PhD THESIS

THE UNIVERSITY of ADELAIDE

The Contribution of Complexity Theory in Resolving Energy Losses in Electrical Smart Grid Systems:

A Case Study of Electricity Supply and Use in Regional New South Wales – Australia

Thesis submitted by

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Statement of Originality

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Abstract

The PhD research addresses the longstanding and unresolved global problem of energy losses from electrical smart grid systems. In particular, it focuses on the potential for a productive new role for end users of electricity at the household level. The research provides a complex systems perspective in approaching this problem, which recognises the benefits of emergence and self-organisation by homeowners in understanding and seeking to contribute to the large networked power distribution system.

A case study use of power by 300 houses in NSW, Australia, is used to address the current inconsistencies between electricity tariff policies and stakeholders, and the lack of knowledge and methodology needed to resolve the phenomena of peak and off-peak demand of electricity, which together, create unfavourable energy losses. A further issue is the inequity of financial benefits for electricity grid power suppliers, retailers and end-users.

A study of homeowners' patterns of use of grid supplied power, of a sample of home owners, over a three year period, was conducted, with usage data at 30 minute intervals, The research used mathematical programming methods, including Python programming software. The resulting calculations are used to devise a model, drawing on complexity theory, which significantly mitigates against energy losses, both to the electricity generators and distributers, and to end users, by factoring in the new element of renewable energy sources.

The contribution to knowledge is primarily the reduction of peak power usage in the grid by reducing maxima by use of home generated power through solar and wind, supplemented by individual battery systems. The research also indicates the business benefits of such an approach.

The research provides a way forward for future research and for a sustainable energy sector, with significant benefits to energy suppliers, retailers and end users at the household level.