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A Comprehensive Review of Renewables and Electric Vehicles Hosting Capacity in Active Distribution Networks

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ABSTRACT The excessive integration of renewable distributed generation (RDG) and electric vehicles (EVs) could be considered the two most problematic elements representing the greatest threat to the distribution network (DN) technical operation. In order to avoid going beyond technical limitations, the term hosting capacity (HC) was proposed to define the highest permitted amount of distributed generation (DG) or EVs that can be integrated safely into the DN. The connection of RDGs was first brought to the attention of researchers and DN operators since it accounts for the most notable portion of these technical issues. Hence, the phrase 'DG-HC' was initially proposed and evolved significantly over the last few years. Currently, EV integration in most DNs worldwide is still low, but given the worldwide support for clean transportation options, expectations are raised for a significant increase. As a result, it is anticipated that over the next years, the effect of EV integration on the DN will be highly noticeable, requiring greater attention from researchers and DN operators to define the accepted limits of EV penetration levels, 'EV-HC,' which is expected to pass along the same line of DG-HC. This article provides an in-depth review of both DG-HC and EV-HC. It first analyses how the DG-HC research has grown over the years and then studies the published EV-HC papers, illustrating to what extent there is a similarity between them and, finally, employs these analyses to expect future development in the EV-HC research area. This article includes the different uses of the term HC, the most common performance indices of DG-HC, the various methods for assessing DG-HC, the different techniques for DG-HC enhancement, the effects of integrating EVs on the DG-HC, and finally, calculating and enhancing methods for EV-HC.

INDEX TERMS Distributed generation, hosting capacity, electric vehicles, distribution networks, optimization techniques, hosting capacity enhancement.

I. INTRODUCTION

The basic feature of distribution systems was the one-way power flow from central generating plants to transmission and DNs. The typical power flow directions have changed recently due to integrating renewable-based technologies, like photovoltaic (PV) and wind turbines, in DNs. Political, social, economic, technological, and environmental objectives have influenced the development of these renewable energy sources (RES). Excessive distributed generation (DG) penetration, however, can adversely affect the system's performance and cause technical issues, such as overvoltage issues, an increased danger of equipment short circuits, and malfunctioning protection systems. Consequently, assessing the DN's ability to accommodate those DGs without violating any technical aspect becomes critical [1–6]. Therefore, the highest level of DG penetration at which the DN operates effectively is mentioned as hosting capacity (HC) or, precisely, DG-HC, as shown in Fig. 1. In addition, this safe limit of DG penetration can be raised

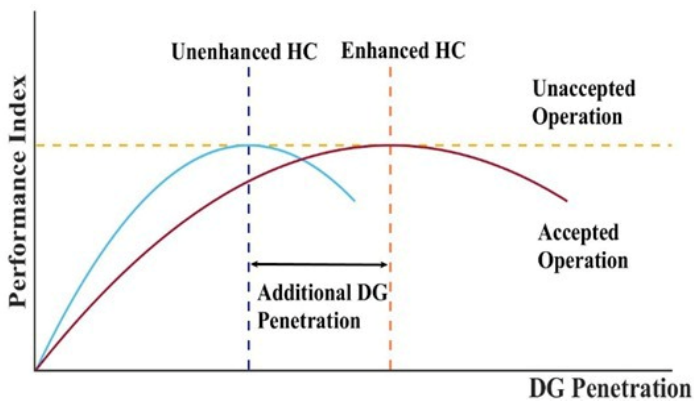

FIGURE 1: DG-HC concept.

above the prior level if an enhancement technique is applied [6]. A few years ago, researchers and distribution system operators (DSOs) focused on the significant effects of DG excessive penetration on DN technical operation, assessing the DG-HC. As a result, the DG-HC research area has advanced in either assessment methods or enhancing techniques. Based on the Scopus database, there have been around 1400 articles in this area. Moreover, the DG-HC limit has been determined globally for numerous distribution networks (DNs). For instance, Egypt's net-metering policy permits the construction of PV systems with net-metering accounts for up to 1.5% of the maximum demand [7]. It was recommended by the DSO in South Africa that the overall DG capacities be below fifteen percent of the feeder maximum demand. In Portugal, the overall DG capacities for low-voltage (LV) networks must be below twenty-five percent of the MV/LV transformer capacity [8].

Moreover, a significant increase in HC research publications has recently been noticed over the years, as shown in Fig. 2. This search was conducted through the Scopus database in the first quarter of 2023, so the number of publications is anticipated to rise considerably during 2023. In addition, countries also differed in their researchers' interests in analyzing HC, as shown in Fig. 3, which presents the number of published papers in the 15 countries most interested in HC research. According to several authorized publisher databases accessible online, including Scopus, Science Direct, Springer Link, and IEEE Explorer, Fig. 4 shows the literature discussing the DG-HC or EV-HC. These search results prove the accelerated development of research on HC. Additionally, that considerable difference between the number of publications in DG-HC and EV-HC indicates that DG-HC has attracted more attention from researchers in the previous few years.

After around 14% share of the global market of passenger cars recorded in the fourth quarter of 2022 [9], authors in [10] expect EVs to gain around 28% by 2040. This will result in an additional rise of 11–20% in the electricity consumed worldwide. There are several factors contributing to this enormous, expected increase in the use of EVs, including reducing hazardous emissions from the transportation industry, which was the second highest producer to those emissions globally in 2020 [11], lower maintenance requirements, and superior performance compared to conventional vehicles [12]. Due to the steadily accelerating expansion in the EVs sector throughout time, as shown in Fig. 4, authors in [13] estimated the number of EVs until 2030.

All prior statistics showing the anticipated sharp rise in EVs highlight the necessity for researchers and DSOs to investigate their effects on the DN and define a secure limit on their penetration, referred to as EV-HC. However, EVs HC publications are still few compared to DG-HC, as seen in Fig. 3, although as shown in Fig. 5, this number is increasing with time. In contrast, the distribution of the keywords from publications that focus on HC is illustrated in Fig. 6, making it easier to see the areas of strength.

The size of the circles corresponds to the frequency of the keywords. In other words, larger clouds and patterns indicate a greater frequency of occurrence. Finally, Fig. 7 also shows the distribution of publications regarding the country. It has been noted that the United States and China had the most publications in this field of study. Therefore, this article gives an in-depth and well-organized overview of both DG-HC and EV-HC. It first studies developments of DG-HC through time, then analyzes published EV-HC articles to see how similar they are, and lastly uses these studies to predict how EV-HC research will develop in the future. This article includes the various terminologies of the term 'HC,' the most popular performance indices for DG-HC, several techniques for enhancing DG-HC, the effects of integrating EVs on DG-HC, and methods for calculating and enhancing EV-HC.

Additionally, between 2018 and the beginning of 2023, the literature review papers published on HC were also investigated. The existing literature reviews on HC are shown in Table 1, and their primary conclusions. The novelty of this article in terms of HC definitions, performance indices, enhancement techniques, EV-HC, and effects of EVs on DG-HC is highlighted by a comparison between the current article and existing literature reviews on HC in Table 2.

In real-life applications, the distribution networks for DG units and EVs are the same; they are not separated and interconnected. However, in this article, the DG-HC is reviewed first, followed by the EV-HC review to serve individually as a focus for each portion. The remaining portion of this paper is structured in the following manner: Section 2 illustrates HC concept and different terminologies. Section 3 presents the HC limiting factors. Section 4 illustrates the different HC assessment methods. Section 5 presents the HC enhancement techniques. Moreover, the impacts of EVs on DG-HC and the EV-HC are analyzed in Section 6. Finally, discussions, conclusions, and upcoming developments in the HC research area are presented in Sections 7 and 8, respectively.

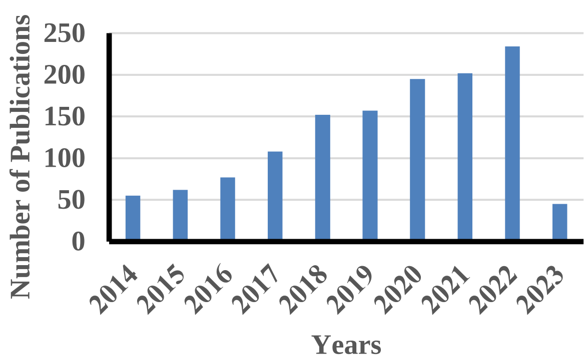

FIGURE 2: Number of literatures using the term HC based on the Scopus database.

TABLE 1: Existing review papers of HC.

Ref.	Author	Year of publication	Location of the main author	Main conclusions
[2]	Ismael et al.	2018	Egypt	This review presents an organized, thorough exposition of the HC concept, historical progression, limiting factors, methods of assessment, and enhancement techniques.
[4]	Abideen et al.	2020	Qatar	This article reviews the main performance indices, compares different assessment methods, and presents the existing software tools used to calculate HC.
[1]	Fatima et al.	2020	Finland	This article provides a thorough overview of PV HC definitions, limiting factors, enhancement methods, and estimation of PV HC for existing networks worldwide.
[14]	Mulengaa et al.	2019	Sweden	This review focuses on the assessment methods for PV HC determination with a comparative study, highlighting the merits and shortages of each method.
[15]	Islam et al.	2023	Australia	This reviews the limiting factors first, then presents a comparative study of conventional assessment methods and artificial intelligence methods that can be applied to HC calculation.
[16]	Umoh et al.	2023	South Africa	This paper reviews the HC definitions, assessment methods showing limitations in each method, the existing software tools used for HC determination, and finally presents EVs HC assessment methods.
[17]	Qamar et al.	2022	Pakistan	This review illustrates a thorough review of the HC definitions, performance indices, calculating approaches, and improvement techniques.
[18]	Moro et al.	2021	Brazil	This review paper focuses only on HC enhancement techniques and compares them.
[19]	Singh et al.	2023	Switzerland	This article reviews the HC definition, the impacts of DG units, especially PV and wind, on DNs, and HC assessment methods.

TABLE 2: **Comparison between existing review papers on HC and the current paper**

Ref.	Author	Ideas discussed					
		Definition	Performance indices	Assessment methods	Enhancement techniques	EV- HC	EVs' impact on DG-HC
[2]	Ismael et al.	✓	✓	X	✓	X	X
[4]	Abideen et al.	✓	✓	✓	X	X	X
[1]	Fatima et al.	✓	✓	X	✓	X	X
[14]	Mulengaa et al.	✓	X	✓	X	X	X
[15]	Islam et al.	✓	✓	✓	X	X	X
[16]	Umoh et al.	✓	✓	✓	X	✓	X
[17]	Qamar et al.	✓	✓	✓	✓	X	X
[18]	Moro et al.	✓	X	X	✓	X	X
[19]	Singh et al.	✓	✓	✓	X	X	X
Current paper		✓	✓	✓	✓	✓	✓

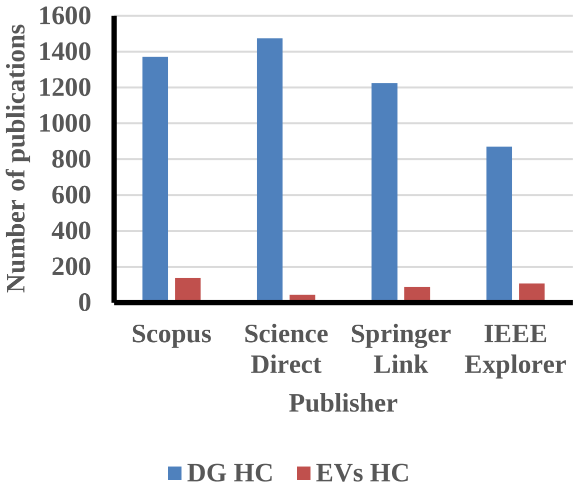

FIGURE 3: **Number of literatures discussed either the DG-HC or EV-HC among different publishers.**

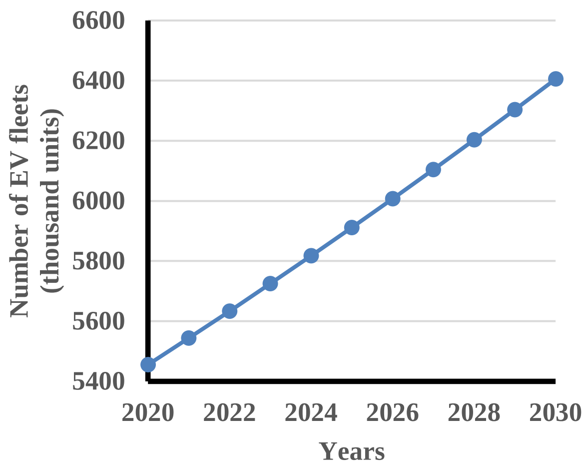

FIGURE 4: **Number of EV fleets forecast until 2030.**

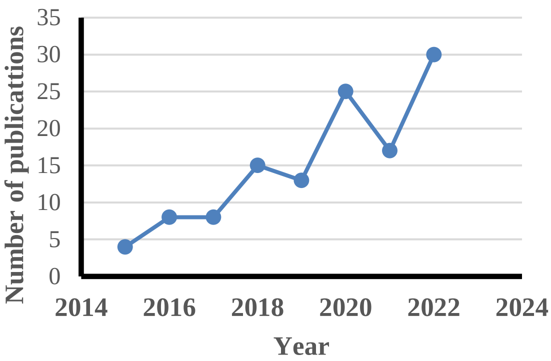

FIGURE 5: **Number of EV-HC publications over the past years-based Scopus.**

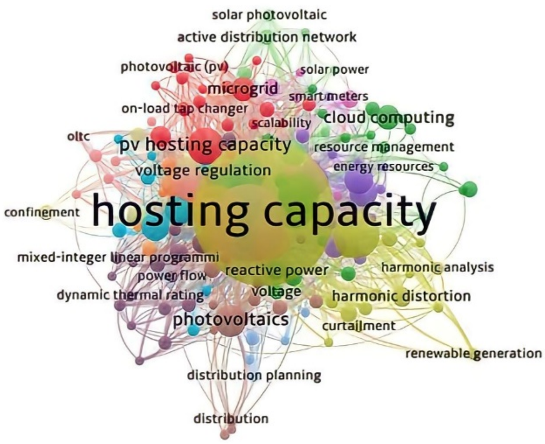

FIGURE 6: **Co-occurrence analysis map of the papers focusing on the HC.**

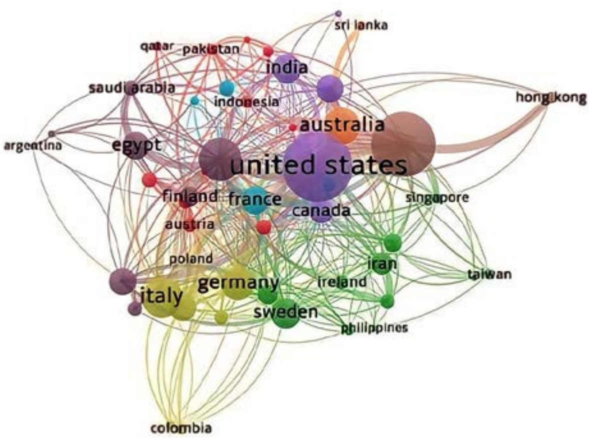

FIGURE 7: **Distribution of HC papers regarding countries in the period between 2018 and early 2023.**

II. HOSTING CAPACITY TERMINOLOGIES

Historically, computer engineers first developed the term 'HC' to describe the web server's capacity for handling many access demands. Then, André Even developed the term "HC" to describe the implications of an excessive DG penetration into the DN. In 2004, Math Bollen extended the idea and described the HC clearly as the highest DG amount above it the technical aspects of the DN are unacceptable. Therefore, the first use of the term HC in power systems referred to DG-HC. Lately, authors started to use that term for EV publications. In 2017, authors in [20] first defined the EVs HC as the maximum amount of EV charging load that may be hosted in DN while still meeting the DN's technical requirements.

Besides DG-HC and EV-HC, the word HC has recently been applied in power systems applications in other terms such as Loading HC (LHC) and Feeder HC (FHC). However, the most used terms are DG-HC and EV-HC. In some works, the term FHC is presented [21–26]. The capacity of DG that can be hosted without having a negative effect under the current configuration and without upgrading or altering the main feeder is called the feeder hosting capacity. The FHC relies on a number of things, for example the size of DG units, location of DG units, feeder characteristics, feeder configuration, and protection coordination. In [25], the Monte Carlo simulation-based probabilistic analysis is employed to assess the PV HC as a percentage of the peak load of 17 distribution feeders involved in five distinct utilities. Results show that by selecting appropriate PV installation sites and modifying the PV inverter's power factor, the FHC for PV can be significantly raised. Authors in [22] studied how the PV site and kind of phase connection can affect the FHC. Additionally, the sensitivity of FHC to feeder characteristics, PV sites, and power factors of PV inverter is examined in [21].

Finally, some papers introduced the term loading capacity (LC) instead of HC [27,28]. LC refers to the maximum extra loading in the DN that can be hosted without violating the performance indices. The optimal LC is calculated in [28], while a comparison between the LC and HC is presented in [27].

III. HC LIMITING FACTORS

The characteristics of the DN which are impacted by DG's connection and limit DG's integration according to a specific criterion are referred to as limiting criteria, impact factors, and performance index/indices. Although employed in different situations, these terms refer to the same aspects. Several studies combine those limiting criteria to determine the HC of a specific DN [4]. The most important limiting factors covered by the published papers are presented in this section.

A. VOLTAGE LEVEL

As long as the output power of a DG unit is more than the load demand, the extra power is fed back into the network. Consequently, the load bus's voltage rises above the allowed level, and the surrounding feeder may overload [1,4,8]. The voltage rise is considered the most common performance index that limits DG hosting capacity [3,11]. The five widely used voltage standards are summarized in Table 3 [1]. With a maximum value of 1.05 p.u depending on the ANSI C84.1 standard, the authors in [10–13] only viewed overvoltage as the primary performance index, while the allowable voltage variation is defined at 2% of the nominal value in [7], and a 10% variation from the nominal voltage is permitted in [30]. Finally, the Canadian Standard Association (CSA), e.g. (±6%) of nominal voltage (V_r), is applied in [31].

TABLE 3: The five widely used voltage standards.

Voltage Standard	Allowable voltage deviation
European Standard EN-50160	± 10% of Vr
German Standard VDE-AR-N 4105	± 3% of Vr
American Standard ANSI C84.1	± 5% of Vr
Australian Standard	(−6/+10%) of Vr
Canadian Standard Association (CSA)	± 6% of Vr

The term FHC is proposed in [10,11]. A swarm-based intelligent approach (inspired by particle swarm optimization algorithm) is proposed in [26]. The best locations at different penetration levels of PV, keeping the maximum feeder voltage under the allowable limit, are selected. In [25], the FHC of PV is maximized by a mixed-integer non-linear optimization problem and GA. The findings demonstrate that coordinated operation of switching capacitor banks, voltage regulation, and modifying power factors may greatly boost the maximum PV-HC. A non-linear programming optimization technique is developed to determine a distribution circuit's maximum PV hosting capacity [29]. The outcomes are contrasted with those of two traditional stochastic approaches. The findings demonstrate the limits of the traditional approaches in estimating the maximum HC of PV in the DN. The suggested method tackles the nonlinearity in power flow issue while taking into account all grid restrictions to find the highest PV HC. In [32], authors applied a Monte Carlo approach to calculate the HC of three real DNs in Canada. The main limiting factor was determined to be overvoltage. In addition, a framework for assessing the impact of a pair of solar PV system kinds —those installed by customers and those installed by utilities—on a particular realistic distribution network has been put forth [33]. It was observed that overvoltage arises for customer-based scheme above 30% penetration and that the utility-based scheme may increase the penetration level to a greater amount.

In some literature, such as [34], over/under voltage and voltage unbalance through various phases were considered limiting factors. For the purpose of assessing the FHC, a Monte Carlo approach is conducted. Between 10% and 100% with a 10% step, the PV penetration level is chosen, and for each penetration level, 25 different scenarios are selected by varying the location of PV installation on the feeder. It was revealed that PV penetration could only reach 10% on days with high solar irradiance. However, it might reach 50% in the lowest annual load day without suffering from overvoltage.

Most studies introduce iterative methods to determine the DG-HC. Due to some shortages in these standard methods, the non-linear model of HC formulation is linearized in some literature, such as [35,36]. In [36], a two-step approach is proposed to estimate the maximum HC of DGs considering over-voltage and voltage variation as limiting factors. A linear approximation of terms includes nonlinearity in power flow approach is considered in the first step. Then, a probabilistic technique is proposed to tackle the issues related to uncertainties of DGs and loads. The suggested technique is tested via the IEEE 123 bus system. While in [35], the DN power flow equations are linearized via a few approximations derived from realistic assumptions. It was demonstrated that the suggested approach provided roughly equivalent HC results while significantly reducing computing time.

Additionally, HC studies in [21,22,37,38] took voltage deviation and voltage unbalance into account in addition to overvoltage as performance indices. The impacts of residential PVs on DN voltage via several scenarios of different PV sizes and locations are presented in [38]. While in [22], the locational sensitivity of FHC is examined by Monte Carlo simulation. Results show that an increase in PV HC may be attained if PV interconnection points are located nearer to the substation and have lower impedance. Using a stochastic technique, 500 potential PV integration scenarios (from 50% of the peak demand to 400%) were modeled in a benchmark distribution feeder, and by checking the voltage limiting factors, the PV HC is determined in [37].

B. OVERLOADING OF FEEDERS AND TRANSFORMERS (THERMAL LOADING)

The second significant performance index for the HC, as mentioned in the literature, is the limit on the amount of current (ampacity) that feeders can transport and overload constraints of transformers [1]. The integration of DG units can subsequently lower the hazards of overloading, eliminate system losses, extend the equipment's lifespan, and enhance thermal characteristics of cables and transformers. With maximal generation and lowest loading, the catastrophic situation that raises the chance of overloading occurs [2].

The worst case, which leads to thermal loading issues, occurs during high production and low demand. There is a maximum rated current that both lines and transformers can accommodate. Breaking this limit results in these components overheating and malfunctioning in various ways [4]. Overloading limits of transformers and cables are stated in different values in the literature; however, Transformer overloading limits are less rigorous than the cable overloading restrictions, as shown in Table 4. The conductor ampacity is mentioned in [43-45] without considering the transformer ampacity. In [44], it is shown that smart PV inverter functions may make it possible to enhance the PV HC of the distribution feeders without spending money on expensive distribution improvement methods. The HC was calculated by incrementally increasing output power (Pout) of PV by 1 kW till the voltage level violates the allowable limit (±5%) or the

TABLE 4: Cables and transformer overloading limits in the literature

Transformer overloading limits	Feeders overloading limits
100% of nominal rating [39]	105% of nominal line current [40]
100% of the design rating [31]	150% of rated power [41]
150% of rated power [41]	100 % of the design rating [31]
187.5 % of rated capacity [42]	85% of line rating [39]

current exceeds the conductor's ampacity. The FHC with massive amount of scattered PV systems is assessed in [43]. The voltage magnitude, line ampacity, and voltage stability are mentioned to restrict the penetration of PV. The DG-HC is estimated hourly, considering uncertainties in solar radiation and load variations [45]. Overvoltage and line ampacity are stated as the limiting criteria. The bus's voltage magnitude, each line's loading, and the transformer's loading are considered the limiting factors in several works such as [30,31,39,40,46-48]. The effect of upcoming PV integration on a realistic city low-voltage region in Zurich was discussed in [39]. Three solutions were presented to mitigate the transformer overloading: installing a system of batteries beside the transformer station, active power curtailment, and demand side management. In [30], the HC of PV systems was quantified using a Monte Carlo method-based analysis. Then, it was examined whether using an on-load tap changer in a DN would increase the penetration of PV.

Moreover, a probabilistic planning method that boosts the DG-HC depending on accepting active power curtailment is presented in [46]. According to the results, it was feasible to double the quantity of installed PV power if an active power curtailment is applied for short periods. In [47], in contrast to most of the literature, the proposed model considers the distribution line's shunt capacitance, frequently overlooked when calculating power flow in DG applications. The results demonstrated that incorporating this capacitance enhances the available DG power. Moreover, for HC of roof PVs maximization, authors in [48] present a quadratic power control optimization technique for determining optimal capacity and location of a central battery storage system in DNs. Thermal limits according to component ampere rating and bus voltages are considered limiting factors.

C. POWER QUALITY ISSUES (HARMONICS-FLICKERS)

Providing the power source voltage to the consumer inside tolerable bounds is what is meant by "voltage quality". Numerous power quality issues, including power system harmonics, steady state voltage variations, voltage dips, and flickers, may be caused by excessive DG penetration [2,4]. Numerous studies investigated the issue of power quality, such as harmonics and flickers, for DG-HC limitation. HC can be affected by harmonics, particularly those from PV inverters. Despite having outputs that are very close to sinusoidal, new inverters with a higher switching frequency are injecting supra-harmonics (the harmonic content in the frequency range (2-150 kHz)) [49]. Therefore, utilities must keep total harmonic distortion (THD) at the point of common coupling within limitations set by IEEE 519 to maintain network performance [1,50]. Harmonic restrictions, total and individual harmonic distortion limits specified in IEEE 519 Standard, conventional HC restrictions such as bus voltage constraint, and the ampacity of supply cables are considered the limiting constraints [51,52]. The DG-HC for a traditional distorted DN is studied in [52]. First, the maximum HC at different nonlinearity degrees of loads is determined in the uncompensated system. Second, the *C*-type filter is integrated to enhance the HC, maintaining acceptable constraints. Optimizing the filter size and the DG rating capacity to achieve the maximum HC by genetic algorithm (GA) is presented in [51].

Similarly, authors in [53] presented a filter of type "C" to enhance the probabilistic hosting capacity (PHC) in a distorted DN. Several limiting factors were taken into account, including voltage constraint, feeder's ampacity, power factor, and limits on both individual and total harmonic distortion. The size of the proposed filter is optimized via a hybrid PSOGSA optimization algorithm. The results are compared to other optimization techniques.

In [50], a rural Mauritius domestic DN is presented for PV HC study with harmonics as the performance indices. Additionally, HC of the IEEE 13 bus benchmark is evaluated via the harmonic voltage distortion as a limiting factor [54]. In comparison, the HC assessment of a DN in UK is performed in [55]. Several limiting factors are considered, for example overvoltage, power losses, feeders and transformer ampacity, and voltage imbalance. A maximum of 5% THD is imposed on the harmonics with respect to the limiting criteria.

The term "flicker" refers to how electrical voltage fluctuations affect incandescent lights and other electrical lighting lamps [56]. Authors in [57] revealed that voltage flickers are regarded as the most important issue when wind power penetration is high at the distribution level. Unlike most mitigating techniques for lowering flicker emissions mentioned in other literature used at the generating end, this research introduces a demand side management (DSM) approach based on the electric spring technique (ES). The ES offers compensating reactive power for reducing voltage flickers and is coupled in series with non-critical loads, forming smart loads [57-58]. In addition, most works that determine the HC of DNs are based only on the static characteristic of bus voltage (the variation that lasts at least 10 minutes), while the PV-HC in a German DN was limited by the dynamic voltage characteristics (e.g., voltage flickers as limiting factor) for the first time in [59]. Moving clouds and partial shading over DNs with a high penetration of PV have the potential to quickly alter PV production and result in rapid voltage fluctuations. Therefore, the effect of voltage flickers caused by moving clouds and partial shading is illustrated by comparing HC from perspective of the static and dynamic characteristics. To manage the dynamic voltage profile and enhance the HC, a static synchronous compensator

(STATCOM) is suggested. Additionally, authors in [60] consider voltage rise and flicker as limiting factors for the first time. Three main flicker indices of an existing DN that already has a 16% penetration of PV are calculated in [61] (HC is not investigated; there are no limiting factors).

D. PROTECTION ISSUES

Whenever DG power generated rises above demand needs, power flow reversed, and protection difficulties might arise. Too Much DG penetration affects the magnitude and direction of the fault currents. As a result, it might raise the chance that protection systems will fail, either through unneeded operation under normal circumstances or through failing to operate when there is a fault [2]. Many studies highlight that protection issues could restrict the HC limit [4].

In Yogyakarta, HC of PV in a DN is determined with the use of an iterative approach. [62]. Different loading situations were examined along with the selected limiting factors of overvoltage, current ampacity, and reverse power flow. Findings illustrated that power flow is reversed in most cases, nevertheless, voltage violations happen whenever the demand is below 48% of its typical value. Authors in [63] conducted a comprehensive study to evaluate the dangers that the protection system would meet in the event of higher amount of DG integration. Additionally, findings revealed that some changes to the current protection schemes might be necessary to address the DG existence.

Additionally, some protection issues were covered by authors in [64], including coordination of protection devices, the impact of DG on fault identification techniques, islanding issues, and device interrupting ratings. Authors emphasized that at low DG amount, negative consequences are not expected; nevertheless, these implications are discernible with significant DG penetration and should be considered. Moreover, the DG technology affects the DG contribution in the fault current [65]. Besides, authors in [66] showed that the traditional protection coordination parameters should be updated to guarantee that the protection mechanism operates well after severe DG penetration.

Finally, as stated in [35], the DG-HC published papers can be divided into two main categories: DG-HC assessment (or calculation) and DG-HC enhancement. Some studies apply one of them, but some literature assesses the HC level and then introduces an enhancement technique to raise this level. Therefore, the following two sections are presenting these two topics.

IV. DISTRIBUTED GENERATION HOSTING CAPACITY ASSESSMENT (CALCULATION) METHODS

In DG-HC literature, there are three main techniques for assessing (calculating) the DN HC: optimization-based, stochastic, and deterministic approaches. Although the approaches vary significantly in how they are carried out, they all apply the main procedures for the HC calculation. As mentioned in the previous section, some works in the literature concentrate on HC calculation and HC enhancement. Fig. 8 shows a flowchart for the main procedure of HC calculation and enhancement [4]. This section presents the primary approaches applied in the published papers for calculating the DN HC.

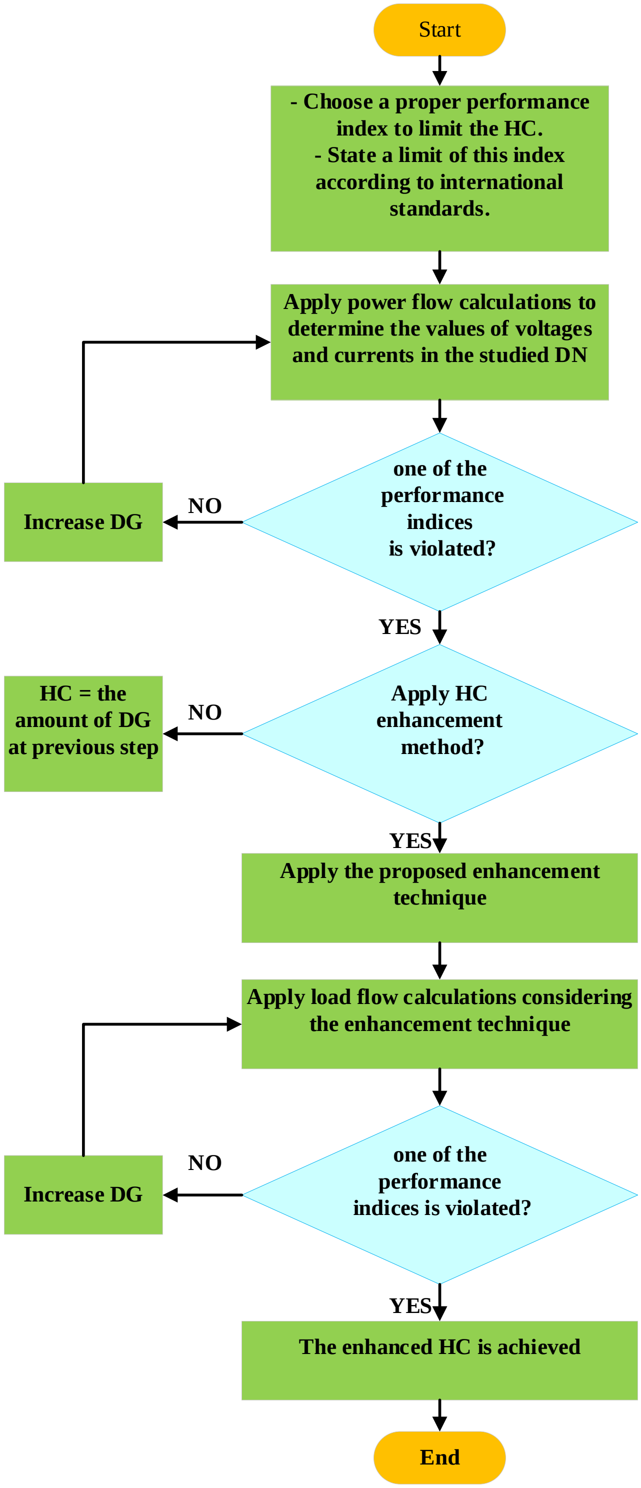

FIGURE 8: The main procedure of HC calculation and enhancement.

A. DETERMINISTIC METHOD

As stated in [14], deterministic methods are the most common approaches in HC assessment in DNs. In deterministic methods, the computation of the HC relies on known and deterministic input values of renewable generating sources and load profiles to give a single output value of HC. In other words, the uncertainty of solar radiation, wind speed, or load consumption is not considered. The deterministic technique is separated into two approaches according to the stated assumption of DG output power, whether constant with time or varying with time (following a generation profile), as shown in Fig. 9. These approaches are time series approaches and constant generation approaches [4].

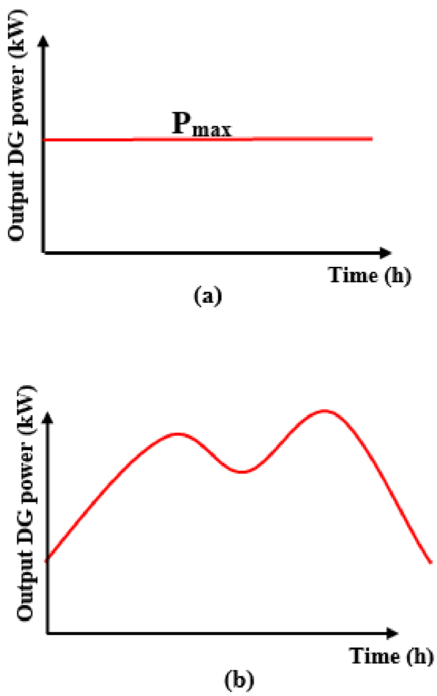

FIGURE 9: Output power from DG units: (a) constant generation methods, and (b) time series method.

1) CONSTANT GENERATION METHODS

The DG unit output power is assumed to be constant, irrespective of their technology, during the calculation period when using the constant generation approach. This methodology disregards the changing nature of DG units. Authors in [47,54,62,67,68] applied constant generation approaches to solve the HC problem. When computing the HC using this approach, P_{out} of DG units is commonly considered to be at its highest value, while in some literature, the HC assessment of distribution networks is calculated considering the worst-case scenario, such as [47,68]. To determine the HC in these methods, these scenarios gradually increase the DG units' capacity/number until there is a violation of any of the performance criteria [4]. There are three ways to increase the DG output power at grid nodes incrementally: forward, backward, and forward-backward [14]. It is important to note that only a small number of literatures computes the HC using the constant generation method. This is because it is a simplified method and can only be applied for HC value estimation. Additionally, it is probable to underestimate the HC, especially when considering the worst-case scenario [4].

A constant generation approach was applied in [69] to calculate the HC of three real DNs in the US. Firstly, a proper site of the DG unit is selected, then the size is gradually increased by 1 kW. In [54], a sensitivity analysis was carried out to investigate the voltage harmonics limiting the PV systems' HC. The impact of two types of PV inverters and capacitor banks was investigated. The study's primary conclusions are as follows: capacitor banks increase the voltage THD, reducing the network's HC.

Additionally, integrating PV systems close to heavy loads might reduce distribution losses. In addition, the effects of the site of DG units on the HC of DNs were examined in [67,68]. In [67], performance indices, including voltage levels and transmission capacity, are considered, and the effects of various penetration levels are evaluated. Values of HC at different sites were computed. The impacts of various DG technologies on the distribution network's HC were taken into account in [68].

2) TIME SERIES METHODS

The time series approach outperforms the constant generation approach. It considers the changing nature of the DGs. This means that the time series technique depends heavily on data, and additional data can show more details regarding how DG dynamics affect the HC. However, much data might make the computation time longer [4]. PV technology has been the subject of most time series literature to calculate the HC, such as [70-73]. Only a few studies [74,75] have examined the HC of wind turbines using the time series method.

Time series-based techniques were provided in [70] and [75] to determine the DN HC of PV and wind turbines. For various types of DNs, the PV HC was determined in [70]. It was revealed that the residential network's HC ranged between 82% and 150%. The industrial network's HC was 31%, and the available roof area constrained the commercial network's HC. The wind HC of a practical distribution feeder in a Brazilian city is introduced in [75]. The limiting factors are voltage level, cable overloading, and reverse power flow.

Additionally, the authors in [71] and [73] performed the time series approach to examine the effects of integrating PV systems in DNs. In [71], the authors modeled a real DN in Sri Lanka, which already has a 40% penetration of PV. The objective of the study is to check the technical consequences that will occur at higher penetration levels. The authors in [73] examined the impact of PV system integration on the current and voltage profile and the network losses using actual consumption and generation profiles from PV systems in the IEEE 69 benchmark. In Virginia, a DN was used to gather data, and this data were used to create load curves for three different types of loads: domestic, commercial, and industrial. The concept of quasi-static time-series (QSTS) analysis is proposed in various literature to accurately estimate HC by handling the time-varying aspects such as load profile, solar, and Wind generated power. In contrast, historically, analysis has been carried out at specific periods, such as peak load, worst-case periods of the greatest or lowest demand, or the highest Photovoltaic to demand ratio, is called "static, snapshot HC.". Nevertheless, a main barrier to QSTS employment is the enormous computational burden of running their simulations. According to the IEEE definition, the QSTS must be conducted for at least 1 second of resolution, over the course of a year to 1 hour maximum [76]. Each literature proposes a different way to overcome the computational burden in the QSTS approach. In [77], the seasonal properties of the DN are analyzed to reduce the number of simulations, so the daily load profile is grouped into only three groups: winter, summer, and transition season load profiles. A vector quantization approach is introduced in [78] as an approximate rapid time-series QSTS analysis. Results show that the computational time was reduced by 98.9% for a one-year simulation of 1-second resolution. A quick and innovative QSTS simulation technique, adapted from machine learning's predictive modeling with linear regression, is presented in [79]. The results showed a 99.45% reduction in computational time. In [80], a QSTS analysis of one-year duration with a one-minute resolution is presented. To perform the QSTS analysis, a typical day in August was selected, and linear interpolation was employed to the hourly load data to raise the resolution to one minute.

B. STOCHASTIC METHODS

Production of RDG power, such as PV and wind turbines, is unpredictable and is based on different factors affected by variable weather patterns, such as both solar irradiance as well as wind speed. The production becomes stochastic as a result. Additionally, consumption profiles are also unknown. All these unknown parameters are called uncertainties [4,14]. Stochastic approaches relied on probabilistic power flow (PPF) are employed to tackle these uncertainties [81]. Stochastic methods can be considered a development over the deterministic power flow (DPF), which disregards uncertainty [82].

Regarding DG-HC literature, stochastic methods are the most widely used approaches for calculating HC. There are several mathematical techniques to generate random possible scenarios, but Monte Carlo (MC) approach is most frequently employed calculating method in the stochastic method [4]. Authors in [25,32,33,42,45,81,83-90] proposed the MC technique to assess the HC. Other methods, such as Quasi-Monte Carlo and Sparse DG grid, are proposed in [91] and [92]. Authors in [83] introduce a novel study that assesses, for the first time, how the considered resolution of the historical data and the modeling of uncertainties affect the HC level. For HC assessment, the MC approach is employed and tested on an Australian agricultural DN. It is demonstrated that as historical data resolution is reduced, the HC's probability distribution function (PDF) shifts to the right, which implies a rise in the calculated HC. Besides this, it is demonstrated that setting DG capacity as constant values rather than accurately modeling the uncertainty associated with their capacity underestimates the determined HC in the network. The value of data gathered through Smart Metering (SM) in estimating the PV HC in a real DN is introduced in [85]. The paper presents a probabilistic technique based on the MC algorithm that calculates PV HC relying on consumer energy data obtained from SM equipment. According to the findings, the predicted PV HC is significantly greater than the result obtained using a deterministic worst-case technique.

In addition, the harmonic constrained HC of a 6-consumer rural DN in Northern Sweden is calculated in [86] relying on an MC-based stochastic study. While the HC in two of Sweden's DNs is assessed in [90], taking voltage unbalance into account. The negative-sequence voltage unbalance is calculated using a stochastic method based on the MC approach for each potential location of the DG.

Unlike the traditional stochastic techniques, such as the MC approach, a more effective technique known as Latin Hypercube Sampling with Cholesky Decomposition (LHS-CD) was first created in [93] for performing the PLF calculations in an Australian DN. Results show that this method is more accurate than the MC technique and requires less calculation time. In contrast, considering the probability distributions of the PV generation and consumer power consumption uncertainties was introduced in [94] using a cumulant-based approach, a more advanced version of the MC approach. Regarding risk assessment, authors in [95] proposed a numerical description of risk as the sum of the product of the probability of these contingencies and the consequence that will result from it (also known as the severity). In order to estimate the DN HC, authors in [92] introduce a novel risk assessment tool that considers PV, wind turbine, and load-related uncertainties. Additionally, the Sparse Grid Technique (SGT) is proposed as an efficient method for computing uncertainty, meanwhile the MC technique is used for comparison.

C. OPTIMIZATION-BASED METHOD

The last category of methods illustrated in literature for calculating the DN HC are those optimization-based methods. In such methods, the problem of computing the HC is modeled as an optimization problem where its objective is addressed mainly as maximizing the DG-HC while keeping the technical performance indices in the allowable range. In some works, in the literature, maximizing the HC is combined with other objectives, such as minimizing losses or cost, creating a multi-objective function such as [33,96,97]. While authors in [28,35,98–100] introduced the optimization problem as a single-objective function.

Additionally, different optimization techniques are presented in HC literature. The most popular technique is Particle Swarm Optimization (PSO), as presented in [96,101], because it is simple to use. Moreover, the Artificial Bee Colony (ABC) was introduced in [102] because it converges quickly. Robust

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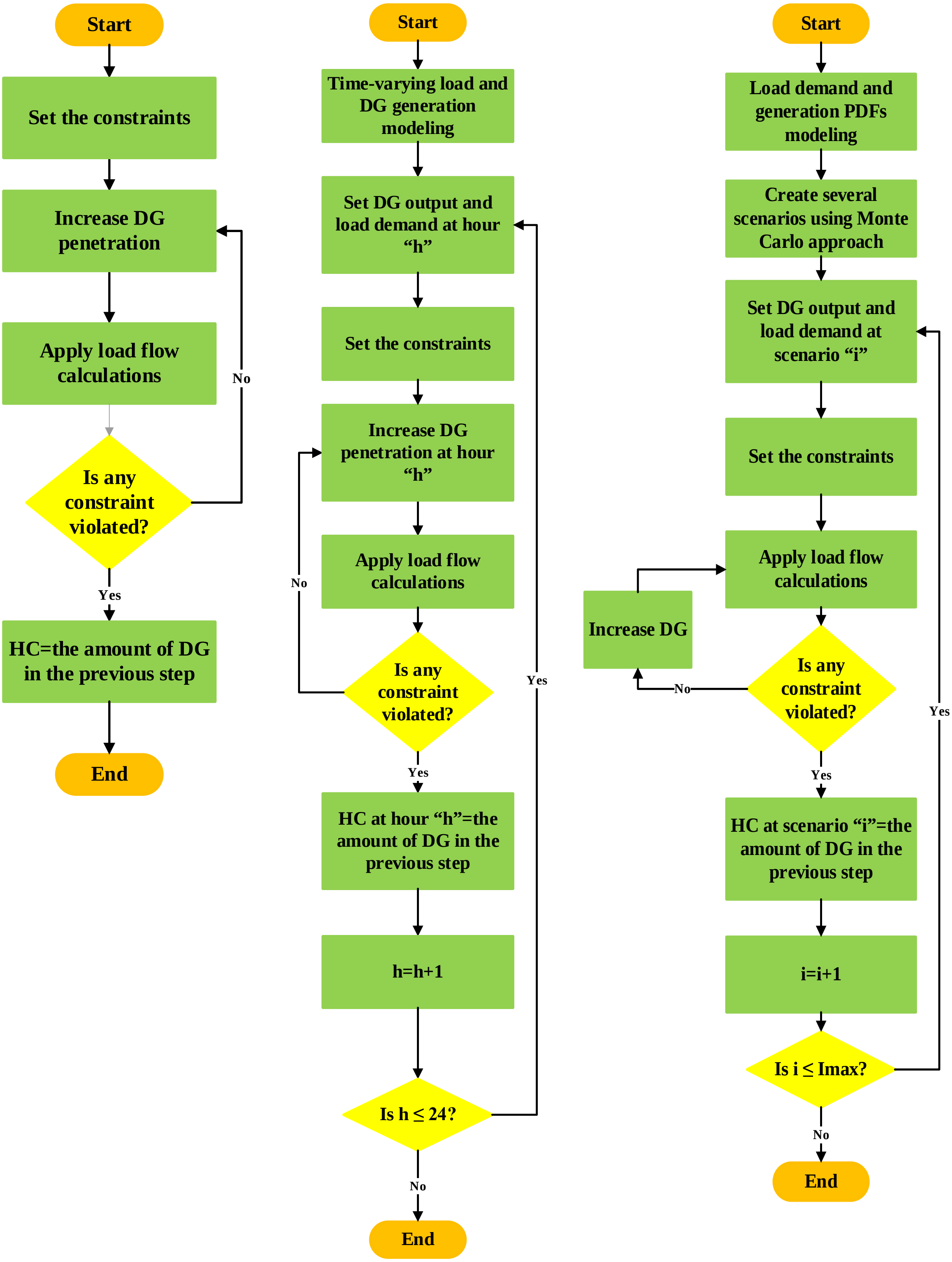

(a) (b) (c)

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content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3349235

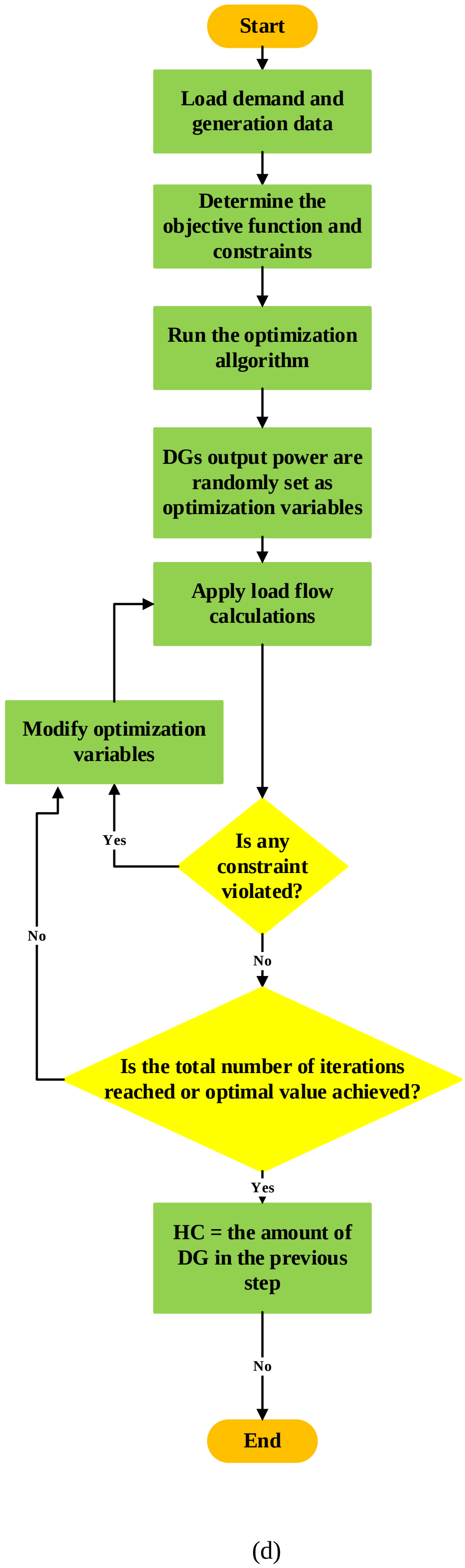

FIGURE 10: Flow charts of different HC determination methodologies: (a) constant-generation, (b) time-series (for one day), (c) stochastic, and (d) optimization-based.

optimization techniques are employed in [20,103,104] because the output of the DG, size, and location are considered uncertain.

The primary drawback of these optimization methods comes from the fact that they require several iterations to produce the optimal result. They also involve power flow analysis, which is iterative-based, which in turn means longer computational times. Therefore, it is recommended to choose an optimization technique that gives fast convergence [4]. To deal with nonlinearity of power flow equations, they are linearized, like in [28,100], using linear programming.

As a way to handle uncertainties in HC assessment, stochastic optimization (SO) and robust optimization (RO) have been the two most common methods presented in the literature. Some literature introduces a stochastic optimization approach for determining the maximum HC considering uncertainties such as [97,105]. Load consumption uncertainty is considered in [105], while the uncertainties in generation, i.e., wind power, are presented in [97]. In [105], a probabilistic multi-objective optimization approach considering load uncertainties of two

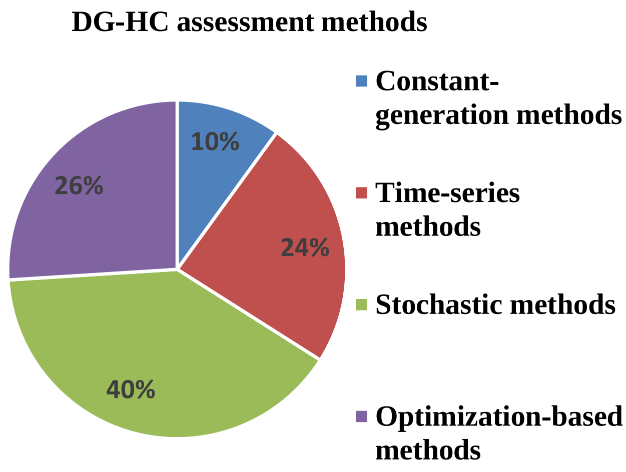

FIGURE 11: Summary of DG-HC assessment methods.

real DNs in Egypt and Taiwan is employed using two enhancement techniques, e.g., DN reconfiguration and soft open point (SOP). In DNs, SOPs have been placed instead of Normally Open Points (NOP) to combine the advantages of radial and mesh-operated networks while avoiding the disadvantages of both [106].

Regarding RO, to represent the stochastic character of the DG output and load profile, Pout of DGs and load demand are created probabilistically in [103]. The HC is determined using an RO technique based on a distributionally robust capacity assessment model (DR-CAM). Using the IEEE 33-bus system and the IEEE 123-bus system, the DR-CAM approach is validated and compared with the deterministic DG capacity assessment model (D-CAM). In contrast, the RO algorithm presented in [104] is validated via an unbalanced DN.

Regarding single-objective optimization, authors in [98] formulated the HC problem of a hybrid system for renewable energy, i.e., wind and PV resources, as a single-objective optimization problem. This article aimed to evaluate the merits of the hybrid system for renewable energy and compare it to one that used only one RDG technology. It was discovered that the hybrid system had a larger hosting capacity. Unlike HC, authors in [28] determined the maximum LC of IEEE 33 bus DN. Linearizing the power flow equations presented as an alternative for tackling the nonlinearity issue. The primary focus of multi-objective optimization issues is on conflicting objective functions, where improving one objective function deteriorates the other. As a result, numerous approaches have been employed to tackle such a problem, such as the weighted sum, Pareto-dominance-based, and ε-constraint [97]. Pareto-dominance-based approach is employed in [96], while the ε-constraint method is presented in [97] and [107]. Pareto-based bat algorithm is presented in [108].

Moreover, an approach for preferences ranking by closeness to the perfect result (TOPSIS) is employed to determine the optimal result between the Pareto solutions [105]. A Pareto-based multi-objective firefly algorithm (MOFA) is proposed in [109]. Finally, a comparison between the flow chart of each DG-HC assessment technique and a statistical summary gathered from publications are presented in Fig. 10, 11 respectively.

V. DISTRIBUTED GENERATION HOSTING CAPACITY ENHANCEMENT TECHNIQUES

Several technical solutions have recently been applied to raise the allowable HC level of DNs significantly. Based on technical issues caused by high penetration of DG in DNs, e.g., voltage level violation and higher harmonic content, the enhancement techniques have been contemplated to solve or mitigate these issues, which in turn enables DSOs to accept additional DG to be integrated into the DN and the HC level is enhanced. As stated in [2], DSOs, consumers, or both might apply these improvement methods as an interactive solution. The most common enhancement techniques mentioned in the literature are illustrated in Fig. 12.

A. NETWORK RECONFIGURATION AND REINFORCEMENT

Distribution Network Reconfiguration (DNR) involves modifying the state of switches, tie switches, and sectionalizing switches to change the topology of the DN. The DN has many candidate-switching possibilities, so the DNR problem is presented as an optimization problem [110]. The HC is enhanced during DNR in several works in the literature [111-113,116-119]. Additionally, based on time frame, DNR may be categorized to static and dynamic reconfiguration. The crucial difference between static and dynamic reconfiguration approaches is considering the load variance during the research period [120]. DN reinforcement is employed in [111,112] to enhance the DG-HC and deal with increasing loads. Network reinforcement (or cable reinforcement) means replacing smaller conductors with larger ones to provide the load while staying within the thermal limits.

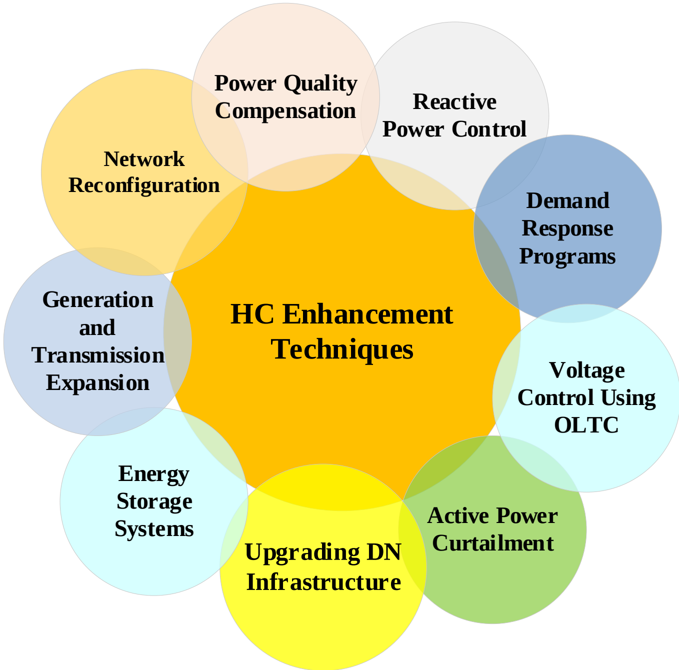

FIGURE 12: Summary of the most common DG-HC enhancement techniques

On the other hand, cable oversizing is not cost-free and will undoubtedly result in additional expenses. Therefore, optimizing the conductor size is crucial in DN planning. Authors in [112] introduced two different enhancement techniques, i.e., on-load tap changer (OLTC) and conductors' reinforcement, to enhance the PV HC level. After comparing results, the reinforcement approach is noticed to be more economical in case of lower penetration amount (up to 60%) in the studied network. In [111], the optimal size of the main feeder of a real DN in Egypt is selected among a library of 20 different cables to decrease yearly costs of power loss besides the capital cost of feeders using a slap swarm optimization algorithm. Regarding comparing static and dynamic reconfiguration, authors in [115] investigate how both static and dynamic DNR might boost the HC level of DNs. According to results, dynamic reconfiguration can result in a higher DG-HC than static reconfiguration due to its flexibility to adjust to shifting operational conditions. However, there are several negatives, including the cost of switching actions' wear and tear and the possibility of failure. The authors in [116] introduced a novel technique to deal with the numerous switches involved in the DN.

On the other hand, the shortest route methods are employed to determine the minimum cost of modifications needed to achieve a target penetration amount of PV is introduced in

[114]. The HC of renewable energy is maximized via a novel two-stage approach in [119].

B. Power Quality Compensation

Various power quality issues, e.g., harmonics, flickers, and unbalance, might appear in case of excessive penetration of DG into DNs. Therefore, studies have suggested different technical solutions to mitigate these power quality issues, enhancing the DN HC. The impacts of DG's excessive penetration on aspects related to power quality are proposed in [51,57,59,109,121-127].

Regarding harmonics mitigation, the HC enhancement via optimal passive filter design in a distorted DN with PV-based DG units is addressed in [51] and [109]. A single objective function is used to construct the optimization problem in [51]. In contrast, [109] formulated a multi-objective function for HC maximization and PF at the Point of Common Coupling (PCC), taking the filter design parameters and DG capacity as optimization variables. In [51], for the sake of maximizing the DG-HC of the test system while adhering to the limitations, a passive filter of type "C" is developed. The suggested filter could achieve higher HC levels after comparing it to three other traditional filter designs. The authors in [109] concluded that the HC enhancement obtained by the novel strategy, i.e., MOFA, is markedly more prominent than that achieved based on the methods that were most recently mentioned in literature. With the suggested method, the overall filter cost for improving the HC of the system is also considerably reduced.

Additionally, two power quality problems, voltage fluctuation and unbalance, might arise due to excessive penetration of domestic PV systems into DN. Therefore, different objectives, i.e., DG cost minimization, DN total active power loss minimization, and voltage unbalances factor minimization, were combined with proper weighting factors in [125], forming a multi-objective to tackle these two problems. In contrast, the Imbalance distribution of one-phase PV systems causes the neutral voltage rise issue. Therefore, an innovative dynamic mitigating strategy relying on community energy storage is presented in [124] to tackle this issue. Moreover, for power quality improvement in a single phase DN integrated into PV and wind energy generation system, an amplitude adaptive notch filter (AANF)-based control method is presented in [126]. The system's performance is evaluated on a designed prototype in the laboratory. While the study of a 33-bus DN includes an effective inverter's voltage control technique, it is presented in [127]. This mechanism reacts quickly to reduce voltage fluctuations and flicker.

C. Energy Storage Systems

Energy storage devices assist in reducing the overvoltage caused by higher DG amount, increasing the system's HC. Battery Energy Storage Systems (BESS) are the most widely used technique of energy storage in HC enhancement. However, energy storage still has a high cost and has certain advantages that cannot be obtained through other methods. The DSO's plans for DN reinforcements might be delayed by the BESS's proper sizing and allocation [2]. In [27,36,118–128], the influence of energy storage systems on the allowable limit of DG penetration was introduced.

Using BESS and forecasting together, an almost doubling HC improvement from 19.64% to 39.29% has been observed in [131]. The proposed methodology analyzes the merits of short-term PV forecasts and BESS to raise the PV HC. In addition, coordinating the operation of three voltage regulators and BESS enables a DN in Canada to boost its HC by 60% [130]. However, the authors claimed that in the feeders with poor connections to the main grid, the BESS would be a cost-competitive alternative to raise the HC as opposed to grid reinforcement options.

Although using BESS in high DG penetration cases is a beneficial strategy for avoiding overvoltage and, in turn, enhancing HC, energy storage control (or management) is required to achieve higher HC with a lower required capacity of energy storage [132,139]. In order to prevent overvoltage and boost the FHC of PV in a real feeder in Denmark, an innovative control strategy depending on the voltage sensitivity analysis was suggested in [132]. According to results, installing just 5 kWh of battery per consumer can enhance HC by as much as 50%. In comparison, a decentralized energy storage approach is proposed in [139] to avoid overvoltage in a real feeder in Belgium with high amount of PV. Unlike the conventional strategy of operating BESS, each BESS in this study is activated at a specific threshold PV output power (PTH) determined by the proposed technique based on avoiding overvoltage. In addition, the BESS capacity and location can be optimized to achieve maximum HC, as presented in [48,128,133]. By determining the optimal BESS allocation, authors in [128] suggest a BESS planning approach to maximize the PV HC of an unbalanced DN in Australia, considering uncertainties. A SO-based technique is employed to solve the problem. According to the findings, the HC was significantly increased, and the phase imbalance was reduced by installing the BESS in the optimal sites. A proposed technique for capacity and site optimization of a central BESS to raise the HC in a German DN is presented in [48].

On the other hand, studying the economic feasibility of installing BESS to enhance HC is presented in [135,136]. It was suggested in [135] to employ a systematic approach regarding choosing when to use storage systems. The authors compared BESSs with other alternative HC improvement strategies due to the high cost of BESSs. It is concluded that network upgrades may be delayed by the battery storage systems' proper sizing and placement. In addition, a cost-based multi-objective optimization technique was employed in [136] to find the optimal BESS size. Finally, with the goal of higher wind energy penetration in a remote DN, authors in [140] examine the control mechanisms for DGs, BESS, and demand response. The study controls frequency variations, and wind energy is maximized by energy storage and demand response. Results indicated that energy storage and demand

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response could provide the desired frequency response while also successfully compensating for wind variability.

D. ACTIVE POWER CURTAILMENT

To maintain the grid's operational limitations, Active Power Curtailment (APC) takes place when DG units are requested to reduce their output power to fit the load demand needs [2]. APC is one of the most economical alternatives to expensive grid upgrades, which might be necessary only for a few hours [141]. Several works introduced APC methods to enhance the DG-HC, such as [34,130-136]. The deployment of advanced communication technology between power system operators and DG units plays a significant role in achieving the most effective APC [7,145]. The APC of the generated power by consumer PV systems based on the Internet of Things (IoT) is proposed for increasing HC in [7]. In addition, the authors described the APC approaches and their participation in HC increase [145]. It is concluded that the DG curtailment ought to be evaluated while taking into account both technical and economic factors as it would not be profitable to purchase new DG unit additions and then limit the extra power for extended periods. In addition, APC can be classified into two types: hard curtailment and soft curtailment [141,146]. Authors in [146] discuss using APC to overcome overcurrent and overvoltage limitations and connect more wind or PV to four case studies. It has been demonstrated that soft curtailment usually increases the overall quantity of energy produced from DGs. In [144], different PV penetration scenarios are examined for DNs in rural, urban, and remote areas with varying levels of PV penetration. Findings demonstrate that curtailment is the strategy that is most economical to enhance the PV HC compared to BESS and reactive power control. By choosing a probabilistic strategy in [46], a slight APC applied to PV power allowed for raising PV penetration twice. Finally, one of the common issues in literature is the unfairness in APC distribution between the installed PV inverters in the system [137,138,142]. A novel approach is utilized in [149] to evaluate the fairness of various PV-curtailment schemes from several viewpoints. The authors in [142] showed that the curtailment needed in DNs when adopting optimal inverter dispatch is around half that necessary when employing the Volt/VAr scheme. The main novelty of this study is proposing the fair optimum inverter dispatch formulation, that makes certain that the power curtailment is distributed equitably among all the consumers.

E. VOLTAGE CONTROL USING ON-LOAD TAP CHANGER

Incorporating OLTC is among the most efficient strategies of voltage control that can automatically compensate for the DN voltage profiles. As a way to keep the transformer output voltage throughout the required bounds, the tap position is changed, which in turn alters the turns number in one winding of the transformer, often on the high voltage side [150]. The effect of OLTC on HC is presented in several literature works such as [102,140–150]. The techno-economic merits of equipping OLTC with transformers to handle high PV penetration rates are introduced in [112], and the findings are compared to conventional network reinforcements. It is demonstrated that the reinforcing alternative is more economical in lower penetration levels (up to 60%). In addition, the effect of the number of taps is illustrated in [161]. A 5-tap and 9-tap OLTC are employed to raise the PV HC in 631 French DNs. Findings show that DNs vary significantly concerning the effect of OLTC on their HC. Additionally, the OLTC with nine taps does not significantly boost HC compared to the one with five taps for the tested networks.

It is noticed that some literature works introduced more than one technical solution to tackle the overvoltage issue and, in turn, enhance HC [158,160]. Two improvement methods, i.e., OLTC and voltage control via PV inverters, are presented in [160] to raise the HC. The authors introduce a novel concept of the cable's critical length. It is defined as the length at which the performance limitations begin to go over their limits. OLTC and capacitor banks were introduced in [158] to tackle the overvoltage problem associated with high PV penetration in a real DN in the UK. In [152], OLTC, inverters reactive power control, network reinforcement, and hybrid of these methods are employed to enhance DG-HC and then compared. The findings show that a network upgrade is the best strategy to maximize the HC from a technical perspective, but economic perspective does not support its viability. Additionally, OLTC employment will double HC in case of tighter voltage limits. Moreover, when OLTC is shown to be the more costly (low PV penetration circumstances), reactive power control is the sole method that might be used.

Regarding experimental studies, authors in [162] introduced the advantages of two enhancement methods, i.e., OLTC and network balancing, on HC. A novel experimental planning tool in Belgium to compute HC is used. Findings show that the proposed methods can achieve a 67% rise in HC. Moreover, authors in [159] estimate the maximum PV HC of a rural DN in Brazil using a time-series-based assessment approach. The HC is limited by voltage level and overload in distribution transformers. Thus, the technological effect of using OLTC and VAr absorption was studied to boost this capacity.

F. REACTIVE POWER CONTROL

The biggest obstacle to substantial DG penetration is thought to be overvoltage issues. The most successful techniques for resolving these issues are reactive power control techniques. Shunt and series capacitor banks, STATCOM, and reactive power control via PV inverter are just a few examples of the various reactive power control methods that can be employed [1,2,138]. The influence of reactive power control (RPC) on the HC of DNs is illustrated in [9,152–162]. A novel probabilistic mathematical formulation is illustrated in [164-165] to optimize the HC of renewable energy while preserving the allowable limits at the lowest possible cost via energy storage units and capacitor banks. To be novel, the proposed method optimized the size and location of DGs, i.e., solar and wind, energy storage units, and capacitor banks simultaneously.

Authors in [103] evaluated the influence of OLTC and controlling the output reactive power of the integrated DG unit, following the $Q(V)$ approach, on HC improvements. It is mentioned that during periods of high DG penetration, RPC in rural regions may result in an unbalanced flow of reactive power. To balance reactive power flows, it was suggested to install DG sources adjacent to substations. The authors in [163] examine how RPC via the PV smart inverter affects the feeder PV HC. It employs a $Q(V)$ droop control technique and simulations in OpenDNS and MATLAB. It was discovered that smart inverter characteristics improved the feeder HC. For HC enhancement, [169,171] have used combined APC and RPC techniques. As stated in [169], the findings of applying the APC technique show the effectiveness of this strategy in keeping the voltage within the accepted standards, but it might cause unfairness in APC distribution between the installed PV inverters.

Regarding RPC, findings illustrate that the inverter should be oversized by almost 18% to extend its operation region. A comparison between APC, RPC, and combined active-reactive power control is conducted in [171]. It is discovered that implementing APC is a vital step to significantly enhance voltage quality and boost the PV HC in DNs.

G. DEMAND RESPONSE PROGRAMS

Demand response (DR) programs, e.g., price-based or direct load control, significantly improve the DN voltage profile, enhancing HC. However, effective execution of DR necessitates sophisticated optimization challenges. Instead of costly solutions such as DN upgrades, DR programs represent an economical alternative to overcome voltage quality issues during high penetration periods of RDGs, relieve stress on the grid during peak demand, and, in turn, create an opportunity to increase the HC [167,173].

Authors in [173] formulated a multi-objective optimization to achieve several objectives simultaneously, i.e., minimizing the cost of DR, the total losses cost, voltage unbalance, and enhancing the voltage profile. The coordinated operation of domestic DR and OLTC using a Particle Swarm Optimization (PSO) technique is a powerful solution for voltage management and, in turn, voltage-constrained PV HC enhancement. At the same time, DR and switchable capacitor bank scheduling are two efficient methods [167] to enhance wind-based HC. According to findings, applying DR and capacitor switching raises the HC by about 26.3%.

A load-shifting DR approach was also suggested in [174] to raise the PV HC. A 33.6% average increase in PV HC was achieved after applying the proposed scheme. On the other hand, a DR program based on load shifting is applied in [175] to maximize wind-based HC and minimize the system losses simultaneously. However, a DR scheme based on switching flexible loads, e.g., water heaters, is suggested in [176] to enhance PV HC. A DR program is applied in [177] to tackle the overvoltage issue brought on by higher penetration of PV panels. This study presents an approach to control the use of the home's air conditioner and electrical water heater to prevent voltage raise, which would boost PV hosting capacity.

H. Upgrading Network infrastructure

When the integration of DG causes operational issues on the DN to diverge from allowable limits, DN upgrades become necessary, and mitigating measures must be put in place to guarantee power quality, safety, and dependability. As the DG-HC term refers to the higher penetration level at which the DN still operates within accepted limits without infrastructure upgrading, some modifications, such as conductors oversizing, raising transformers ratings, and integrating voltage regulators, may enhance this DG-HC [178,179].

DN infrastructure upgrading was introduced as an effective solution for HC improvement in various recent publications [111, 178–182]. Depending on two upgrading alternatives, i.e. replacing feeders, and installing voltage regulators, authors in [182] introduced a multi-objective optimization scheme to enhance DG-HC and minimize the upgrading cost simultaneously. To guarantee the proposed scheme robustness, load consumption and DGs output are considered time-varying and uncertain. Findings show that the proposed DN infrastructure scheme can dramatically raise DG-HC to almost 65%. On the other hand, upgrading cost function is formulated as a function in PV penetration amount for three real feeders in US as presented in [179].

Cables oversizing is one of the most effective upgrading actions to enhance HC as illustrated in [111,180]. 10 mm^2 cables of a Swedish DN are oversized to higher cross-sectional areas, without any cost calculations, and then the voltage-restricted HC is calculated in [180]. Findings reveal higher HC is achieved with higher cross sectional area cables. While a slap swarm optimization algorithm is employed in [111] to determine the optimal size of the main feeder of a real DN in Egypt from a library of twenty different cables in order to reduce annual costs of power loss in addition to the capital cost of feeders.

On the other hand, some recent publications focused on the track of comparing DN upgrading with other enhancement techniques as presented in [178,181]. Authors in [181] compare PV curtailment and DN infrastructure upgrading, from economical point of view, to determine which is the least expensive way to eliminate network violations and integrate higher PVs. It is revealed that DN upgrading becomes reasonable at the breakeven point, which is the intersection of curtailment and upgrade costs, since the marginal cost of curtailment is greater than the upgrade cost. While DN upgrading is compared in [178] with Volt/Var control and energy management system with four points of comparison, i.e. effectiveness, total cost, amount of curtailed output power and total losses.

I. Generation and Transmission Expansion Planning

An alternate and practical solution to the issues raised by the extensive usage of RDGs is to raise the HC during the planning stage. A lot of effort is still being made to develop planning strategies that can raise the HC and prevent the previously listed issues [183]. Although there have been a number of planning models put forth to boost the integration of DGs, there is currently a lack of research in the literature to quantify the capacity of the networks to host RDGs, during the planning stage, that adhere reliability and security requirements [183,184]. Recent publications, for example [183–186], conducted research to enhance DG-HC, during the planning phase, depending on generation and transmission expansion planning models.

A proposed DG-HC planning approach is suggested in [183] to supply future load demands. To forecast yearly load growth, a load forecasting approach based on adaptive neural fuzzy technique is integrated with the planning model. in addition, a hybrid optimization method is developed which incorporates the features of two meta-heuristic techniques. The primary goal is to determine the best locations and sizes of fault current limiters, and BESSs in order to raise the HC level and ensure the reliability and security requirements. While smart inverters are implemented into a proposed expansion strategy to enhance the voltage-restricted PV-HC through planning years in [186]. Findings illustrate that a 50%-increase in PV-HC can be achieved through the proposed technique.

When it comes to [184], DG-HC is maximized through planning period considering batteries and fault current limiters using a combined artificial rabbits and sine-cosine techniques. The proposed approach is applied to Garver DN and shows almost a 100% increase in DG-HC. While a bi-level proposed approach is applied in [185] to minimize the total cost of generation and transmission expansions first and then the DG-HC calculations are executed. Findings demonstrate that limitations considered in HC assessment level greatly affect the best plans for transmission expansion and dramatically raise system costs overall. Finally, the published papers that studied DG-HC are summarized in Table 5.

VI. HOSTING CAPACITY OF ELECTRIC VEHICLES

More than a quarter of all greenhouse gases are emitted by the transportation sector, which is the main source of CO_2. This prompted governments and people worldwide to encourage using electric vehicles (EVs) to decrease these harmful emissions. In 2020, sales in the EV sector climbed by 137% in the European Union and 43% globally. Nearly 50% of Sweden's newly registered passenger cars during December 2020 were plug-in hybrids or electric-based. In the United States, EV electricity usage climbed from 0.1 terawatt-hours to 1.9 terawatt-hours between 2012 and 2017. The excessive increase in EVs integrated into the DN has some technical issues that should be considered [3,187,188].

A. IMPACTS OF GRID-CONNECTED ELECTRIC VEHICLES ON DISTRIBUTION NETWORKS

While using EVs more frequently has introduced several positive effects, the excessive penetration of grid-connected electric vehicles (GCEV) into DNs has some negative impacts, as shown in Fig. 13. The merits of integrating GCEVs into DNs are summarized in Table 6. In contrast, the demerits are introduced in Table 7.

B. THE EFFECT OF INTEGRATING EVS ON DG-HC

Whereas many studies proposed various approaches to assessing the DG-HC, only [203-207] considered the effect of GCEV integration on the DG-HC problem. The work presented [204] is considered the first article that took the effect of the EV charging process into account during DG-HC calculation. As mentioned before, DSM programs can be applied to enhance the DG-HC. Due to their growing use, GCEVs offer a significant promise for DSM. This section presents the consequences of integrating EVs into the DG-HC problem; however, the EV-HC is discussed in the

TABLE 5: DG-HC publications summary.

Ref.	Year	Limiting factors	Assessment methods	Enhancement methods	Comments
[165]	2016	Voltage limits Feeders ampacity	Mixed-integer linear programming optimization	BESS, Capacitor banks	The size and site of DGs, capacitor sizes, and battery capacity are optimized simultaneously.
[115]	2015	Voltage Limits Thermal loading	Mixed-integer linear programming optimization	Static and dynamic network reconfiguration	Dynamic reconfiguration enhances the HC more than static reconfiguration.
[145]	2011	Overvoltage Thermal loading	Deterministic approach	APC	APC should be assessed considering both technical and economic conditions.
[128]	2021	Voltage rises Voltage imbalance	Mixed-integer Linear programming optimization with Monte Carlo method	BESS	Optimal sizing and site of BESS enhance the HC.
[111]	2018	Voltage limits Feeders ampacity	Salp swarm optimization	Conductors' reinforcement	Optimizing the conductors' sizes is crucial.

[109]	2021	Voltage limits Thermal loading THD	Pareto-based MOFA optimization algorithm	Harmonics mitigation (passive filter)	The proposed technique achieves lower filter costs with accepted performance.
[112]	2015	Voltage limits feeders ampacity	A proposed stochastic approach	OLTC conductors reinforcement	Reinforcement is more economical (for lower penetration levels).
[51]	2017	Voltage limits Thermal loading THD	GA	Harmonics mitigation (*C*-type filter)	The proposed filter type achieves higher HC compared to the conventional one.
[131]	2019	Voltage limits	Sky-imagery technique for PV forecast	Short-term PV forecast BESS	HC is almost doubled by applying the proposed technique.
[7]	2021	Overvoltage limits	MATLAB Simulink	APC using IoT technique	IoT technology has a strong effect on HC increase
[157]	2017	Voltage limits	Monte Carlo	OLTC, Capacitor banks	The technique proposed can replace remote monitoring.
[173]	2018	Voltage limits	PSO	OLTC, DR program	Total losses in case of OLTC with DR is less than considering DR only
[182]	2022	Voltage magnitude Thermal limits	Pareto optimal method	Upgrading network infrastructure	To guarantee the proposed scheme robustness, load consumption and DGs output are considered time-varying and uncertain
[183]	2022	N-1 security Short circuit current Thermal limits	Hybrid optimization algorithm	Generation and transmission expansion planning	To forecast yearly load growth, a load forecasting approach based on adaptive neural fuzzy technique is integrated with the planning model
[174]	2022	Voltage limits	A proposed iterative optimization method based on linearizing power flow equations	Load-shifting DR program	A 33.6% average increase in PV HC was achieved after applying the proposed scheme
[181]	2023	Voltage limits	Monte Carlo	PV curtailment DN infrastructure upgrading	PV curtailment and DN infrastructure upgrading is compared from economical point of view

TABLE 6: EVs integration into DNs merits.

Impact	Brief description
Renewable energy enhancement	RDG can be enhanced by achieving minimum cost and greenhouse gas emissions using GCEVs [180]. The most economical solution is to install RDG with storage using fast-charging EV stations [181].
Voltage and frequency regulation (via V2G capability)	The effect of GCEVs on regulating the frequency of a Danish DN via V2G facility [182]. With the facility of V2G, GCEVs offer several positive effects, such as voltage regulation, frequency management, active power management, and load balancing [183].
Power management	Using planned charging and discharging can improve power management [184].
Power quality support	Using smart parks might introduce power quality improvement, as illustrated in [185]. The ability of V2G facility to improve the voltage stability of the DN (considering uncertainties of EVs) is presented in [186].

TABLE 7: EVs integration into DNs demerits

Impact	Brief description
Stability problems	Since EV demands are non-linear and require a huge amount of power in a small period, they make the power grid unstable [187]. GCEVs can improve the stability of the DN if it is correctly controlled [188].
Power loss increase	A significant quantity of real power is consumed as EVs become increasingly integrated into the grid, resulting in distribution system power loss [189]. Since 60% of the EVs are connected to the grid, the power loss increase can climb to 40% in the off-peak hours [189].
Harmonics	Because EV chargers are power electronic equipment, they produce harmonics during power conversion, and if their penetration is larger, they raise the harmonic content in the DN [190]. Some studies find that the voltage THD percent produced by a few numbers of fast charging stations reached 11.4% [190].
Voltage unbalance and voltage profile problems	Because EV chargers are single-phased, charging many EVs simultaneously might result in phase unbalance [190]. The voltage of some buses decreases significantly (below the allowable limits) when more than 50% penetration of GCEVs is considered [191].
Transformer and cables overloading	Huge numbers of GCEVs provide an incremental load demand which needs to be produced and delivered. The new demands are too much for the components of the existing power systems, that may result in overloading and decrease transformer lifetime [190] [192].
Load demand rise	Almost 1000 TWh increase in load demand can be added by GCEVs [184]. Unscheduled charging increases load consumption through peak periods., which can be a huge utility problem [193].

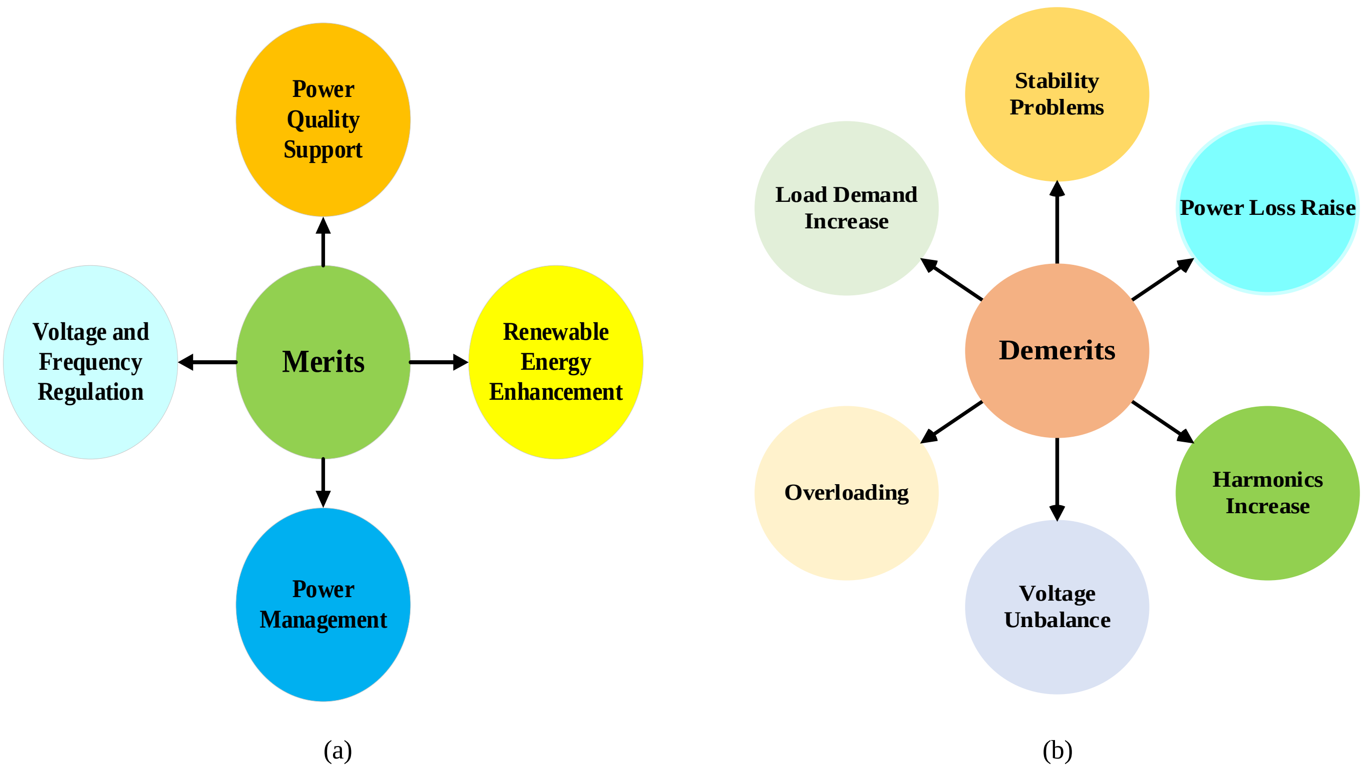

FIGURE 13: Impacts of integrating EVs into DNs (a) merits; (b) demerits.

following section. The HC of wind-based DGs is presented in [206] as a two-stage optimization problem; maximizing the penetration of the DG units via OLTC was the first stage and minimizing the energy loss by optimizing the charging/discharging process of EVs was the second. The mixed-integer linear programming approach was applied to formulate the optimization problem. The findings indicate that, compared to the uncontrolled strategy, managing the charging/discharging process of GCEVs can boost the DG-HC by up to 15%. Similarly, authors in [205] applied a bi-level optimization problem to maximize the wind-base DG-HC via controlling the charging/discharging process of GCEVs, OLTC, and RPC. The gravitational search algorithm solved the optimization problem. The findings show that the best enhancement of HC occurs when using all these methods simultaneously. By considering a different DG type, i.e., PV HC, in [203], the authors also proposed a bi-level optimization approach for optimizing the DG-HC via controlling GCEVs, OLTC, and RPC charging. One of the challenges faced in considering EV charging/discharging operations in DG-HC assessment is modeling the uncertainties related to this process. In addition, publications that simultaneously assess the DG-HC and EV-HC in AC DNs are rare. Only [208] and [209] were published in this area. A multi-objective optimization problem was proposed in [209] to maximize the penetration level of PV and wind DGs to minimize the total losses besides maximizing the EV demand in the DN simultaneously without violating the allowable limits of bus voltages and cable thermal loading. The findings show that, contrasted to the scenario of uncontrolled EV charging, it is possible to boost the DG penetration by 9% by controlling the consumed power by EV aggregators. Authors in [208] calculated the DN HC of both PV-based DG and EV demand simultaneously in four energy management cases: (i) uncontrolled scenario, (ii) controlling EVs charging only, (iii) with APC of PV units only, and (iv) with both EVs charging control and APC of PV units. Considering the uncertainty of EVs, authors in [210] assessed the maximum DG-HC and EV-HC simultaneously in an islanded DC grid.

C. ELECTRIC VEHICLES HOSTING CAPACITY

The term EV-HC has recently been introduced in different works to find the maximum EV charging demand, or EV number, that can be accommodated in the DN without experiencing technical issues or requiring infrastructure adjustments [20]. Various articles discussed EV-HC assessment and enhancement, such as [3, 20, 87, 187, 188, 211–217]. Like DG-HC publications, research articles in EV-HC also cover two main groups: EV-HC assessment and HC enhancement. Authors in [3,87,187,212,215,216] applied stochastic methods to tackle the uncertainty in EV charging demand, while [20,216,217] formulated the EV-HC problem as an optimization problem. To our knowledge, publications that solved the EV-HC problem by deterministic methods are rare, as the charging load of the EV could not be assumed as a fixed profile. Authors in [213] only proposed a simple iterative method based on assuming a deterministic load.

In contrast to the DG-HC publication area, papers that recommend techniques for EV-HC enhancement are still few. Authors in [211,217] studied different methods to increase the

EV-HC. Regarding EV-HC evaluation, authors in [20] formulated the HC problem as a two-stage optimization problem, considering the uncertainty of EV charging load to minimize the operating cost. They proposed a chargeable region optimization concept to define the EV charging profile without the complex communication between the DN aggregator and EV owners. When it comes to [216], the number of GCEVs that can be connected to the recommended DN was maximized using a linear programming solver. After calculating, EV-HC was determined for the chosen buses daily. On the other hand, the authors in [3] tackled the EV-HC problem as a stochastic method, with no optimization applied, which was solved by the MC approach. Depending on survey data, the charging load of EVs was defined as PDFs. The findings indicated that the EV-HC, considering the uncontrolled charging scenario, was 438 cars, while it reached 1510 cars in case of applying the controlled scenario. To decrease the execution time, authors in [212] applied a novel technique called the parallel computation concept. The HC problem was formulated as a time-series quasi-static problem and solved by the MC approach. The computation time decreased by almost 73% after applying the proposed approach.
Additionally, authors in [87,187] applied stochastic methods adapted from DG-HC publications to assess the EV-HC. The maximum number of GCEVs that can be connected to each bus of the DN was calculated in [87], relying on the Combined Cumulants and Gram-Charlier approach. Findings illustrated that the EV-HC strongly depends on the site of connecting the charging station. Regarding [187], the authors implemented an MC-based approach, executed previously to calculate PV HC, to assess the EV-HC. Taking both aleatory and epistemic uncertainties into account, the maximum charging load of EVs was determined based on under voltage constraints. Moreover, a novel technique based on the Interval Undervoltage Probability method (IUP) was applied to assess the EV-HC [214]. The proposed method achieved better performance compared to other conventional methods. However, it has some limitations, e.g., it could not consider Vehicle-to-Grid (V2G).
Regarding EV-HC enhancement, authors in [211] proposed a demand response program based on optimal charging/discharging operations of EVs to enhance the DN reliability, which raises the EV-HC. Given that the excessive integration of EVs to DN affects its reliability negatively, authors proposed different reliability indices as the limiting factors of EV-HC. The MC approach was presented to calculate the system's reliability. Findings indicate that the proposed method could raise the EV-HC. The EV-HC problem was presented as an optimization problem in [217]. Applying the GA method, the number of EVs and tie-switch statuses were considered the optimization variables to maximize the EV-HC. Findings indicated that the optimal network reconfiguration can raise the EV-HC in DNs. Finally, Table 8 summarizes the articles that studied EV-HC.

VII. DISCUSSION

Excessive penetration of DGs, especially renewable-based, into DNs causes some technical issues; therefore, choosing proper limiting factors to restrict this DG-HC is crucial. The node overvoltage is considered the most common performance index in literature, while components thermal loading, which occurs during high generation and low demand, comes second. Transformer overloading limitations are less rigorous than the cable overloading restriction. Additionally, a few authors decided to limit DG-HC via unusual but effective indices such as reliability indices.
In addition, the most common DG technology in HC studies is PV. Given that HC is a location-dependent concept, it is shown that if PV interconnection points are closer to the substation and have lower impedance, a higher PV hosting capacity may be attained. In addition, as concluded from some literature, combining different renewable energy technologies has a larger hosting capacity than integrating just one. Moreover, a few DG-HC studies applied constant generation approaches to assess the DN HC. Stochastic methods are the most widely used approach for calculating DG-HC. Several mathematical techniques exist to generate random possible scenarios, but MC simulation is the most widely used. Moreover, to reduce computation times, linearizing power flow equations, a vector quantization approach, and considering only seasonal variation in load profiles were presented in the literature.
Network reconfiguration is an effective technique to enhance DG-HC. Dynamic reconfiguration can result in a higher DG-HC than static reconfiguration, while it involves some negatives. In addition, the optimal design of a passive filter to mitigate harmonic effects might enhance DG-HC, especially in distorted DNs. Energy storage devices assist in reducing the overvoltage caused by high DG penetration, increasing the system's HC. BESS is the most common energy storage technique in HC enhancement. BESS is still expensive, so performing a feasibility study and optimizing its size and site is recommended. In some situations, the BESS would be cost-competitive compared to grid reinforcement options. Finally, APC is one of the most economical alternatives to other expensive enhancement techniques, e.g., network upgrades and OLTC; however, effective APC requires advanced communication technology between DSO and DG units. While using EVs more frequently has introduced several positive effects, the excessive penetration of GCEV into DNs has some negative impacts. Publications considering the effect of GCEV integration on the DG-HC problems are rare. It is noticed that managing the charging/discharging operation of GCEVs has a strong effect on DG-HC raise.
Similar to DG-HC publications, research articles in EV-HC can also be divided into two main groups: HC assessment and HC enhancement. Most EV-HC papers discussed EV-HC assessment, and only a few papers proposed techniques for enhancement. It is shown that EV-HC strongly depends on the site of connecting the charging station. Given the similarity and convergence between DG-HC and EV-HC concepts, the assessment approaches applied in the literature

to calculate DG-HC could be adapted and used to assess the EV-HC, such as MC and Gram-Charlier Expansion. Finally, a novel idea has recently been proposed in a few publications. They assessed the DG-HC and EV-HC simultaneously. The most common research points mentioned in both DG-HC and EV-HC publications are summarized in Fig. 14.

VIII. CONCLUSION

The term HC has recently been proposed in power system publications to determine the maximum capacity of these newcomers, e.g., DGs or EVs, that could be integrated into the DN without breaking the accepted operation. However, it is commonly used in literature for DG-HC, and EVs HC comes second. Unlike HC, some papers calculated the loading capacity of the DN.

This paper presents a comprehensive and organized review of the DG-HC and EV-HC research for the first time. Similarities and differences between these two publication areas are illustrated. This article includes the different uses of the term HC, the most common performance indices, the various methods for assessing HC, the different techniques for HC enhancement, the contribution of DSM programs to raise the HC, the effects of integrating EVs on the DG-HC, and finally calculating and enhancing methods for EV-HC.

REFERENCES

[1] S. Fatima, V. Püvi, and M. Lehtonen, “Review on the PV hosting capacity in distribution networks,” Energies, vol. 13, no. 18, 2020, doi: 10.3390/en13184756.
[2] 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. Elsevier Ltd, pp. 1002–1020, Jan. 01, 2019. doi: 10.1016/j.renene.2018.07.008.
[3] M. Kamruzzaman, N. Bhusal, and M. Benidris, “Determining Maximum Hosting Capacity of Electric Distribution Systems to Electric Vehicles,” 2019 IEEE Ind. Appl. Soc. Annu. Meet. IAS 2019, pp. 1–7, 2019, doi: 10.1109/IAS.2019.8911848.
[4] M. Z. Ul Abideen, O. Ellabban, and L. Al-Fagih, “A review of the tools and methods for distribution networks’ hosting capacity calculation,” Energies, vol. 13, no. 11, pp. 1–25, 2020, doi: 10.3390/en13112758.

TABLE 8: EV-HC publications summary.

Ref.	Year	Limiting factors	Assessment method	Enhancement technique	Comments
[211]	2020	Reliability indices	Monte Carlo (stochastic method)	Demand Response (DR) program	Controlling charging/discharging enhances EV-HC
[20]	2017	Voltage Constraints	Modified column and constraint optimization method	-	The concept of chargeable region is first proposed.
[3]	2019	Voltage constraints	Monte Carlo	-	EVs HC=438 cars (uncontrolled case) EVs HC = 1510 cars
[212]	2020	Voltage constraints, thermal loading, and THD	QSTS with Monte Carlo	-	Applying parallel computation to reduce simulation time
[87]	2019	Voltage constraints	Combined Cumulants and Gram-Charlier approach (stochastic)	-	Proper selection of charging station sites affects EV-HC positively
[187]	2021	Undervoltage limit	Monte Carlo	-	Both aleatory and epistemic uncertainties are considered
[214]	2021	Voltage Constraints	IUP (stochastic)	-	One of its limitations, it could not consider V2G
[215]	2018	Undervoltage limit	A stochastic method based on the risk of undervoltage	-	EV-HC= 45% (for the proposed case study)
[217]	2020	Reliability constraints	Monte Carlo & Genetic Algorithm (optimization)	Feeder reconfiguration	Optimal feeder reconfiguration enhances both EV-HC and system reliability
[216]	2020	Voltage constraints and thermal loading	Monte Carlo with linear programming solver (optimization)	-	The proposed case study can host 20-41 electric cars.
[213]	2021	Voltage constraints, and feeders’ ampacity	Simple iterative algorithm without considering uncertainties	-	The number of fast charging stations that could be hosted is introduced.

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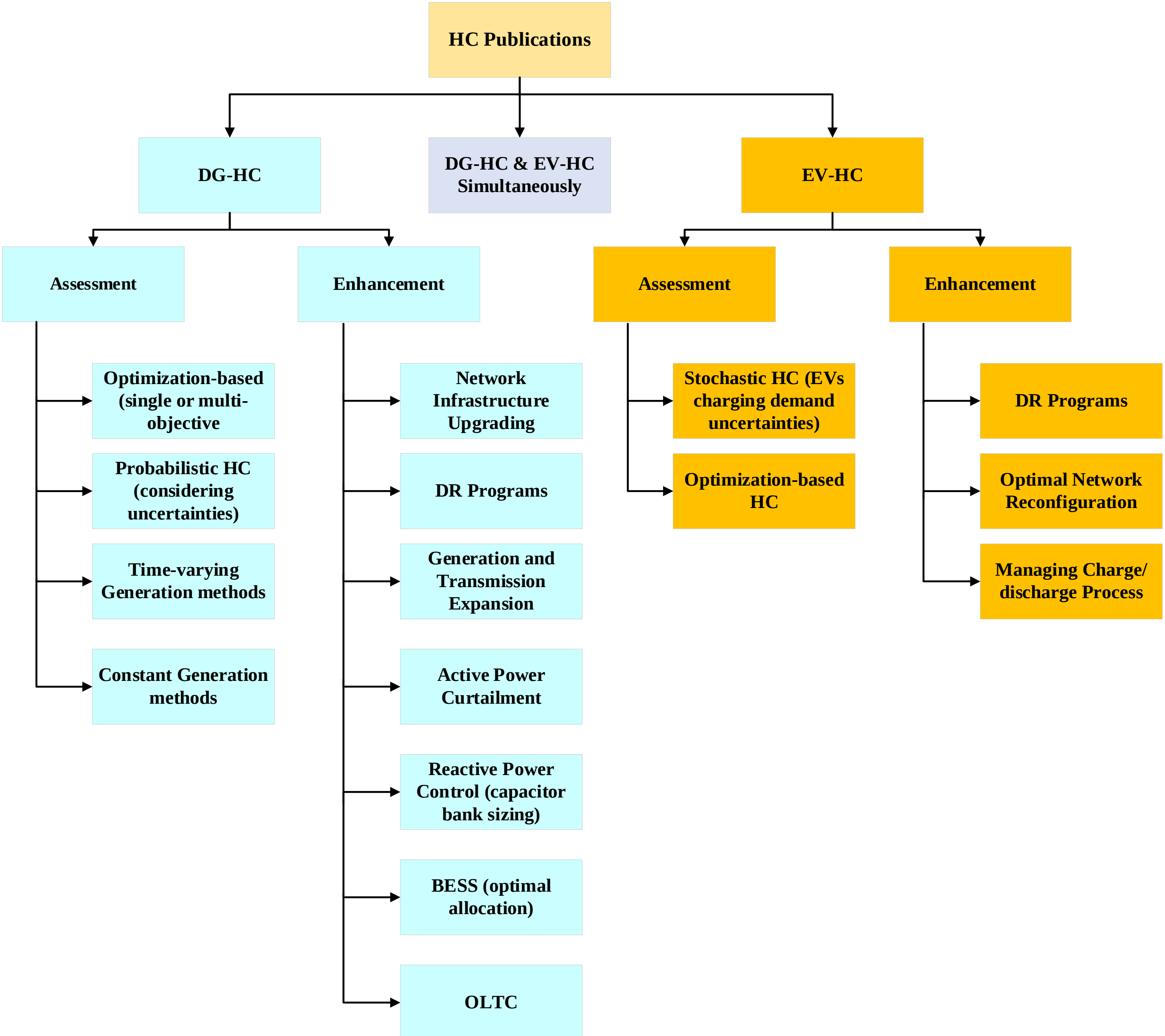

FIGURE 14: **Most common research points in DG-HC and EV-HC.**

[5] Z. M. Zenhom, T. A. Boghdady, and H. K. Youssef, "A Proposed Economical Based Approach for Optimal Sizing and Placement of Distributed Generation," 2019 21st Int. Middle East Power Syst. Conf. MEPCON 2019 - Proc., pp. 342–347, 2019, doi: 10.1109/MEPCON47431.2019.9007932.
[6] B. Azibek, A. Abukhan, H. S. V. S. K. Nunna, B. Mukatov, S. Kamalasadan, and S. Doolla, "Hosting Capacity Enhancement in Low Voltage Distribution Networks: Challenges and Solutions," 2020 IEEE Int. Conf. Power Electron. Smart Grid Renew. Energy, PESGRE 2020, no. January, 2020, doi: 10.1109/PESGRE45664.2020.9070466.
[7] I. A. Soliman, M. Numair, M. M. Akl, D. E. A. Mansour, A. M. Elkholy, and M. G. Hussien, "Hosting Capacity Enhancement Through IoT-based Active Power Curtailment of PV Generation," 22nd Int. Middle East Power Syst. Conf. MEPCON 2021 - Proc., pp. 259–264, 2021, doi: 10.1109/MEPCON50283.2021.9686240.
[8] CIGRE WG C6.24, "Capacity of Distribution Feeders for Hosting Distributed Energy Resources," Cigre, no. June, pp. 1–148, 2014.
[9] "Global Electric Vehicle Market Share, Q1 2021 – Q4 2022." https://www.counterpointresearch.com/global-electric-vehicle-market-share/ (accessed Mar. 17, 2023).
[10] N. O. Kapustin and D. A. Grushevenko, "Long-term electric vehicles outlook and their potential impact on electric grid," Energy Policy, vol. 137, no. April 2019, p. 111103, 2020, doi: 10.1016/j.enpol.2019.111103.
[11] P. Miklautsch and M. Woschank, "A framework of measures to mitigate greenhouse gas emissions in freight transport: Systematic literature review from a Manufacturer's perspective," J. Clean. Prod., vol. 366, no. July, p. 132883, 2022, doi: 10.1016/j.jclepro.2022.132883.
[12] M. Muratori et al., "The rise of electric vehicles-2020 status and future expectations," Prog. Energy, vol. 3, no. 2, 2021, doi: 10.1088/2516-1083/abe0ad.

[13] T. Nogueira, E. Sousa, and G. R. Alves, “Electric vehicles growth until 2030: Impact on the distribution network power,” Energy Reports, vol. 8, pp. 145–152, 2022, doi: 10.1016/j.egyr.2022.01.106.
[14] Mulenga, Enock, Math HJ Bollen, and Nicholas Etherden. "A review of hosting capacity quantification methods for photovoltaics in low-voltage distribution grids." International Journal of Electrical Power & Energy Systems 115 (2020): 105445.
[15] Islam, Md Tariqul, and M. J. Hossain. "Artificial Intelligence for Hosting Capacity Analysis: A Systematic Literature Review." Energies 16.4 (2023): 1864.
[16] Umoh, Vincent, et al. "Methods and Tools for PV and EV Hosting Capacity Determination in Low Voltage Distribution Networks—A Review." Energies 16.8 (2023): 3609.
[17] Qamar, Naveed, et al. "Hosting capacity in distribution grids: A review of definitions, performance indices, determination methodologies, and enhancement techniques." Energy Science & Engineering 11.4 (2023): 1536-1559.
[18] Moro, Vinicius C., and Fernanda CL Trindade. "A Review on Techniques to Increase Hosting Capacity of Distribution Systems to DERs." 2021 Workshop on Communication Networks and Power Systems (WCNPS). IEEE, 2021.
[19] Singh, Utkarsh. "The role of hosting capacity study in power system advancements: a review." arXiv preprint arXiv:2301.04765 (2023).
[20] Zhao, Jian, et al. "Distribution network electric vehicle hosting capacity maximization: A chargeable region optimization model." IEEE Transactions on Power Systems 32.5 (2017): 4119-4130.
[21] F. Ding, B. Mather, and P. Gotseff, “Technologies to increase PV hosting capacity in distribution feeders,” IEEE Power Energy Soc. Gen. Meet., vol. 2016–Novem, pp. 1–5, 2016, doi: 10.1109/PESGM.2016.7741575.
[22] F. Ding, B. Mather, N. Ainsworth, P. Gotseff, and K. Baker, “Locational sensitivity investigation on PV hosting capacity and fast track PV screening,” Proc. IEEE Power Eng. Soc. Transm. Distrib. Conf., vol. 2016–July, pp. 1–5, 2016, doi: 10.1109/TDC.2016.7519878.
[23] T. S. Ustun, J. Hashimoto, and K. Otani, “Impact of Smart Inverters on Feeder Hosting Capacity of Distribution Networks,” IEEE Access, vol. 7, pp. 163526–163536, 2019, doi: 10.1109/ACCESS.2019.2952569.
[24] O. Ceylan, S. Paudyal, B. P. Bhattarai, and K. S. Myers, “Photovoltaic hosting capacity of feeders with reactive power control and tap changers,” 2017 IEEE PES Innov. Smart Grid Technol. Conf. Eur. ISGT-Europe 2017 - Proc., vol. 2018–Janua, pp. 1–6, 2017, doi: 10.1109/ISGTEurope.2017.8260243.
[25] F. Ding and B. Mather, “On Distributed PV Hosting Capacity Estimation, Sensitivity Study, and Improvement,” IEEE Trans. Sustain. Energy, vol. 8, no. 3, pp. 1010–1020, 2017, doi: 10.1109/TSTE.2016.2640239.
[26] A. Y. Saber, T. Khandelwal, and A. K. Srivastava, “Fast Feeder PV Hosting Capacity using Swarm Based Intelligent Distribution Node Selection,” IEEE Power Energy Soc. Gen. Meet., vol. 2019–Augus, pp. 1–5, 2019, doi: 10.1109/PESGM40551.2019.8973389.
[27] D. Menniti, M. Merlo, N. Scordino, and F. Zanellini, “Distribution network analysis: A comparison between hosting and loading capacities,” SPEEDAM 2012 - 21st Int. Symp. Power Electron. Electr. Drives, Autom. Motion, pp. 926–933, 2012, doi: 10.1109/SPEEDAM.2012.6264635.
[28] M. Alturki and A. Khodaei, “Optimal loading capacity in distribution grids,” 2017 North Am. Power Symp. NAPS 2017, 2017, doi: 10.1109/NAPS.2017.8107355.
[29] S. Jothibasu, S. Santoso, and A. Dubey, “Optimization Methods for Evaluating PV Hosting Capacity of Distribution Circuits,” Conf. Rec. IEEE Photovolt. Spec. Conf., no. July, pp. 887–891, 2019, doi: 10.1109/PVSC40753.2019.8980606.
[30] A. Arshad, M. Lindner, and M. Lehtonen, “An analysis of photo-voltaic hosting capacity in finnish low voltage distribution networks,” Energies, vol. 10, no. 11, 2017, doi: 10.3390/en10111702.
[31] N. K. Singh, M. Z. C. Wanik, A. A. Jabbar, and A. Sanfilippo, “Enhancing PV hosting Capacity of a Qatar Remote Farm Network using Inverters Ability to Regulate Reactive Power-a Case Study,” Proc. 2019 IEEE PES Innov. Smart Grid Technol. Eur. ISGT-Europe 2019, pp. 1–5, 2019, doi: 10.1109/ISGTEurope.2019.8905545.
[32] M. Al-Saffar, S. Zhang, A. Nassif, and P. Musilek, “Assessment of Photovoltaic Hosting Capacity of Existing Distribution Circuits,” 2019 IEEE Can. Conf. Electr. Comput. Eng. CCECE 2019, pp. 1–4, 2019, doi: 10.1109/CCECE.2019.8861957.
[33] H. Sadeghian and Z. Wang, “A novel impact-assessment framework for distributed PV installations in low-voltage secondary networks,” Renew. Energy, vol. 147, pp. 2179–2194, 2020, doi: 10.1016/j.renene.2019.09.117.
[34] Duwadi, Kapil, Aravind Ingalalli, and Timothy M. Hansen. "Monte carlo analysis of high penetration residential solar voltage impacts using high performance computing." 2019 IEEE International Conference on Electro Information Technology (EIT). IEEE, 2019.
[35] M. Alturki, A. Khodaei, A. Paaso, and S. Bahramirad, “Optimization-based distribution grid hosting capacity calculations,” Appl. Energy, vol. 219, no. September, pp. 350–360, 2018, doi: 10.1016/j.apenergy.2017.10.127.
[36] M. S. S. Abad, J. Ma, D. Zhang, A. S. Ahmadyar, and H. Marzooghi, “Probabilistic Assessment of Hosting Capacity in Radial Distribution Systems,” IEEE Trans. Sustain. Energy, vol. 9, no. 4, pp. 1935–1947, 2018, doi: 10.1109/TSTE.2018.2819201.
[37] N. C. Tang and G. W. Chang, “A stochastic approach for determining PV hosting capacity of a distribution feeder considering voltage quality constraints,” Proc. Int. Conf. Harmon. Qual. Power, ICHQP, vol. 2018–May, pp. 1–5, 2018, doi: 10.1109/ICHQP.2018.8378864.
[38] A. Dubey, S. Santoso, and A. Maitra, “Understanding photovoltaic hosting capacity of distribution circuits,” IEEE Power Energy Soc. Gen. Meet., vol. 2015–Septe, 2015, doi: 10.1109/PESGM.2015.7286510.
[39] M. J. Weisshaupt, B. Schlatter, P. Korba, E. Kaffe, and F. Kienzle, “Evaluation of Measures to Operate Urban Low Voltage Grids Considering Future PV Expansion,” IFAC-PapersOnLine, vol. 49, no. 27, pp. 336–341, 2016, doi: 10.1016/j.ifacol.2016.10.714.
[40] P. Mohammadi and S. Mehraeen, “PMU optimal placement using sensitivity analysis for power systems fault location,” 2015 IEEE Electr. Power Energy Conf. Smarter Resilient Power Syst. EPEC 2015, no. October 2015, pp. 244–249, 2016, doi: 10.1109/EPEC.2015.7379957.
[41] T. Stetz, F. Marten, and M. Braun, “Improved low voltage grid-integration of photovoltaic systems in Germany,” IEEE Trans. Sustain. Energy, vol. 4, no. 2, pp. 534–542, 2013, doi: 10.1109/TSTE.2012.2198925.
[42] Torquato, D. Salles, C. O. Pereira, P. C. M. Meira, and W. Freitas, “A Comprehensive Assessment of PV Hosting Capacity on Low-Voltage Distribution Systems,” IEEE Trans. Power Deliv., vol. 33, no. 2, pp. 1002–1012, 2018, doi: 10.1109/TPWRD.2018.2798707.
[43] S. Kikuchi et al., “Hosting capacity analysis of many distributed photovoltaic systems in future distribution networks,” 2017 IEEE Innov. Smart Grid Technol. - Asia Smart Grid Smart Community, ISGT-Asia 2017, pp. 1–5, 2018, doi: 10.1109/ISGT-Asia.2017.8378408.
[44] H. V. Haghi et al., “Feeder Impact Assessment of Smart Inverter Settings to Support High PV Penetration in California,” IEEE Power Energy Soc. Gen. Meet., vol. 2019–Augus, pp. 2–6, 2019, doi: 10.1109/PESGM40551.2019.8974016.
[45] H. Al-Saadi, S. Al-Sarawi, R. Zivanovic, and H. G. Abood, “Hourly-assessment of grid hosting capacity for active distribution network,” 2018 Int. Conf. Probabilistic Methods Appl. to Power Syst. PMAPS 2018 - Proc., pp. 1–7, 2018, doi: 10.1109/PMAPS.2018.8440346.
[46] W. Niederhuemer and R. Schwalbe, “Increasing PV hosting capacity in LV grids with a probabilistic planning approach,” Proc. - 2015 Int. Symp. Smart Electr. Distrib. Syst. Technol. EDST 2015, pp. 537–540, 2015, doi: 10.1109/SEDST.2015.7315266.
[47] N. Soukaina, E. Hassane, E. M. Hassan, and L. Tijani, “Hosting capacity estimation of underground distribution feeder in Urbain Areas,” 2019 Int. Conf. Wirel. Technol. Embed. Intell. Syst. WITS 2019, no. September, 2019, doi: 10.1109/WITS.2019.8723822.
[48] P. Hasanpor Divshali and L. Soder, “Improving Hosting Capacity of Rooftop PVs by Quadratic Control of an LV-Central BSS,” IEEE Trans. Smart Grid, vol. 10, no. 1, pp. 919–927, 2019, doi: 10.1109/TSG.2017.2754943.
[49] J. Behkesh Noshahr, “Emission phenomenon of supra-harmonics caused by switching of full-power frequency converter of wind turbines generator (PMSG) in smart grid,” EEEIC 2016 - Int. Conf. Environ. Electr. Eng., pp. 2–7, 2016, doi: 10.1109/EEEIC.2016.7555625.
[50] I. A. Essackjee and R. T. F. Ah King, “Maximum rooftop photovoltaic hosting capacity with harmonics as limiting factor - Case study for Mauritius,” icABCD 2019 - 2nd Int. Conf. Adv. Big Data, Comput. Data Commun. Syst., Aug. 2019, doi: 10.1109/ICABCD.2019.8851002.

[51] S. Sakar, M. E. Balci, S. H. E. Abdel Aleem, and A. F. Zobaa, “Increasing PV hosting capacity in distorted distribution systems using passive harmonic filtering,” Electr. Power Syst. Res., vol. 148, pp. 74–86, 2017, doi: 10.1016/j.epsr.2017.03.020.
[52] S. Sakar, M. E. Balci, S. H. E. A. Aleem, and A. F. Zobaa, “Hosting capacity assessment and improvement for photovoltaic-based distributed generation in distorted distribution networks,” EEEIC 2016 - Int. Conf. Environ. Electr. Eng., 2016, doi: 10.1109/EEEIC.2016.7555515.
[53] S. M. Ismael, S. H. E. A. Aleem, and A. Y. Abdelaziz, “Non-Sinusoidal Power Distribution Systems Using,” 2019, doi: 10.3390/en12061018.
[54] M. D. Braga, S. D. Machado, I. C. Oliveira, T. E. C. De Oliveira, P. F. Ribeiro, and B. I. L. Lopes, “Harmonic hosting capacity approach in a radial distribution system due to PV integration using OpenDSS,” 2018 13th IEEE Int. Conf. Ind. Appl. INDUSCON 2018 - Proc., pp. 222–228, 2019, doi: 10.1109/INDUSCON.2018.8627342.
[55] P. B. Kitworawut, D. T. Azuatalam, and A. J. Collin, “An investigation into the technical impacts of microgeneration on UK-type LV distribution networks,” pp. 1–5, Nov. 2016, doi: 10.1109/AUPEC.2016.7749321.
[56] J. A. Carta, Wind power integration, vol. 2. Elsevier Ltd., 2012. doi: 10.1016/B978-0-08-087872-0.00221-3.
[57] S. K. Sharma, A. Chandra, M. Saad, S. Lefebvre, D. Asber, and L. Lenoir, “Voltage Flicker Mitigation Employing Smart Loads With High Penetration of Renewable Energy in Distribution Systems,” IEEE Trans. Sustain. Energy, vol. 8, no. 1, pp. 414–424, 2017, doi: 10.1109/TSTE.2016.2603512.
[58] A. Aoun, M. Ghandour, A. Ilinca, and H. Ibrahim, “Demand-side management,” Hybrid Renew. Energy Syst. Microgrids, pp. 463–490, Jan. 2021, doi: 10.1016/B978-0-12-821724-5.00001-5.
[59] P. H. Divshali and L. Soder, “Improving PV hosting capacity of distribution grids considering dynamic voltage characteristic,” 20th Power Syst. Comput. Conf. PSCC 2018, no. June, 2018, doi: 10.23919/PSCC.2018.8442517.
[60] F. Ferdowsi, S. Mehraeen, and G. B. Upton, “Assessing distribution network sensitivity to voltage rise and flicker under high penetration of behind-the-meter solar,” Renew. Energy, vol. 152, pp. 1227–1240, 2020, doi: 10.1016/j.renene.2019.12.124.
[61] S. Rahman, M. Moghaddami, A. I. Sarwat, T. Olowu, and M. Jafaritalarposhti, “Flicker Estimation Associated with PV Integrated Distribution Network,” Conf. Proc. - IEEE SOUTHEASTCON, vol. 2018–April, no. March 2020, pp. 1–6, 2018, doi: 10.1109/SECON.2018.8479058.
[62] F. F. S. Rahman, K. W. Adi, Sarjiya, and L. M. Putranto, “Study on Photovoltaic Hosting in Yogyakarta Electric Distribution Network,” Proc. - 2018 5th Int. Conf. Inf. Technol. Comput. Electr. Eng. ICITACEE 2018, pp. 240–244, 2018, doi: 10.1109/ICITACEE.2018.8576961.
[63] Deuse, J., et al. "Effective impact of DER on distribution system protection." International Conference on Electricity Distribution: 21/05/2007-24/05/2007. AIM, 2007.
[64] R. A. Walling, R. Saint, R. C. Dugan, J. Burke, and L. A. Kojovic, “Summary of distributed resources impact on power delivery systems,” IEEE Trans. Power Deliv., vol. 23, no. 3, pp. 1636–1644, 2008, doi: 10.1109/TPWRD.2007.909115.
[65] M. Bollen and F. Hassan, “Integration of Distributed Generation in the Power System,” Integr. Distrib. Gener. Power Syst., Oct. 2011, doi: 10.1002/9781118029039.
[66] W. Sun, “Maximising Renewable Hosting Capacity in Electricity Networks,” Doctor of Philosophy Dissertation,The University of Edinburgh, Edinburgh. 2014.
[67] V. Quintero-Molina, M. Romero-L, and A. Pavas, “Assessment of the hosting capacity in distribution networks with different DG location,” 2017 IEEE Manchester PowerTech, Powertech 2017, 2017, doi: 10.1109/PTC.2017.7981243.
[68] L. K. L. Estorque and M. A. A. Pedrasa, “Utility-scale DG planning using location-specific hosting capacity analysis,” IEEE PES Innov. Smart Grid Technol. Conf. Eur., no. November 2016, pp. 984–989, 2016, doi: 10.1109/ISGT-Asia.2016.7796519.
[69] J. Peppanen, M. Bello, and M. Rylander, “Service Entrance Hosting Capacity,” 2018 IEEE 7th World Conf. Photovolt. Energy Conversion, WCPEC 2018 - A Jt. Conf. 45th IEEE PVSC, 28th PVSEC 34th EU PVSEC, pp. 1451–1456, 2018, doi: 10.1109/PVSC.2018.8547340.
[70] A. F. W. Steyn and A. J. Rix, “Modelling the technical in uence of randomly distributed solar PV uptake on electrical distribution networks by Anrich Frederik Willem Steyn,” 2019 Int. Conf. Clean Electr. Power, no. April, pp. 690–698, 2019.
[71] D. Chathurangi, U. Jayatunga, M. Rathnayake, A. Wickramasinghe, A. Agalgaonkar, and S. Perera, “Potential power quality impacts on LV distribution networks with high penetration levels of solar PV,” Proc. Int. Conf. Harmon. Qual. Power, ICHQP, vol. 2018–May, pp. 1–6, 2018, doi: 10.1109/ICHQP.2018.8378890.
[72] M. T. Do, A. Bruyere, and B. Francois, “Sensitivity analysis of the CIGRE distribution network benchmark according to the large scale connection of renewable energy generators,” 2017 IEEE Manchester PowerTech, Powertech 2017, 2017, doi: 10.1109/PTC.2017.7981041.
[73] M. H. Athari, Z. Wang, and S. H. Eylas, “Time-series analysis of photovoltaic distributed generation impacts on a local distributed network,” 2017 IEEE Manchester PowerTech, Powertech 2017, 2017, doi: 10.1109/PTC.2017.7980908.
[74] S. Fan, T. Pu, L. Li, T. Yu, Z. Yang, and B. Gao, “Evaluation of impact of integrated distributed generation on distribution network based on time-series analysis,” China Int. Conf. Electr. Distrib. CICED, vol. 2016–Septe, no. Ciced, pp. 10–13, 2016, doi: 10.1109/CICED.2016.7576171.
[75] R. M. Gonzaga, J. A. D. Massigan, and J. B. A. London, “Analysis of the Hosting Capacity of a Real Distribution Feeder with Wind Generation,” 2019 IEEE PES Conf. Innov. Smart Grid Technol. ISGT Lat. Am. 2019, 2019, doi: 10.1109/ISGT-LA.2019.8895318.
[76] A. K. Jain, K. Horowitz, F. Ding, N. Gensollen, B. Mather, and B. Palmintier, “Quasi-Static Time-Series PV Hosting Capacity Methodology and Metrics,” 2019 IEEE Power Energy Soc. Innov. Smart Grid Technol. Conf. ISGT 2019, no. February, 2019, doi: 10.1109/ISGT.2019.8791569.
[77] K. A. Joshi and N. M. Pindoriya, “Reactive resource reallocation in DG integrated secondary distribution networks with time-series distribution power flow,” 2014 IEEE Int. Conf. Power Electron. Drives Energy Syst. PEDES 2014, no. February 2015, 2014, doi: 10.1109/PEDES.2014.7042111.
[78] J. Deboever, S. Grijalva, M. J. Reno, and R. J. Broderick, “Fast Quasi-Static Time-Series (QSTS) for yearlong PV impact studies using vector quantization,” Sol. Energy, vol. 159, pp. 538–547, 2018, doi: 10.1016/j.solener.2017.11.013.
[79] M. U. Qureshi, S. Grijalva, M. J. Reno, J. Deboever, X. Zhang, and R. J. Broderick, “A Fast Scalable Quasi-Static Time Series Analysis Method for PV Impact Studies Using Linear Sensitivity Model,” IEEE Trans. Sustain. Energy, vol. 10, no. 1, pp. 301–310, 2019, doi: 10.1109/TSTE.2018.2833748.
[80] Y. Xue et al., “Voltage impact analyses of solar photovoltaics on distribution load tap changer operations,” 2017 North Am. Power Symp. NAPS 2017, 2017, doi: 10.1109/NAPS.2017.8107252.
[81] M. Rossi, G. Vigano, D. Moneta, and D. Clerici, “Stochastic evaluation of distribution network hosting capacity: Evaluation of the benefits introduced by smart grid technology,” 2017 AEIT Int. Annu. Conf. Infrastructures Energy ICT Oppor. Foster. Innov. AEIT 2017, vol. 2017–Janua, pp. 1–6, 2017, doi: 10.23919/AEIT.2017.8240490.
[82] T. Busatto, A. Larsson, S. K. Ronnberg, and M. H. J. Bollen, “Including Uncertainties from Customer Connections in Calculating Low-Voltage Harmonic Impedance,” IEEE Trans. Power Deliv., vol. 34, no. 2, pp. 606–615, 2019, doi: 10.1109/TPWRD.2018.2881222.
[83] M. S. S. Abad, J. Ma, D. Zhang, A. S. Ahmadyar, and H. Marzooghi, “Sensitivity of hosting capacity to data resolution and uncertainty modeling,” Australas. Univ. Power Eng. Conf. AUPEC 2018, no. September, 2018, doi: 10.1109/AUPEC.2018.8757980.
[84] J. Le Baut et al., “Probabilistic evaluation of the hosting capacity in distribution networks,” IEEE PES Innov. Smart Grid Technol. Conf. Eur., 2017, doi: 10.1109/ISGTEurope.2016.7856213.
[85] V. Klonari, J. F. Toubeau, J. Lobry, and F. Vallée, “Photovoltaic integration in smart city power distribution : A Probabilistic photovoltaic hosting capacity assessment based on smart metering data,” SMARTGREENS 2016 - Proc. 5th Int. Conf. Smart Cities Green ICT Syst., no. April, pp. 166–178, 2016, doi: 10.5220/0005792001660178.
[86] D. Schwanz, T. Busatto, M. Bollen, and A. Larsson, “A stochastic study of harmonic voltage distortion considering single-phase photovoltaic inverters,” Proc. Int. Conf. Harmon. Qual. Power, ICHQP, vol. 2018–May, no. June 2019, pp. 1–6, 2018, doi: 10.1109/ICHQP.2018.8378889.
[87] S. Wang, C. Li, Z. Pan, and J. Wang, “Probabilistic method for distribution network electric vehicle hosting capacity assessment based on

combined cumulants and gram-charlier expansion," Energy Procedia, vol. 158, no. 2018, pp. 5067–5072, 2019, doi: 10.1016/j.egypro.2019.01.643.
[88] A. Navarro-espinosa and G. S. Member, "Probabilistic Impact Assessment of Low Carbon Technologies in LV Distribution Systems," pp. 1–12.
[89] Hung, Duong Quoc, and Yateendra Mishra. "A multiobjective voltage unbalance factor for pv hosting capacity with probabilistic zip load models." 2018 IEEE Power & Energy Society General Meeting (PESGM). IEEE, 2018.
[90] Schwanz, Daphne, Sarah K. Rönnberg, and Math Bollen. "Hosting capacity for photovoltaic inverters considering voltage unbalance." 2017 IEEE Manchester PowerTech. IEEE, 2017.
[91] H. Al-Saadi, R. Zivanovic, and S. F. Al-Sarawi, "Probabilistic analysis of maximum allowable PV connections across bidirectional feeders within a distribution network," 2017 Asian Conf. Energy, Power Transp. Electrif. ACEPT 2017, vol. 2017–Decem, pp. 1–18, 2017, doi: 10.1109/ACEPT.2017.8168540.
[92] H. Al-saadi, S. Member, R. Zivanovic, and S. F. Al-sarawi, "Probabilistic Hosting Capacity for Active Distribution Networks," vol. 3203, no. c, 2017, doi: 10.1109/TII.2017.2698505.
[93] M. N. Kabir, Y. Mishra, and R. C. Bansal, "Probabilistic load flow for distribution systems with uncertain PV generation," Appl. Energy, vol. 163, pp. 343–351, 2016, doi: 10.1016/j.apenergy.2015.11.003.
[94] D. D. Le, K. V. Pham, D. V. Ngo, K. V. Huynh, N. T. A. Nguyen, and A. Berizzi, "An enhancement to cumulant-based probabilistic power flow methodologies," Proc. 2015 IEEE Innov. Smart Grid Technol. - Asia, ISGT ASIA 2015, 2016, doi: 10.1109/ISGT-Asia.2015.7387150.
[95] R. Rocchetta, Y. F. Li, and E. Zio, "Risk assessment and risk-cost optimization of distributed power generation systems considering extreme weather conditions," Reliab. Eng. Syst. Saf., vol. 136, pp. 47–61, 2015, doi: 10.1016/j.ress.2014.11.013.
[96] S. Lakshmi and S. Ganguly, "Simultaneous optimisation of photovoltaic hosting capacity and energy loss of radial distribution networks with open unified power quality conditioner allocation," IET Renew. Power Gener., vol. 12, no. 12, pp. 1382–1389, 2018, doi: 10.1049/iet-rpg.2018.5389.
[97] A. Rabiee and S. M. Mohseni-Bonab, "Maximizing hosting capacity of renewable energy sources in distribution networks: A multi-objective and scenario-based approach," Energy, vol. 120, pp. 417–430, 2017, doi: 10.1016/j.energy.2016.11.095.
[98] W. Sun and G. P. Harrison, "Wind-solar complementarity and effective use of distribution network capacity," Appl. Energy, vol. 247, no. June 2018, pp. 89–101, 2019, doi: 10.1016/j.apenergy.2019.04.042.
[99] Z. Wang, X. Wang, and L. Tang, "Practical power distance test tool based on OPF to assess feeder DG hosting capacity," 2017 IEEE Electr. Power Energy Conf. EPEC 2017, vol. 2017–Octob, no. 1, pp. 1–6, 2018, doi: 10.1109/EPEC.2017.8286214.
[100] M. Alturki and A. Khodaei, "Marginal Hosting Capacity Calculation for Electric Vehicle Integration in Active Distribution Networks," Proc. IEEE Power Eng. Soc. Transm. Distrib. Conf., vol. 2018–April, pp. 1–9, 2018, doi: 10.1109/TDC.2018.8440134.
[101] Y. Wang, Y. Yu, and J. Zhang, "Analysis for distribution network on hosting capacity of distributed wind turbines considering additional income under procedure conditions," J. Eng., vol. 2017, no. 13, pp. 1373–1377, 2017, doi: 10.1049/joe.2017.0556.
[102] E. R. Mmary and B. Marungsri, "Optimal Hybrid Renewable Generator for Techno-Economic Benefits in Smart Distribution Network," iEECON 2018 - 6th Int. Electr. Eng. Congr., pp. 1–4, 2018, doi: 10.1109/IEECON.2018.8712179.
[103] X. Chen, W. Wu, B. Zhang, and C. Lin, "Data-Driven DG Capacity Assessment Method for Active Distribution Networks," IEEE Trans. Power Syst., vol. 32, no. 5, pp. 3946–3957, 2017, doi: 10.1109/TPWRS.2016.2633299.
[104] X. Chen, W. Wu, and B. Zhang, "Robust Capacity Assessment of Distributed Generation in Unbalanced Distribution Networks Incorporating ANM Techniques," IEEE Trans. Sustain. Energy, vol. 9, no. 2, pp. 651–663, 2018, doi: 10.1109/TSTE.2017.2754421.
[105] I. M. Diaaeldin, S. H. E. Abdel Aleem, A. El-Rafei, A. Y. Abdelaziz, and A. F. Zobaa, "Enhancement of hosting capacity with soft open points and distribution system reconfiguration: Multi-objective bilevel stochastic optimization," Energies, vol. 13, no. 20, 2020, doi: 10.3390/en13205446.
[106] W. Cao, J. Wu, N. Jenkins, C. Wang, and T. Green, "Operating principle of Soft Open Points for electrical distribution network operation," Appl. Energy, vol. 164, pp. 245–257, Feb. 2016, doi: 10.1016/J.APENERGY.2015.12.005.
[107] A. Soroudi, A. Rabiee, and A. Keane, "Distribution networks' energy losses versus hosting capacity of wind power in the presence of demand flexibility," Renew. Energy, vol. 102, pp. 316–325, 2017, doi: 10.1016/j.renene.2016.10.051.
[108] M. Bajaj and A. K. Singh, "Optimal design of passive power filter for enhancing the harmonic-constrained hosting capacity of renewable DG systems," Comput. Electr. Eng., vol. 97, p. 107646, Jan. 2022, doi: 10.1016/J.COMPELECENG.2021.107646.
[109] M. Bajaj and A. Kumar Singh, "Hosting capacity enhancement of renewable-based distributed generation in harmonically polluted distribution systems using passive harmonic filtering," Sustain. Energy Technol. Assessments, vol. 44, p. 101030, Apr. 2021, doi: 10.1016/J.SETA.2021.101030.
[110] C. T. Su, C. F. Chang, and J. P. Chiou, "Distribution network reconfiguration for loss reduction by ant colony search algorithm," Electr. Power Syst. Res., vol. 75, no. 2–3, pp. 190–199, 2005, doi: 10.1016/j.epsr.2005.03.002.
[111] S. M. Ismael, S. H. E. Abdel Aleem, A. Y. Abdelaziz, and A. F. Zobaa, "Practical Considerations for Optimal Conductor Reinforcement and Hosting Capacity Enhancement in Radial Distribution Systems," IEEE Access, vol. 6, pp. 27268–27277, 2018, doi: 10.1109/ACCESS.2018.2835165.
[112] A. Navarro-Espinosa and L. F. Ochoa, "Increasing the PV hosting capacity of Lv networks: OLTC-fitted transformers vs. reinforcements," 2015 IEEE Power Energy Soc. Innov. Smart Grid Technol. Conf. ISGT 2015, 2015, doi: 10.1109/ISGT.2015.7131856.
[113] Y. Y. Fu and H. D. Chiang, "Toward optimal multi-period network reconfiguration for increasing the hosting capacity of distribution networks," IEEE Power Energy Soc. Gen. Meet., vol. 2018–Janua, pp. 1–5, 2018, doi: 10.1109/PESGM.2017.8274614.
[114] N. Gensollen, K. Horowitz, B. Palmintier, F. Ding, and B. Mather, "Beyond Hosting Capacity: Using Shortest-Path Methods to Minimize Upgrade Cost Pathways," IEEE J. Photovoltaics, vol. 9, no. 4, pp. 1051–1056, 2019, doi: 10.1109/JPHOTOV.2019.2904540.
[115] F. Capitanescu, L. F. Ochoa, H. Margossian, and N. D. Hatziargyriou, "Assessing the potential of network reconfiguration to improve distributed generation hosting capacity in active distribution systems," IEEE Trans. Power Syst., vol. 30, no. 1, pp. 346–356, 2015, doi: 10.1109/TPWRS.2014.2320895.
[116] Y. Takenobu, S. Kawano, Y. Hayashi, N. Yasuda, and S. I. Minato, "Maximizing hosting capacity of distributed generation by network reconfiguration in distribution system," 19th Power Syst. Comput. Conf. PSCC 2016, 2016, doi: 10.1109/PSCC.2016.7540965.
[117] Falabretti, Davide, Marco Merlo, and Maurizio Delfanti. "Network reconfiguration and storage systems for the hosting capacity improvement." 22nd International Conference and Exhibition on Electricity Distribution (CIRED 2013). IET, 2013.
[118] Y. Y. Fu and H. D. Chiang, "Toward optimal multi-period network reconfiguration for increasing the hosting capacity of distribution networks," IEEE Power Energy Soc. Gen. Meet., vol. 2018–Janua, no. 51337007, pp. 1–5, 2018, doi: 10.1109/PESGM.2017.8274614.
[119] J. Liu and H. D. Chiang, "Maximizing Available Delivery Capability of Unbalanced Distribution Networks for High Penetration of Distributed Generators," IEEE Trans. Power Deliv., vol. 32, no. 3, pp. 1196–1202, 2017, doi: 10.1109/TPWRD.2014.2359291.
[120] A. E. Milani and M. R. Haghifam, "An evolutionary approach for optimal time interval determination in distribution network reconfiguration under variable load," Math. Comput. Model., vol. 57, no. 1–2, pp. 68–77, 2013, doi: 10.1016/j.mcm.2011.05.047.
[121] K. H. Chua, Y. S. Lim, P. Taylor, S. Morris, and J. Wong, "Energy storage system for mitigating voltage unbalance on low-voltage networks with photovoltaic systems," IEEE Trans. Power Deliv., vol. 27, no. 4, pp. 1783–1790, 2012, doi: 10.1109/TPWRD.2012.2195035.
[122] K. Turitsyn, P. Šulc, S. Backhaus, and M. Chertkov, "Options for control of reactive power by distributed photovoltaic generators," Proc. IEEE, vol. 99, no. 6, pp. 1063–1073, 2011, doi: 10.1109/JPROC.2011.2116750.

[123] T. E. C. De Oliveira, P. M. S. Carvalho, P. F. Ribeiro, and B. D. Bonatto, “PV hosting capacity dependence on harmonic voltage distortion in low-voltage grids: Model validation with experimental data,” Energies, vol. 11, no. 2, 2018, doi: 10.3390/en11020465.
[124] M. J. E. Alam, K. M. Muttaqi, and D. Sutanto, “Community Energy Storage for Neutral Voltage Rise Mitigation in Four-Wire Multigrounded LV Feeders with Unbalanced Solar PV Allocation,” IEEE Trans. Smart Grid, vol. 6, no. 6, pp. 2845–2855, 2015, doi: 10.1109/TSG.2015.2427872.
[125] X. Su, M. A. S. Masoum, and P. J. Wolfs, “Optimal PV inverter reactive power control and real power curtailment to improve performance of unbalanced four-wire LV distribution networks,” IEEE Trans. Sustain. Energy, vol. 5, no. 3, pp. 967–977, 2014, doi: 10.1109/TSTE.2014.2313862.
[126] T. N. Gupta, S. Murshid, and B. Singh, “Power Quality Improvement of Single Phase Grid Connected Hybrid Solar PV and Wind System,” 8th IEEE Power India Int. Conf. PIICON 2018, pp. 1–6, 2018, doi: 10.1109/POWERI.2018.8704455.
[127] A. Arshad and M. Lehtonen, “A comprehensive voltage control strategy with voltage flicker compensation for highly PV penetrated distribution networks,” Electr. Power Syst. Res., vol. 172, no. October 2018, pp. 105–113, 2019, doi: 10.1016/j.epsr.2019.02.019.
[128] B. Wang, C. Zhang, Z. Y. Dong, and X. Li, “Improving Hosting Capacity of Unbalanced Distribution Networks via Robust Allocation of Battery Energy Storage Systems,” IEEE Trans. Power Syst., vol. 36, no. 3, pp. 2174–2185, 2021, doi: 10.1109/TPWRS.2020.3029532.
[129] T. Verschueren, K. Mets, B. Meersman, M. Strobbe, C. Develder, and L. Vandevelde, “Assessment and mitigation of voltage violations by solar panels in a residential distribution grid,” 2011 IEEE Int. Conf. Smart Grid Commun. SmartGridComm 2011, pp. 540–545, 2011, doi: 10.1109/SmartGridComm.2011.6102381.
[130] K. Joshi and R. R. Gokaraju, “An Iterative Approach to Improve PV Hosting Capacity for a Remote Community,” IEEE Power Energy Soc. Gen. Meet., vol. 2018–Augus, pp. 1–5, 2018, doi: 10.1109/PESGM.2018.8586196.
[131] T. Jamal, C. Carter, T. Schmidt, G. M. Shafiullah, M. Calais, and T. Urmee, “An energy flow simulation tool for incorporating short-term PV forecasting in a diesel-PV-battery off-grid power supply system,” Appl. Energy, vol. 254, no. January, 2019, doi: 10.1016/j.apenergy.2019.113718.
[132] S. Hashemi and J. Østergaard, “Efficient Control of Energy Storage for Increasing the PV Hosting Capacity of LV Grids,” IEEE Trans. Smart Grid, vol. 9, no. 3, pp. 2295–2303, 2018, doi: 10.1109/TSG.2016.2609892.
[133] P. Chaudhary and M. Rizwan, “Voltage regulation mitigation techniques in distribution system with high PV penetration: A review,” Renew. Sustain. Energy Rev., vol. 82, no. September, pp. 3279–3287, 2018, doi: 10.1016/j.rser.2017.10.017.
[134] M. Zillmann, R. Yan, and T. K. Saha, “Regulation of distribution network voltage using dispersed battery storage systems: A case study of a rural network,” IEEE Power Energy Soc. Gen. Meet., pp. 1–8, 2011, doi: 10.1109/PES.2011.6039094.
[135] N. Etherden and M. Bollen, “The use of battery storage for increasing the hosting capacity of the grid for renewable electricity production,” Conf. Innov. Secur. …, 2014, [Online]. Available: http://swepub.kb.se/bib/swepub:oai:pure.atira.dk:publications/96e42c10-5e1e-4cc0-8155-11ac861351ab?tab2=abs&language=en
[136] N. Jayasekara, M. A. S. Masoum, and P. J. Wolfs, “Optimal operation of distributed energy storage systems to improve distribution network load and generation hosting capability,” IEEE Trans. Sustain. Energy, vol. 7, no. 1, pp. 250–261, 2016, doi: 10.1109/TSTE.2015.2487360.
[137] O. C. Rascon, B. Schachler, J. Buhler, M. Resch, and A. Sumper, “Increasing the hosting capacity of distribution grids by implementing residential PV storage systems and reactive power control,” Int. Conf. Eur. Energy Mark. EEM, vol. 2016–July, 2016, doi: 10.1109/EEM.2016.7521338.
[138] S. Hashemi and J. Østergaard, “Methods and strategies for overvoltage prevention in low voltage distribution systems with PV,” IET Renew. Power Gener., vol. 11, no. 2, pp. 205–214, 2017, doi: 10.1049/iet-rpg.2016.0277.
[139] F. Marra, G. Yang, C. Træholt, J. Østergaard, and E. Larsen, “A decentralized storage strategy for residential feeders with photovoltaics,” IEEE Trans. Smart Grid, vol. 5, no. 2, pp. 974–981, 2014, doi: 10.1109/TSG.2013.2281175.
[140] Lu, Shuai, et al. "Control strategies for distributed energy resources to maximize the use of wind power in rural microgrids." 2011 IEEE Power and Energy Society General Meeting. IEEE, 2011.
[141] B. Bletterie, S. Kadam, and J. Le Baut, “Increased hosting capacity by means of active power curtailment,” IET Conf. Publ., vol. 2016, no. CP686, pp. 4–7, 2016, doi: 10.1049/cp.2016.0794.
[142] P. Lusis, L. L. H. Andrew, A. Liebman, G. Tack, and S. Chakraborty, “Reducing the unfairness of coordinated inverter dispatch in pv-rich distribution networks,” 2019 IEEE Milan PowerTech, PowerTech 2019, vol. 675318, no. 675318, pp. 1–6, 2019, doi: 10.1109/PTC.2019.8810940.
[143] D. Jenicek, W. Inam, and M. Ilic, “Locational dependence of maximum installable PV capacity in LV networks while maintaining voltage limits,” NAPS 2011 - 43rd North Am. Power Symp., 2011, doi: 10.1109/NAPS.2011.6025197.
[144] C. Heinrich, P. Fortenbacher, A. Fuchs, and G. Andersson, “PV-integration strategies for low voltage networks,” 2016 IEEE Int. Energy Conf. ENERGYCON 2016, vol. 2, no. 1, 2016, doi: 10.1109/ENERGYCON.2016.7514141.
[145] N. Etherden and M. H. J. Bollen, “Increasing the hosting capacity of distribution networks by curtailment of renewable energy resources,” 2011 IEEE PES Trondheim PowerTech Power Technol. a Sustain. Soc. POWERTECH 2011, pp. 1–7, 2011, doi: 10.1109/PTC.2011.6019292.
[146] M. H. J. Bollen and N. Etherden, “Overload and overvoltage in low-voltage and medium-voltage networks due to renewable energy Some illustrative case studies,” IEEE PES Innov. Smart Grid Technol. Conf. Eur., pp. 1–8, 2011, doi: 10.1109/ISGTEurope.2011.6162645.
[147] S. Ab, “Paper 654 LUND 2015 Increasing hosting capacity through dynamic line rating – risk aspects Nicholas Etherden , Math Bollen , Jonas Tjäder The availability of monitoring , control and communication technology makes it possible to estimate the ampacity of a,” pp. 1–10, 2015.
[148] Y. Z. Gerdroodbari, R. Razzaghi, and F. Shahnia, “Decentralized Control Strategy to Improve Fairness in Active Power Curtailment of PV Inverters in Low-Voltage Distribution Networks,” IEEE Trans. Sustain. Energy, vol. 12, no. 4, pp. 2282–2292, 2021, doi: 10.1109/TSTE.2021.3088873.
[149] M. Z. Liu et al., “On the Fairness of PV Curtailment Schemes in Residential Distribution Networks,” IEEE Trans. Smart Grid, vol. 11, no. 5, pp. 4502–4512, 2020, doi: 10.1109/TSG.2020.2983771.
[150] C. R. Sarimuthu, V. K. Ramachandaramurthy, K. R. Agileswari, and H. Mokhlis, “A review on voltage control methods using on-load tap changer transformers for networks with renewable energy sources,” Renew. Sustain. Energy Rev., vol. 62, pp. 1154–1161, 2016, doi: 10.1016/j.rser.2016.05.016.
[151] M. Asano et al., “On the Interplay between SVCs and Smart Inverters for Managing Voltage on Distribution Networks,” IEEE Power Energy Soc. Gen. Meet., vol. 2019–Augus, pp. 1–5, 2019, doi: 10.1109/PESGM40551.2019.8973743.
[152] A. Arshad and M. Lehtonen, “A Stochastic Assessment of PV Hosting Capacity Enhancement in Distribution Network Utilizing Voltage Support Techniques,” IEEE Access, vol. 7, pp. 46461–46471, 2019, doi: 10.1109/ACCESS.2019.2908725.
[153] J. Hu, M. Marinelli, M. Coppo, A. Zecchino, and H. W. Bindner, “Coordinated voltage control of a decoupled three-phase on-load tap changer transformer and photovoltaic inverters for managing unbalanced networks,” Electr. Power Syst. Res., vol. 131, pp. 264–274, 2016, doi: 10.1016/j.epsr.2015.10.025.
[154] M. M. Haque and P. Wolfs, “A review of high PV penetrations in LV distribution networks: Present status, impacts and mitigation measures,” Renew. Sustain. Energy Rev., vol. 62, pp. 1195–1208, 2016, doi: 10.1016/j.rser.2016.04.025.
[155] D. E. Mawarni, M. M. V. M. Ali, P. H. Nguyen, W. L. Kling, and M. Jerele, “A case study of using OLTC to mitigate overvoltage in a rural european low voltage network,” Proc. Univ. Power Eng. Conf., vol. 2015–Novem, no. 608998, 2015, doi: 10.1109/UPEC.2015.7339875.
[156] M. Nijhuis, M. Gibescu, and J. F. G. Cobben, “Incorporation of on-load tap changer transformers in low-voltage network planning,” IEEE PES Innov. Smart Grid Technol. Conf. Eur., 2016, doi: 10.1109/ISGTEurope.2016.7856207.
[157] A. T. Procopiou and L. F. Ochoa, “Voltage Control in PV-Rich LV Networks Without Remote Monitoring,” IEEE Trans. Power Syst., vol. 32, no. 2, pp. 1224–1236, 2017, doi: 10.1109/TPWRS.2016.2591063.

[158] C. Long and L. F. Ochoa, “Voltage control of PV-rich LV networks: OLTC-fitted transformer and capacitor banks,” IEEE Trans. Power Syst., vol. 31, no. 5, pp. 4016–4025, 2016, doi: 10.1109/TPWRS.2015.2494627.
[159] D. A. Sarmiento, P. P. Vergara, L. C. P. Da Silva, and M. C. De Almeida, “Increasing the PV hosting capacity with OLTC technology and PV VAr absorption in a MV/LV rural Brazilian distribution system,” Proc. Int. Conf. Harmon. Qual. Power, ICHQP, vol. 2016–Decem, pp. 395–399, 2016, doi: 10.1109/ICHQP.2016.7783454.
[160] B. Bletterie, J. Le Baut, S. Kadam, R. Bolgaryn, and A. Abart, “Hosting capacity of LV networks with extended voltage band,” Proc. - 2015 Int. Symp. Smart Electr. Distrib. Syst. Technol. EDST 2015, no. Lv, pp. 531–536, 2015, doi: 10.1109/SEDST.2015.7315265.
[161] Rauma, Kalle, et al. "Assessment of the MV/LV on-load tap changer technology as a way to increase LV hosting capacity for photovoltaic power generators." (2016): 44-4.
[162] R. Pellerej, T. Trouillon, C. Benoit, Q. Garnier, and A. Versyp, “Impact of flexibility on low-voltage networks’ hosting capacity - Belgium experimentation,” CIRED - Open Access Proc. J., vol. 2020, no. 1, pp. 209–212, 2020, doi: 10.1049/oap-cired.2021.0308.
[163] J. Seuss, M. J. Reno, R. J. Broderick, and S. Grijalva, “Improving distribution network PV hosting capacity via smart inverter reactive power support,” IEEE Power Energy Soc. Gen. Meet., vol. 2015–Septe, no. 1, pp. 0–4, 2015, doi: 10.1109/PESGM.2015.7286523.
[164] S. F. Santos, D. Z. Fitiwi, M. Shafie-Khah, A. W. Bizuayehu, C. M. P. Cabrita, and J. P. S. Catalão, “New Multistage and Stochastic Mathematical Model for Maximizing RES Hosting Capacity - Part I: Problem Formulation,” IEEE Trans. Sustain. Energy, vol. 8, no. 1, pp. 304–319, 2017, doi: 10.1109/TSTE.2016.2598400.
[165] S. F. Santos, D. Z. Fitiwi, M. Shafie-Khah, A. W. Bizuayehu, C. M. P. Cabrita, and J. P. S. Catalão, “New Multi-Stage and Stochastic Mathematical Model for Maximizing RES Hosting Capacity - Part II: Numerical Results,” IEEE Trans. Sustain. Energy, vol. 8, no. 1, pp. 320–330, 2017, doi: 10.1109/TSTE.2016.2584122.
[166] R. Jorge and A. Carrapatoso, “CIRED Workshop - Lisbon 29-30 May 2012 CIRED Workshop - Lisbon 29-30 May 2012,” vol. 319, no. 356, pp. 1–4, 2012.
[167] A. SOROUDI, A. RABIEE, A. K.- CIRED 2015, undefined June15G18, and undefined 2015, “Distribution network hosting capacity maximization using demand response,” Researchgate.Net, no. June, pp. 15–18, 2015, [Online]. Available: https://www.researchgate.net/profile/Alireza-Soroudi/publication/279959901_Distribution_Network_Hosting_Capacity_Maximization_using_Demand_Response/links/559fe4b208aef92d04ce2271/Distribution-Network-Hosting-Capacity-Maximization-using-Demand-Response.pdf
[168] S. Hashemi, J. Ostergaard, and G. Yang, “Effect of reactive power management of PV inverters on need for energy storage,” Conf. Rec. IEEE Photovolt. Spec. Conf., pp. 2304–2308, 2013, doi: 10.1109/PVSC.2013.6744938.
[169] E. Demirok, D. Sera, R. Teodorescu, P. Rodriguez, and U. Borup, “Clustered PV inverters in LV networks: An overview of impacts and comparison of voltage control strategies,” 2009 IEEE Electr. Power Energy Conf. EPEC 2009, pp. 1–6, 2009, doi: 10.1109/EPEC.2009.5420366.
[170] J. Seuss and R. G. Harley, “A low-cost distributed control strategy for rooftop PV with utility benefits,” IEEE Power Energy Soc. Gen. Meet., 2013, doi: 10.1109/PESMG.2013.6672739.
[171] Z. Xu, X. Wang, J. Yang, and F. Zhang, “A review on voltage control for distribution systems with large-scale distributed photovoltaic power integration,” IOP Conf. Ser. Earth Environ. Sci., vol. 371, no. 5, 2019, doi: 10.1088/1755-1315/371/5/052027.
[172] X. Su, M. A. S. Masoum, and P. J. Wolfs, “Optimal PV Inverter Reactive Power Control and Real Power Curtailment to Improve the Performance of Low Voltage Distribution System,” IEEE Trans. Sustain. Energy, vol. 5, no. 3, pp. 967–977, 2014.
[173] M. M. Rahman, A. A. Shafiullah, A. Arefi, H. Pezeshki, and S. Hettiwatte, “Improvement of voltage magnitude and unbalance in LV network by implementing residential demand response,” IEEE Power Energy Soc. Gen. Meet., vol. 2018–Janua, pp. 1–5, 2018, doi: 10.1109/PESGM.2017.8273831.
[174] Son, Ye-Ji, et al. "Residential demand response-based load-shifting scheme to increase hosting capacity in distribution system." IEEE Access 10 (2022): 18544-18556.
[175] Soroudi, Alireza, Abbas Rabiee, and Andrew Keane. "Distribution networks' energy losses versus hosting capacity of wind power in the presence of demand flexibility." Renewable energy 102 (2017): 316-325.
[176] Li, Xiangkun, Theodor Borsche, and Göran Andersson. "PV integration in Low-Voltage feeders with Demand Response." 2015 IEEE Eindhoven PowerTech. IEEE, 2015.
[177] Mahroo-Bakhtiari, Reza, et al. "Distributed load management scheme to increase PV hosting capacity in LV feeders." IET Renewable Power Generation 14.1 (2020): 125-133.
[178] K. A. W. Horowitz, A. Jain, F. Ding, B. Mather, and B. Palmintier, “A techno-economic comparison of traditional upgrades, volt-var controls, and coordinated distributed energy resource management systems for integration of distributed photovoltaic resources,” Int. J. Electr. Power Energy Syst., vol. 123, 2020, doi: 10.1016/j.ijepes.2020.106222.
[179] K. A. W. Horowitz, F. Ding, B. Mather, and B. Palmintier, “The Cost of Distribution System Upgrades to Accommodate Increasing Penetrations of Distributed Photovoltaic Systems on Real Feeders in the United States,” Golden, CO Natl. Renew. Energy Lab., no. April, p. NREL/TP-6A20-70710, 2018, [Online]. Available: http://www.osti.gov/servlets/purl/1432760/
[180] E. Mulenga and M. H. J. Bollen, “Impact of service and feeder cable upgrade on hosting capacity for single phase connected photovoltaics,” Proc. Int. Conf. Harmon. Qual. Power, ICHQP, vol. 2018–May, pp. 1–6, 2018, doi: 10.1109/ICHQP.2018.8378861.
[181] S. Fatima, V. Püvi, M. Pourakbari-Kasmaei, and M. Lehtonen, “Photovoltaic hosting capacity improvement based on the economic comparison between curtailment and network upgrade,” IET Gener. Transm. Distrib., vol. 17, no. 17, pp. 3848–3860, 2023, doi: 10.1049/gtd2.12936.
[182] O. D. Melgar-Dominguez, D. A. Quijano, J. R. S. Mantovani, and G. Chicco, “A Robust Multiobjective Strategy for Short-Term Distribution System Upgrading to Increase the Distributed Generation Hosting Capacity,” IEEE Trans. Power Syst., vol. 37, no. 6, pp. 4352–4364, 2022, doi: 10.1109/TPWRS.2022.3155934.
[183] A. Almalaq et al., “Towards Increasing Hosting Capacity of Modern Power Systems through Generation and Transmission Expansion Planning,” Sustain., vol. 14, no. 5, pp. 1–26, 2022, doi: 10.3390/su14052998.
[184] M. Vellingiri et al., “Maximum hosting capacity estimation for renewables in power grids considering energy storage and transmission lines expansion using hybrid sine cosine artificial rabbits algorithm,” Ain Shams Eng. J., vol. 14, no. 5, p. 102092, 2023, doi: 10.1016/j.asej.2022.102092.
[185] S. N. M. Saad and A. H. van der Weijde, “Evaluating the Potential of Hosting Capacity Enhancement Using Integrated Grid Planning modeling Methods,” Energies, vol. 12, no. 19, pp. 1–23, 2019, doi: 10.3390/en12193610.
[186] M. Hamedi et al., “Developing an Integration of Smart-Inverter-Based Hosting-Capacity Enhancement in Dynamic Expansion Planning of PV-Penetrated LV Distribution Networks,” Sustain., vol. 15, no. 14, pp. 1–27, 2023, doi: 10.3390/su151411183.
[187] E. Mulenga, M. H. J. Bollen, and N. Etherden, “Adapted Stochastic PV Hosting Capacity Approach for Electric Vehicle Charging Considering Undervoltage,” Electricity, vol. 2, no. 3, pp. 387–402, 2021, doi: 10.3390/electricity2030023.
[188] R. Lamedica, A. Geri, F. M. Gatta, S. Sangiovanni, M. Maccioni, and A. Ruvio, “Integrating Electric Vehicles in Microgrids: Overview on Hosting Capacity and New Controls,” IEEE Trans. Ind. Appl., vol. 55, no. 6, pp. 7338–7346, 2019, doi: 10.1109/TIA.2019.2933800.
[189] A. Y. Saber and G. K. Venayagamoorthy, “Plug-in vehicles and renewable energy sources for cost and emission reductions,” IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1229–1238, 2011, doi: 10.1109/TIE.2010.2047828.
[190] J. A. Domínguez-Navarro, R. Dufo-López, J. M. Yusta-Loyo, J. S. Artal-Sevil, and J. L. Bernal-Agustín, “Design of an electric vehicle fast-charging station with integration of renewable energy and storage systems,” Int. J. Electr. Power Energy Syst., vol. 105, no. August 2018, pp. 46–58, 2019, doi: 10.1016/j.ijepes.2018.08.001.
[191] N. B. Arias, S. Hashemi, P. B. Andersen, C. Traholt, and R. Romero, “V2G enabled EVs providing frequency containment reserves: Field results,” Proc. IEEE Int. Conf. Ind. Technol., vol. 2018–Febru, pp. 1814–1819, 2018, doi: 10.1109/ICIT.2018.8352459.
[192] S. Iqbal et al., “Frequency Control in a Microgrid- A Review,” 2018 IEEE 2nd Int. Electr. Energy Conf., pp. 563–568, 2018.

[193] H. S. Das, M. M. Rahman, S. Li, and C. W. Tan, "Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review," Renew. Sustain. Energy Rev., vol. 120, no. November, 2020, doi: 10.1016/j.rser.2019.109618.
[194] T. Karthik, M. Prathyusha, R. Thirumalaivasan, and M. Janaki, "Power quality improvement using DSTATCOM," 2019 Innov. Power Adv. Comput. Technol. i-PACT 2019, pp. 311–316, 2019, doi: 10.1109/i-PACT44901.2019.8960234.
[195] W. Zhang, O. Gandhi, H. Quan, C. D. Rodríguez-Gallegos, and D. Srinivasan, "A multi-agent based integrated volt-var optimization engine for fast vehicle-to-grid reactive power dispatch and electric vehicle coordination," Appl. Energy, vol. 229, no. July 2018, pp. 96–110, 2018, doi: 10.1016/j.apenergy.2018.07.092.
[196] H. Shareef, M. M. Islam, and A. Mohamed, "A review of the stage-of-the-art charging technologies, placement methodologies, and impacts of electric vehicles," Renew. Sustain. Energy Rev., vol. 64, pp. 403–420, 2016, doi: 10.1016/j.rser.2016.06.033.
[197] D. Wu, K. T. Chau, C. Liu, S. Gao, and F. Li, "Transient stability analysis of SMES for smart grid with vehicle-to-grid operation," IEEE Trans. Appl. Supercond., vol. 22, no. 3, pp. 1–5, 2012, doi: 10.1109/TASC.2011.2174572.
[198] L. Pieltain Fernández, T. Gómez San Román, R. Cossent, C. Mateo Domingo, and P. Frías, "Assessment of the impact of plug-in electric vehicles on distribution networks," IEEE Trans. Power Syst., vol. 26, no. 1, pp. 206–213, 2011, doi: 10.1109/TPWRS.2010.2049133.
[199] J. Y. Yong, V. K. Ramachandaramurthy, K. M. Tan, and N. Mithulananthan, "A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects," Renew. Sustain. Energy Rev., vol. 49, pp. 365–385, 2015, doi: 10.1016/j.rser.2015.04.130.
[200] H. L. Li, X. M. Bai, and W. Tan, "Impacts of plug-in hybrid electric vehicles charging on distribution grid and smart charging," 2012 IEEE Int. Conf. Power Syst. Technol. POWERCON 2012, pp. 1–5, 2012, doi: 10.1109/PowerCon.2012.6401265.
[201] Q. Yan and M. Kezunovic, "Impact analysis of electric vehicle charging on distribution system," 2012 North Am. Power Symp. NAPS 2012, 2012, doi: 10.1109/NAPS.2012.6336413.
[202] S. W. Hadley and A. Tsvetkova, Potential impacts of plug-in hybrid electric vehicles on regional power generation, no. January. 2011.
[203] A. Ali, K. Mahmoud, and M. Lehtonen, "'Maximizing Hosting Capacity of Uncertain Photovoltaics by Coordinated Management of OLTC, VAr Sources and Stochastic EVs,'" Int. J. Electr. Power Energy Syst., vol. 127, no. September 2020, p. 106627, 2021, doi: 10.1016/j.ijepes.2020.106627.
[204] M. S. S. Abad, J. Ma, A. S. Ahmadyar, and H. Marzooghi, "Distributionally robust distributed generation hosting capacity assessment in distribution systems," Energies, vol. 11, no. 11, pp. 1–19, 2018, doi: 10.3390/en11112981.
[205] A. Ali, K. Mahmoud, and M. Lehtonen, "Enhancing hosting capacity of intermittent wind turbine systems using bi-level optimisation considering oltc and electric vehicle charging stations," IET Renew. Power Gener., vol. 14, no. 17, pp. 3558–3567, 2020, doi: 10.1049/iet-rpg.2020.0837.
[206] D. A. Quijano, O. D. Melgar-Dominguez, C. Sabillon, B. Venkatesh, and A. Padilha-Feltrin, "Increasing distributed generation hosting capacity in distribution systems via optimal coordination of electric vehicle aggregators," IET Gener. Transm. Distrib., vol. 15, no. 2, pp. 359–370, 2021, doi: 10.1049/gtd2.12026.
[207] N. Bhusal, M. Kamruzzaman, and M. Benidris, "Photovoltaic Hosting Capacity Estimation Considering the Impact of Electric Vehicles," 2019 IEEE Ind. Appl. Soc. Annu. Meet. IAS 2019, pp. 1–6, 2019, doi: 10.1109/IAS.2019.8912403.
[208] R. Fachrizal, U. H. Ramadhani, J. Munkhammar, and J. Widén, "Combined PV–EV hosting capacity assessment for a residential LV distribution grid with smart EV charging and PV curtailment," Sustain. Energy, Grids Networks, vol. 26, p. 100445, 2021, doi: 10.1016/j.segan.2021.100445.
[209] E. C. Da Silva, O. D. Melgar-Dominguez, and R. Romero, "Simultaneous distributed generation and electric vehicles hosting capacity assessment in electric distribution systems," IEEE Access, vol. 9, pp. 110927–110939, 2021, doi: 10.1109/ACCESS.2021.3102684.
[210] C. D. Zuluaga-Ríos, A. Villa-Jaramillo, and S. D. Saldarriaga-Zuluaga, "Evaluation of Distributed Generation and Electric Vehicles Hosting Capacity in Islanded DC Grids Considering EV Uncertainty," Energies, vol. 15, no. 20, 2022, doi: 10.3390/en15207646.
[211] M. D. Kamruzzaman and M. Benidris, "A reliability-constrained demand response-based method to increase the hosting capacity of power systems to electric vehicles," Int. J. Electr. Power Energy Syst., vol. 121, 2020, doi: 10.1016/j.ijepes.2020.106046.
[212] C. Dimas, G. Ramos, L. Caro, and A. C. Luna, "Parallel Computing and Multicore Platform to Assess Electric Vehicle Hosting Capacity," IEEE Trans. Ind. Appl., vol. 56, no. 5, pp. 4709–4717, 2020, doi: 10.1109/TIA.2020.3004287.
[213] P. Paudyal, S. Ghosh, S. Veda, D. Tiwari, and J. Desai, "EV Hosting Capacity Analysis on Distribution Grids," IEEE Power Energy Soc. Gen. Meet., vol. 2021–July, no. August, 2021, doi: 10.1109/PESGM46819.2021.9638170.
[214] T. H. Kim, D. Kim, and S. Il Moon, "Evaluation of Electric Vehicles Hosting Capacity Based on Interval Undervoltage Probability in a Distribution Network," IEEE Access, vol. 9, pp. 140147–140155, 2021, doi: 10.1109/ACCESS.2021.3116465.
[215] S. Cundeva, A. K. Mateska, and M. H. J. Bollen, "Hosting capacity of LV residential grid for uncoordinated ev charging," Proc. Int. Conf. Harmon. Qual. Power, ICHQP, vol. 2018–May, pp. 1–5, 2018, doi: 10.1109/ICHQP.2018.8378892.
[216] Kamruzzaman, M. D., et al. "A method to evaluate the maximum hosting capacity of power systems to electric vehicles." 2020 International Conference on Probabilistic Methods Applied to Power Systems (PMAPS). IEEE, 2020.
[217] M. D. Kamruzzaman, M. Benidris, S. Elsaiah, and Y. Tian, "A Method for Maximizing the Hosting Capacity to Electric Vehicles using Feeder Reconfiguration," IEEE Power Energy Soc. Gen. Meet., vol. 2020–Augus, 2020, doi: 10.1109/PESGM41954.2020.9282115.

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