Australian National University

Anonymous examination report for candidate

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Examination report

The GNK value proposed by thesis and the new methods for stratified sampling are rigorously developed and of theoretical interest. These contributions are well presented with very good reviews of the relevant technical literature. My main concern is that although these contributions are interesting from a theoretical perspective, the practical benefits of the work, and the link to the current challenges facing power systems described in the Introduction, are not clearly articulated. However, I do believe the thesis represents a substantial and original contribution to knowledge and opens interesting avenues for future research.

The revisions are detailed below and are divided into “main corrections” and “minor corrections”.

Main Corrections:

- In Chapter 1, sections 1.1 to 1.4 describe important changes which power systems are undergoing and associated challenges. However, it is not clear how these motivate the research question and the problem approach described in Section 1.5. In particular, it is needs to be made more clear how the new electricity market mechanisms proposed by the thesis address specific challenges identified in Sections 1.1 to 1.4.
- Related to this, the title of the thesis “Investigation of Market Mechanisms for Distribution Level Energy Management” does not seem very well matched to the main research question and contributions. In particular, technical issues associated with distribution networks are not addressed, such as voltage constraints, reactive power flows, unbalanced lines, the need for large-scale coordination of distributed energy resources and the interactions between transmission and distribution. The title and introduction should be edited to address this mismatch.

- Chapter 2: “Some Background on Philosophy on Distributive Justice” has some significant areas omissions which need to be reviewed in detail.
    1. The unique properties of electricity markets imposed by physical realities associated with electrical power transmission.
    2. The significant literature on “energy justice”, which includes distributive justice as a component (see e.g. Jenkins, K., McCauley, D., Heffron, R., Stephan, H., and Rehner, R. (2016). Energy justice: A conceptual review. Energy Res. Soc. Sci. 11, 174–182.)
    3. The literature on energy poverty.
    4. Societal costs of greenhouse gas emissions.
- At the start of Chapter 4, the motivation for the GNK value in the context of power systems needs to be clarified. Although it is explained that the GNK includes aspects of the different solution concepts described in Chapter 3, it needs to be clarified why the GNK is expected to address the challenges associated with how electricity markets are changing.
- In Chapter 4 Section 4.5.1 it is mentioned that “The transactions under LMP and VCG are not necessarily budget-balanced and can yield a surplus or deficit”. For LMPs only the situation where a budget surplus occurs is discussed, and in Karaca, O., and Kamgarpour, M. (2020). Core-Selecting Mechanisms in Electricity Markets. IEEE Trans. Smart Grid 11, 2604–2614 it is stated “under DC-OPF exchange problems, the LMP mechanism is budget-balanced”.
- In Chapter 4, Section 4.5.1 it is mentioned that “The GNK value (but not VCG or LMP) can offset those that do not receive or generate power”. A negative aspect which is not discussed is that this could incentivise the construction of generation in locations where it is not valuable due to congestion.
- It is unclear why the M-GNK would be a good approximator of the GNK value. As mentioned, the concept of threat is central to the GNK but is not present in the M-GNK. The extent to which the values are similar is not very clear from Figure 4.11 where there are significant discrepancies for certain players. Moreover, Fig. 4.9 shows that the M-GNK results in negative post payment utility for generators, whereas this type of behaviour is not seen for the GNK in Fig. 4.2(c) (although this may be due to the number of participants). I believe additional analysis is required to justify why the M-GNK could be treated as a proxy for the GNK. This could be theoretical analysis, or empirical examples showing the extent to which the GNK and M-GNK exhibit similar behaviour.
- It is mentioned that the epsilon within the M-GNK equation in (4.25) should be a small positive value. However, it is unclear how a suitable value can be found, and how this value affects the M-GNK calculation if it is too high or too low.

Minor Corrections:

- The thesis should present the candidate’s individual contributions. Therefore, in Section 1.5.1 the contributions should be rephrased from using “we” to “I”. Throughout the thesis, “I” should be used instead of “we”, with contributions from others clearly identified.
- “Managment” in title should be “Management”.

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- A Nomenclature section should be added with definitions for all symbols.
- It seems like the subsection starting on page 134 should be 6.2 (currently ".1").
- In the introduction it is mentioned "one limitation of traditional generating technologies is that they are often unable to respond quickly to assist in the maintaining of system frequency". I believe this statement is overly broad and requires additional clarification with reference to synchronous generator speed control.
- A reference should be included for the definition of the term Prosumers when first introduced.
- The discussion on LMP budget-balance in section 3.2.2 (page 32) should distinguish between strong and weak budget balance.
- In Chapter 4 Section 4.5.1 it is mentioned that the discontinuities associated with the LMPs "might be seen to lead to a somewhat perverse incentive to produce less power than what is socially optimal". Some additional discussion on this point is warranted since the LMPs will incentivise socially optimal supply if generators are price-taking.
- Figure 4.5 requires additional explanation, particularly why there are different numbers of points at different network scales and what the trend line is showing.
- 4.7 to 4.9 require x, y and z axis labels with units. It also needs to be made clear what quantity the colour bar is associated with.
- Under (4.25) it is mentioned "here we assume all the DC power constraints apply in both argmax". However, this information should be made clear within (4.25) e.g. using suitable subscripts.
- Please check the k and j subscripts in equation (5.12).
- Revise sentence: "Note that the last three methods (Ney,Ney-W and SEBM*)…" in Setion 5.5 based on the list order.