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***Abstract*—Nowadays, the growing integration of new industrial technologies into modern power systems (MPSs) such as distributed energy resources (DERs) such as various types of renewable energy sources (RESs), electric vehicles (EVs), and energy storage systems (ESSs), caused various adverse impacts that should be considered broadly. These technologies cause various deteriorations on the performance indices (PIs), e. g. voltage deviation and reverse power flows. Therefore, the hosting capacity (HC) concept is declared to ensure that integration is managed efficiently to accommodate them without any PI violations. Various research fields investigated HC technologies in terms of calculation methods, tools, enhancement techniques, etc. in several articles and books. However, the book entitled "Hosting Capacity for Smart Power Grids, Ahmed F. Zobaa, Shady H.E. Abdel Aleem et al. Springer, 1 2020", is the most recent prominent comprehensive reference for HC strategies in MPSs. Hence, this article proposes a book review and discussion of its most important contributions which helps the reader in realizing the recent developments in HC technologies based on this book's contents.**

Keywords*—*Hosting Capacity, Modern Power Systems, DERs, EVs, ESSs

I. INTRODUCTION

In recent times, there has been a significant rise in the integration of distributed energy resources (DERs) like diverse renewable energy sources (RESs), electric vehicles (EVs), and energy storage systems (ESSs) into modern power systems (MPSs). This surge brings about diverse adverse effects on the operational efficiency of MPSs, necessitating comprehensive consideration [1]. In this regard, the principle of hosting capacity (HC), as primarily originated with Math Bollen in 2004 [2], is utilized to specify the maximum DERs, EVs, and ESSs, that can be accommodated in the MPSs without deterioration on any performance indices (PIs), e.g. voltage deviation and reverse power flows, as depicted in Fig. 1.

The HC concept has several definitions according to peak load, RESs integration, and transform rating which are based on the investigated case and systems which are depicted in detail in [3]-[5]. However, in [3], the HC concept is generally defined as "Total DERs, and ESSs that can be accommodated on the MPS without any violation in various performance indices and exclusive of requiring network upgrades for MPSs, using limited communication infrastructure systems, in the presence of EV charging systems and multi-carrier energy systems (MESs) to deal with electrical, thermal, and cooling demands". Various articles investigated HC technologies in terms of estimation methods, applied software, and enhancement techniques [6]-[10]. In [3], the HC strategies applied for regulating DERs in MPSs were investigated involving calculation methods, tools, enhancement techniques, and historical developments. Further, the authors in [11], discussed the evolution of HC strategies and applications to enhance the acceptable limits of EV penetration levels in terms of methods and challenges. Books in this field have extensively explored the impacts of integrating new industrial technologies into MPSs, offering in-depth technical insights and quality writing accompanied by diverse examples [12], [13]. However, their relevance may be limited due to the rapid evolution of modern energy systems, making them more suitable for undergraduates than for postgraduates or researchers. Thus, the book entitled "Hosting Capacity for Smart Power Grids, Ahmed F. Zobaa, Shady H.E. Abdel Aleem et al. Springer, 1 2020", is the most recent prominent comprehensive reference for HC strategies in MPSs [14].

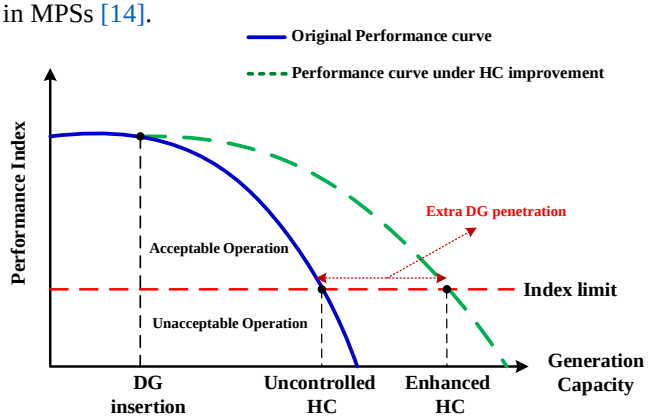

Fig. 1. General HC concept [3]

To cover the significant challenges and solutions associated with the HC concept during the massive integration of RESs into the MPSs, this book investigated the state of the art of the HC in terms of assessment approaches, enhancement techniques and their adverse influences, and

electricity market perspectives. This book is beneficial for various readers, including academic researchers, post-graduate students, distribution system operators and investors, and network planners, with regard to the HC research field. It is considered a vital comprehensive resource for this research trend into such a specified topic.

II. Book Organization

This book involves 10 chapters which discuss various pivotal topics and key findings, as depicted in Fig. 2. The presented chapters are organized as follows:

- Chapter 1: discusses a brief overview of the historical developments of the HC concept, types of operational performance, and some HC enhancement techniques. Moreover, it states the dynamic HC concept in the presence of ESSs.
- Chapter 2: states initially the various HC definitions concerning the rustication of PIs during HC estimation. Then mention examples of HC determination methods for static and dynamic distribution planning in terms of applied case study, method, limits, and power flow directions to introduce new HC method considering new risk indices. The mathematical formation of a new HC method during increased PV penetration considering the system uncertainty, and new risk indices, is evaluated under case studies over feeders and distribution transformers.
- Chapter 3: proposes a new HC estimation method dealing with power quality issues (harmonics) due to the presence of nonlinear loads.
- Chapter 4: Initially reviews the impacts of harmonics on calculating the HC for both static and dynamic HC sorts. An overview of HC calculation and improvement approaches and tools is presented. Further, elaborates the various influences of the DERs, especially harmonics, on calculating the HC-based microgrid in the presence of ESSs.
- Chapter 5: presents a well-organized literature review of ESSs in terms of classifications and applications. Followed by suggesting a calculation method to specify the suitable capacity of ESSs under uncertainties of DERs to improve the HC of distribution systems considering economic benefits.
- Chapter 6: investigates the capacity impacts of DERs integration on the point view of two indices of the electricity market.
- Chapter 7: studies the adverse impacts of increased PV penetration in distribution systems using various case studies by utilizing a generic HC method (deterministic or stochastic approaches) considering many operational performance limits such as voltage violation or thermal loading. In addition to performing the sensitivity analysis of the variety of both PV capacities and placements on operational performance and components such as feeders.
- Chapter 8: utilizes optimization algorithms to estimate the HC accurately and applies a network reconfiguration technique for increasing the HC by improving voltage profile, reducing the power losses, and supporting distribution system reliability.
- Chapter 9: debates the generation regulation of DERs aligned with conventional and modern control systems. Also, the centralized and decentralized control schemes based on the communication infrastructure and Internet of Things (IoT) are investigated.
- Chapter 10: studies the application of the HC concept in the electricity market in terms of profits of both network operators and prosumers and establishing investments in RESs.

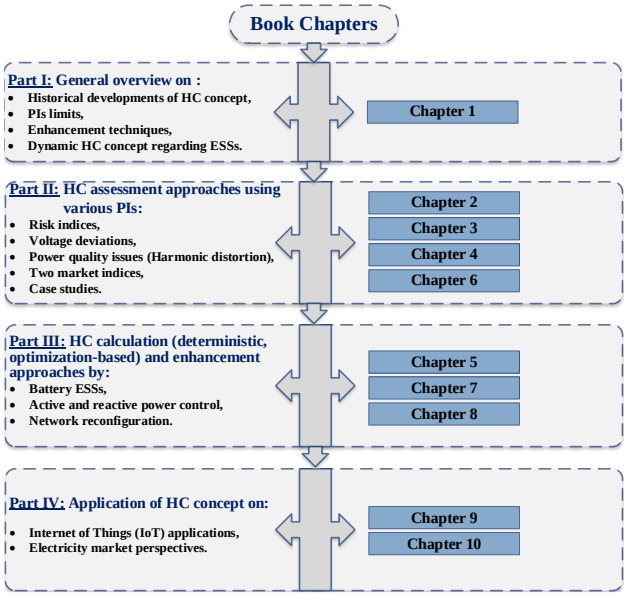

Fig. 2. Overall layout of book chapters

III. Discussion

In general, the book succeeds in discussing some important topics in this research field which makes it suitable for top-up researchers. However, some raised topics are not well-covered and require more investigation. For example, in Chapter 1, the various HC calculation approaches and some PIs and their international limits are not mentioned. Besides, the dynamic HC concept is still questionable in the existence of other HC enhancement techniques not only ESSs.

Chapters 2,3,4 and 6 are associated with the analysis of various HC assessment methods using various PIs. In Chapter 2, the literature review of HC calculation methods over several case studies is not sufficient and the cited references are aged. Although proposing a new HC calculation method using several risk indices, a comparative study with other relevant methods is absent which it is important to show the superiority of the proposed method as well as the beneficial/validity of this method for applying to other system configurations with merits and demerits is not well-studied. The explanation of the HC calculation formally involving harmonics in Chapter 3 is lacking and needs more investigation supported by case studies. However, Chapter 4 successes in depicting the impact of DERs on the point of view of harmonics, are supported with several case studies and verified with various software. Hence, influences of other PIs are not involved. The indices of economic aspects are involved in Chapter 6 and may be expanded to evaluate them during the maintenance scheduling of substation generators or DERs.

For elaborating on various HC estimation and enhancement techniques, Chapters 5,7, and 8, are included, Firstly, Chapter 5 offers HC enhancement methods using battery ESSs and the discussion is sufficient however, the

readers may investigate the capability of using other ESSs regarding electricity prices and HC enhancement ratio, in addition to the benefits of using community ESSs instead of residential ones. Here, Chapter 7 states a comparison of two HC calculation approaches using limited PIs with the capability of PV inverters for reactive power support and control. However, applying realistic systems with various PIs and other reactive power control methods are not considered. Although Chapter 8 suggests using network reconfiguration as an HC enhancement method, a comparison between it and other methods is required in terms of superiority and beneficial aspects.

Regarding Chapters 9 and 10, some applications of the HC term on distribution systems are exhibited. Chapter 9 introduces a comprehensive study of control schemes for regulating the power generation exchange of DERs however several assumptions are used without realistic foundations neglecting the dynamic response of other DERs that apply multi-agent control systems. In addressing this aspect, another book delved into the details of demand-side flexibility applications and methodologies for managing DERs within MPSs [15], [16]. Besides discussions in Chapter 10, it may be expanded to cover other aspects related to the energy market using advanced technologies and strategies such as energy sector coupling or unit commitment solutions.

This book doesn't include several important topics to be useful for intermediate experiences and top-level researchers and experts as follows:

- Discussing several definitions of the HC concept considering various types of operational performance factors such as short circuit capacity, and capacity of both cables and transformers.
- Mentioning various conventional and modern PIs.
- Stating the numerical values of most applied standards of PIs limits.
- Introducing a comprehensive review of various HC calculation methods not only deterministic, stochastics, and optimization methods but also time series, streamlined, and data-driven methods using machine learning applications.
- Specifying the available tools and software to calculate the HC precisely.
- Discussing not only conventional HC enhancement techniques but also modern techniques in the presence of new industrial technologies in inverters or ESSs.
- Covering modern challenges of HC concept for distribution systems and proposed solutions in the future.

The collective list of chapters has a restricted investigation on HC estimation and enhancement techniques, limits of PIs, and case studies. In particular, the references and citations are well-relevant according to the HC research field and discussed topics.

IV. Conclusion

Regarding the HC strategies, this article presents a book review and discussion of the most recently published book and its contents. This book investigated the state of the art of the HC in terms of assessment methods (i. e. deterministic), enhancement techniques (i. e. reactive power control) and their adverse influences, and electricity market perspectives. This book is beneficial for various readers, including academic researchers, post-graduate students, distribution system operators and investors, and network planners, concerning the HC research field. Specifically, the book accomplishes successfully its objectives with the aid of recent references and citations that are well-relevant according to this research field and discussed topics.

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References

[1] A. Ali, H. H. H. Mousa, M. F. Shaaban, M. A. Azzouz and A. S. A. Awad, "A Comprehensive Review on Charging Topologies and Power Electronic Converter Solutions for Electric Vehicles," *John Wiley & Sons*, vol. 12, no. 3, pp. 675-694, 2024, https://doi.org/10.35833/MPCE.2023.000107.

[2] M. Bollen and F. Hassan, "Integration of Distributed Generation in the Power System," *Integration of Distributed Generation in the Power System*, 2011, https://doi.org/10.1002/9781118029039.

[3] H. H. H. Mousa, K. Mahmoud and M. Lehtonen, "A Comprehensive Review on Recent Developments of Hosting Capacity Estimation and Optimization for Active Distribution Networks," *IEEE Access*, vol. 12, pp. 18545-18593, 2024, https://doi.org/10.1109/ACCESS.2024.3359431.

[4] N. Qamar, A. Arshad, K. Mahmoud, and M. Lehtonen, "Hosting capacity in distribution grids: A review of definitions, performance indices, determination methodologies, and enhancement techniques," *Energy Science & Engineering*, vol. 11, no. 4, pp. 1536-1559, 2023, https://doi.org/10.1002/ese3.1389.

[5] S. Fatima, V. Püvi, and M. Lehtonen, "Review on the PV Hosting Capacity in Distribution Networks," *Energies*, vol. 13, no. 18, p. 4756, 2020, https://doi.org/10.3390/en13184756.

[6] W. Y. Atmaja, Sarjiya, and L. M. Putranto, "Battery energy storage system to reduce voltage rise under high penetration of customer-scale photovoltaics," *International Journal of Sustainable Energy*, vol. 41, no. 11, pp. 2150-2168, 2022, https://doi.org/10.1080/14786451.2022.2136176.

[7] M. J. Rana, F. Zaman, T. Ray and R. Sarker, "EV Hosting Capacity Enhancement in a Community Microgrid Through Dynamic Price Optimization-Based Demand Response," *IEEE Transactions on Cybernetics*, vol. 53, no. 12, pp. 7431-7442, 2023, https://doi.org/10.1109/TCYB.2022.3196651.

[8] V. Umoh, I. Davidson, A. Adebiyi, and U. Ekpe, "Methods and Tools for PV and EV Hosting Capacity Determination in Low Voltage Distribution Networks—A Review," *Energies*, vol. 16, no. 8, p. 3609, 2023, https://doi.org/10.3390/en16083609.

[9] S. M. Ismael, S. H. E. Abdel Aleem, A. Y. Abdelaziz, and A. F. Zobaa, "State-of-the-art of hosting capacity in modern power systems with distributed generation," *Renewable Energy*, vol. 130, pp. 1002-1020, 2019, https://doi.org/10.1016/j.renene.2018.07.008.

[10] M. J. Chihota, B. Bekker, and T. Gaunt, "A stochastic analytic-probabilistic approach to distributed generation hosting capacity evaluation of active feeders," *International Journal of Electrical Power & Energy Systems*, vol. 136, p. 107598, 2022, https://doi.org/10.1016/j.ijepes.2021.107598.

[11] Z. M. Zenhom, S. H. E. A. Aleem, A. F. Zobaa and T. A. Boghdady, "A Comprehensive Review of Renewables and Electric Vehicles Hosting Capacity in Active Distribution Networks," *IEEE Access*, vol. 12, pp. 3672-3699, 2024, https://doi.org/10.1109/ACCESS.2023.3349235.

[12] J. D. Glover, T. J. Overbye, M. S. Sarma, "Power system analysis & design," *Cengage Learning*, 2017, https://books.google.co.id/books?id=KHYcCgAAQBAJ&printsec=frontcover&hl=id&source=gbs_vpt_read.

[13] S. E. Razavi *et al*., "Impact of distributed generation on protection and voltage regulation of distribution systems: A review," *Renewable and Sustainable Energy Reviews*, vol. 105, pp. 157-167, 2019, https://doi.org/10.1016/j.rser.2019.01.050.

[14] A. F. Zobaa, S. H. E. Abdel Aleem, S. M. Ismael, and P. F. Ribeiro, "Hosting Capacity for Smart Power Grids," *Springer Cham*, pp. 1-254, 2020, https://doi.org/10.1007/978-3-030-40029-3.

[15] A. Moreno-Muñoz and N. Giacomini, "Energy smart appliances: applications, methodologies, and challenges," *John Wiley & Sons*, 2023, https://doi.org/10.1002/9781119899457.

[16] H. H. H. Mousa, K. Mahmoud, and M. Lehtonen, "Book Review on Antonio Moreno-Munoz; Neomar Giacomini; Energy Smart Appliances: Applications, Methodologies, and Challenges (2023)," *Control Systems and Optimization Letters*, vol. 2, no. 1, pp. 90-93, 2024, http://dx.doi.org/10.59247/csol.v2i1.84.