Sustainability, Inclusiveness and Governance of Mini-Grids in Africa (SIGMA) Project

Mini-Grid Performance Analysis with DEA — Gram Oorja

INTRODUCTION AND PROBLEM STATEMENT

Performance analysis of mini-grids using data envelopment analysis (DEA) has been demonstrated in Bhattacharyya & Kerr (2023). This work applies this methodology, alongside an enhanced DEA methodology for sustainability analysis from Galán-Martín et al (2016), to determine an overall sustainability score for 21 mini-grids in India installed by Gram Oorja, a solar mini-grids company operating in India. Three dimensions of sustainability were considered to determine an overall score: economic, technical and social sustainability.

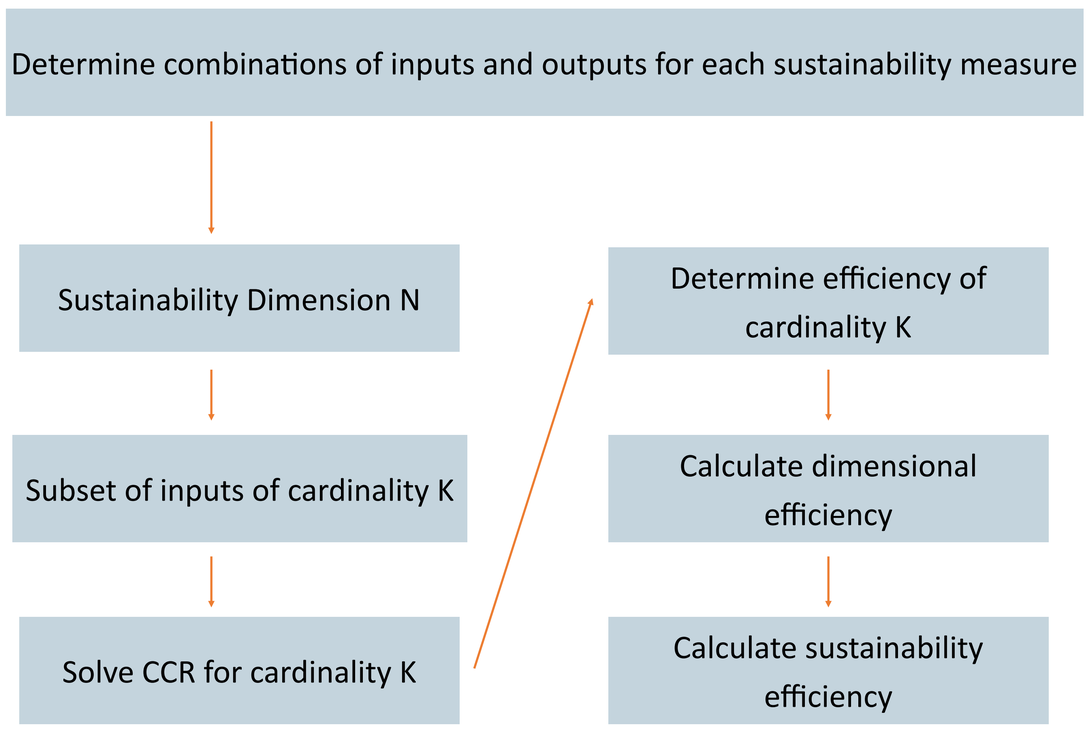
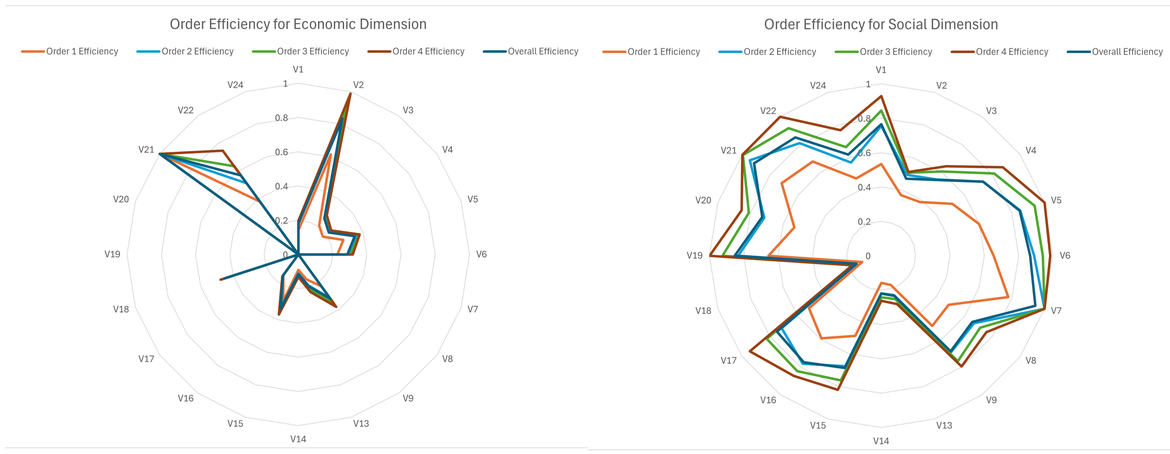


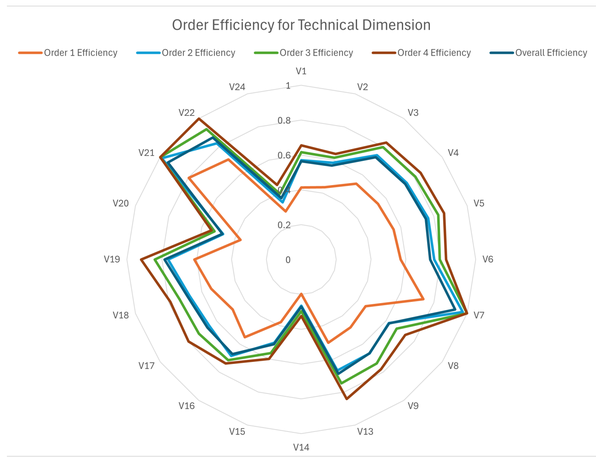
Fig. 1: Analysis Framework (Authors, Galán-Martín et al 2016)

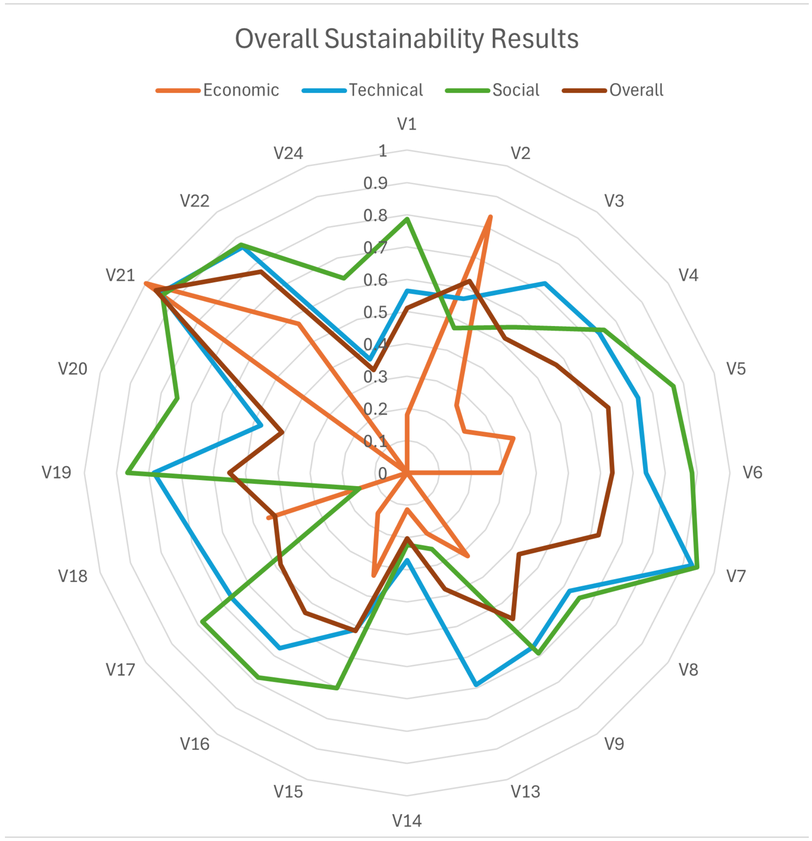
METHODOLOGY

Figure 1 shows the approach used in this work: to eliminate the need to calculate specific weights for each sustainability dimension, each measure was run through several iterations of the Charnes, Cooper & Rhodes (CCR) input-oriented DEA model, using different combinations of input parameters. For four input parameters (system cost per kWh installed, system age, battery capacity per capita and capacity per capita), each sustainability component was analysed for a single output representing that measure (user satisfaction for social, increased productive use for economic, and availability of appliance use for technical), for each order of efficiency of inputs. Mini-grids were said to be efficient overall if they were efficient at all orders of efficiency for inputs (single-input, dual-input etc.).

RESULTS







CONCLUSIONS

Overall, the Gram Oorja mini-grids analysed are performing best in social sustainability, with the majority of mini-grids ranking highly. Economic performance is by far the worst of the three dimensions, with only V2, V21 and V22 achieving reasonable efficiencies. Technical performance is overall high, but some mini-grids are performing notably worse. No mini-grid is operating at the efficiency frontier from this dataset. This analysis shows that economic dimensions need significant attention if mini-grid sustainability is to be achieved, but social outcomes are better than expected, reinforcing the importance of electrification for meeting social goals.

Bhattacharyya, S.C. & Kerr, D. (2024) Mini-Grid Performance Analysis using Data Envelopment Analysis. Sustainability, Inclusiveness and Governance of Mini-Grids in Africa (SIGMA) Project, Working Paper 4

Galán-Martín, A., Guillén-Gosálbez, G., Stamford, L. & Azapagic, A. (2016) Enhanced data envelopment analysis for sustainability assessment: A novel methodology and application to electricity technologies. Computers & Chemical Engineering, 90, pp. 188—200

Katre, A. & Tozzi, A. (2018) Assessing the Sustainability of Decentralized Renewable Energy Systems: A Comprehensive Framework with Analytical Methods. Sustainability, 10 (4), pp. 1058

Katre, A., Tozzi, A. & Bhattacharyya, S.C. (2019) Sustainability of community-owned mini-grids: evidence from India. Energy, Sustainability and Society, 9, article 2

Contact—Prof. Subhes Bhattacharyya, s.c.bhattacharyya@surrey.ac.uk

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