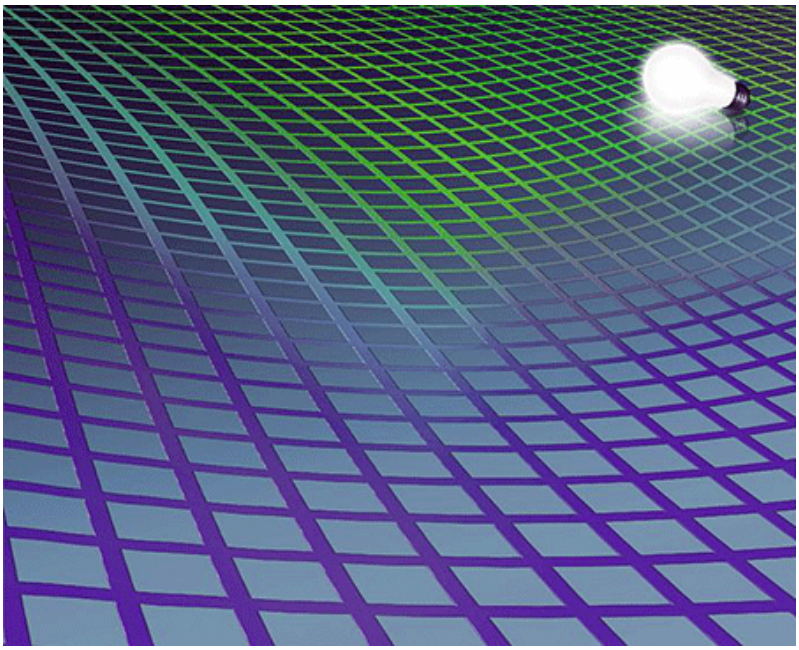
Where would we be without electricity? Assuming that you own a fridge, there won't be many points in your life when you aren't making use of it. But what do we mean when we talk about the electricity grid?



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The grid itself is less of a physical location. Instead, it is a term typically used to describe the three main players involved in the supply of electricity; generators, distributors or transmitters, and retailers.

Let's take a look at each in turn.

The three main players

It all starts with generation.

In Australia, primary sources of energy, such as the sun and wind, are increasingly being used to produce electricity. But, when Australians boiled the kettle to make tea this morning, approximately 90 per cent of the electricity used was generated at a power station by burning coal or gas.

Next step, transmission.

When you flick the kettle's switch, electricity travels along a conductor and straight to your appliance close to the speed of light. Although this occurs instantaneously, it is preceded by a sequence of events.

A transformer converts the electricity, produced at a generation plant, from low to high voltage to enable it to be

transported efficiently on the transmission system, where it travels long distances from the power station to the suburbs we live in.

This part of the grid is very public. You've probably seen the poles and wires so many times now that you've stopped noticing them.

When the high voltage electricity arrives near the location where it is required, a substation transformer will change it to low voltage before carrying it along the distribution lines to individual consumers, who can then access it with the flick of a switch.

The third major player in the electricity grid is the retailer.

This is the middle man who buys wholesale electricity from generators and then sells it to you, sending you a bill every quarter.

National Electricity Market

For an example of where this all comes together, let's look at the National Electricity Market (NEM), which operates the world's longest interconnected power system.

As electricity supply must be closely matched to demand, the NEM uses sophisticated systems to send signals to generators, telling them how much energy to produce every few minutes.

Such control requires careful forecasting of the electricity demand, as well as the generation that will be available.

The job becomes even harder with generation from variable sources, like solar and wind, into the mix.

Once generated, electricity supply is traded much like shares on a stock market – the market operator indicates the demand for a particular time, and generators compete on price to meet that demand.

If demand exceeds supply, prices increase, and vice versa.

Grid losses and rising costs

The grid system is not without its challenges, not least of which is the enormous amount of wasted energy.

Consider this. A typical coal-fired power station loses (or wastes) almost 70 per cent of the energy that goes into it, when converting the energy in coal to electricity, and up to a further 10 per cent is lost during the transmission and distribution stage. An old-fashioned light bulb then loses 98 per cent of this energy to make light.

So we only end up using about half a per cent of the total energy that we started off with. The rest is wasted.

Hot-water systems aren't much better.

In this case, we burn coal to make hot water (or steam), convert this to electricity, and then convert the electricity back to hot water in the house. Along the way, we incur a bunch of losses, and only end up with about 27 per cent of the energy that we started off with.

The real elephant in the room, however, is the issue of affordability.

Retail electricity prices have increased by roughly 60 per cent since 2007. The causes are complex and differ by state, but the replacement and refurbishment of infrastructure (essentially, these are the poles and wires), compliance with reliability licence conditions, and the building of new infrastructure to cater to peak demand played the largest role.

It is the latter that lies at the heart of the problem.

Peak demand typically occurs during heat waves and cold snaps, when three-quarters of all Australian households with air-conditioning turn on these appliances to get some respite from the elements.

Sounds sensible, right? Think again.

Ausgrid, a major electricity distributor, has estimated that $11 billion worth of network infrastructure in the NEM is used for just 100 hours per year (about one per cent of the total) to meet periods of peak demand.

That's like building an extra eight lanes on the Sydney Harbour Bridge just to cater for the worst peak hours of the year.

Is there a solution?

One proposal for combating affordability is to introduce different electricity prices for different time periods of usage. This is known as cost reflective pricing.

While not everyone may be able, or want, to make significant changes to the times when they use electricity, introducing such a scheme should at least allow consumers to make more informed decisions.

A major transformation in the Australian energy landscape, and one that poses a challenge for the traditional grid, is happening right outside your window.

Households are becoming energy generators, with one in ten Australian homes having installed solar panels. Consumers are now pushing power back the other way and, although this is an overwhelmingly positive thing, the amount of electricity that will be generated by these households can be as difficult to predict as the weather itself.

Decision time

Reducing peak demand, allowing renewable energy, and maintaining reliability are all possible. But, we need to make some challenging decisions about how the grid should operate in the future, and how we'll pay for it.

As part of the Future Grid Forum, CSIRO is working with the industry and government to ensure that when Australians boil the kettle in 2050, we are using electricity generated from the most cost-competitive, low-emission energy sources possible.

Restoring the productivity of our electricity system won't reduce prices overnight, but it will lay the foundation for a cost-competitive energy system in the future.

This article is part of CSIRO's Let's Talk About Energy campaign, which is a conversation about Australia's energy future. Glenn Platt leads the CSIRO Energy Transformed Flagship's research in energy efficiency, demand management and smart grids as Theme leader for Local Energy Systems. His team is developing techniques to integrate more renewable energy sources into Australia's electricity system, as well as technologies and strategies to modernise the national grid, manage demand peaks and meet future electricity needs. This article was originally published at The Conversation.

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