Exploring solutions to South Africa's electricity crisis

As part of its focused research in the field of energy, the University is proud to have a number of acknowledged industry leaders who are engaged in studies across a variety of disciplines to address the energy crisis that is facing South Africa.

One of these specialists who is widely recognised for his expertise in this field is Prof Xiaohua Xia, Director of the Centre of New Energy Systems (CNES) and the National Hub for Postgraduate Programme in Energy Efficiency and Demand-side Management (EEDSM).

A topic of particular relevance, especially within the scenario of load shedding that affects both individuals and businesses, and impacts on the economy, is alleviating the pressure on the national power grid.

As part of the UP Expert Lecture Series, Prof Xia explored the value of EEDSM in addressing this challenge.

EEDSM programmes cover the broad categories of conservation, load management, fuel switching, strategic load growth and self-generation.

So far, EEDSM has saved the country more than 4 000 MW, which is the amount of power Eskom needs to save in its Stage 3 load shedding.

When it comes to power supply, the electricity grid can only be stable if there is a balance between supply and demand. When the grid is unbalanced, there are two options for restoring balance. The first is to increase the supply, such as building new power stations. The second is to decrease demand, such as encouraging consumers to switch off appliances or switching to renewable energy sources. As the construction of new power capacity has been experiencing delays, and is unlikely to contribute to the grid in the short run, it is vitally important to find other short- to medium-term solutions to the energy crisis.

During the Expert Lecture, Prof Xia explored the feasibility of a few of these options. In evaluating energy alternatives, it is important to consider time frames, initial capital investment, maintenance and operation costs, as well as potential energy savings.

Load shedding is probably the least popular option for decreasing energy demand from the consumer's point of view. However, it does not require any capital investment and can be implemented immediately. Although load shedding is able to save between 1 000 and 4 000 MW, it is not a very affordable option, as Eskom and other companies will lose revenue.

Smart meters for pool pumps and geysers function in a similar way to load shedding. The idea is that these meters switch off pool pumps and geysers during the day. In order to save 4 000 MW, these meters would have to be installed in at least 10 million households, which can take years to achieve.

The capital investment is also substantial. The benefit, however, is a very low operational cost.

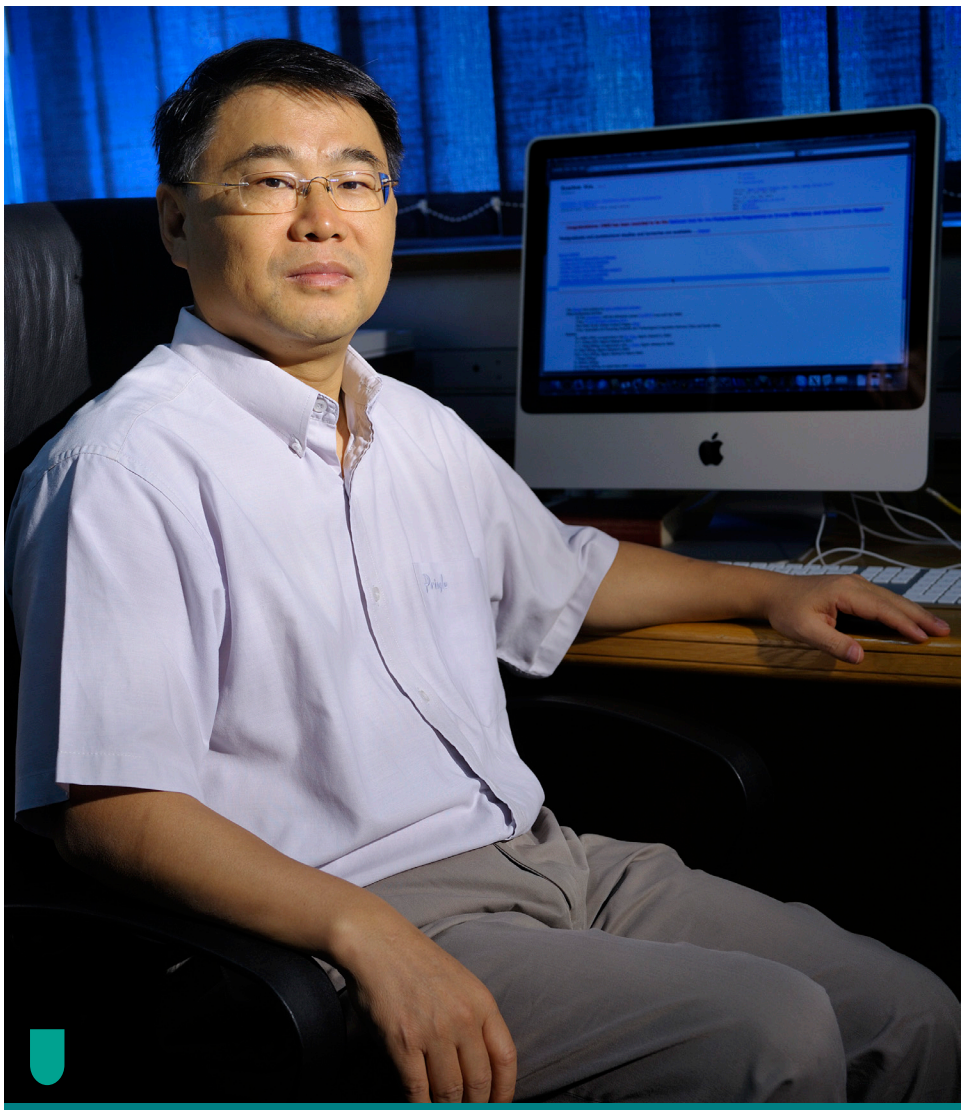
According to Eskom, 40% of electricity consumed by South Africa's residential sector is used for heating water and 31% for operating kitchenware such as ovens, stoves and hot plates. An Eskom report states that the residential sector used 14 105 MW of Eskom's output in 2013, while other sectors used an aggregated 25 160 MW. Currently, the demand for heat in South Africa is met largely by electricity. However, conversion efficiency from coal to electricity and then to heat is much lower than direct conversion from coal or gas to heat. Coal gasification plants are able to reach conversion efficiencies from coal to heat of around 75%, and from coal to gas and then to electricity of around 40%, which is by far the most efficient technology to generate heat and electricity from coal. The cost of this process is less than half of Eskom's current EEDSM benchmark of R5 million/MW, and the operational cost is about a third that of a conventional power plant. In view of South Africa's large coal reserves, clean coal gasification technology offers a very attractive option.

Self-generation offers another short- to medium-term solution for South Africa's electricity crisis.

Systems such as photovoltaics, wind turbines, co-generation systems and gas-fired turbines to supply part or all of customers' needs (heat/power) will be a convenient way to reduce demand from the grid, and consequently alleviate grid pressure and reduce transmission losses. Co-generation systems installed in industrial plants that produce high temperature waste heat. Captive power plants that utilise biomass or gases are good examples of self-generation.

Solar water heating has a high capital investment of R30 million/MW, which is roughly the same as the Medupi power station. However, the operational costs are considerably lower. The time frame for implementation could be short or long, depending on the efficacy of implementation plans. Once these solar water heaters have been installed, they can be operational for at least 20 years. With solar heating being one of the best sources of renewable energy, a solar water heating programme was started in 2008 to switch fuel usage away from electricity and to promote the uptake of one million units of solar energy by 2015. The targeted saving of the solar water heating programme (miscalculated as equivalent to the generating capacity of an average-sized power plant) was not achieved.

EEDSM remains the best option to alleviate the current crisis. In future, we must focus more on fuel switching to satisfy heat demand, and on self-generation.



Prof Xiaohua Xia is the Director of the Centre of New Energy Systems and the Hub for Postgraduate Programme in Energy Efficiency and Demand-side Management at the University of Pretoria.

He obtained his PhD from the Beijing University of Aeronautics in China in 1989. He was an Alexander von Humboldt fellow of the University of Stuttgart in Germany, and a postdoctoral fellow of the Ecole Centrale de Nantes in France and the National University in Singapore. He joined the University of Pretoria in 1998 and became a professor in 2000.

His research interests include non-linear feedback control, observer design, time-delay systems, hybrid systems, modelling and control of HIV/Aids, the control and handling of heavy-haul trains, and energy modelling and optimisation.

Prof Xia is a professional engineer, registered with the Engineering Council of South Africa, a fellow of the Institute of Electrical and Electronics Engineers (IEEE) and a certified measurement and verification professional registered with the American Association of Energy Engineers.

Earlier in 2015, Prof Xia was appointed to the Ministerial Advisory Council on Energy (MACE), which comprises experts across the energy spectrum. He is serving a two-year term. The Council will be a non-statutory body and will be solely advisory in character. It will primarily focus on the coordination of national dialogue and the provision of cross-sectoral advice to the Minister on Energy on the strategic direction and policy development imperatives of the energy sector in South Africa.