DEVELOPMENT OF DC DISTRIBUTION NETWORKS TECHNICALLY AND ECONOMICALLY USING DOMESTIC AND COMMERCIAL LOADS

Shahin Mohammadzadeh[1]

Master's degree, power engineering, power system, Bonab National University, Iran

Abstract

Electricity management involves a series of interconnected activities between the nuclear industry and its customers in order to rationalize electricity consumption. In this way, both the electricity supplier and the consumer will benefit more. Electricity management has a logical output and different plans to reduce energy consumption. Direct current (DC) distribution has recently been considered in building research due to increased on-site generation and battery storage, and the increasing prevalence of DC internal loads. In terms of performance comparison, DC current distribution buildings are much more efficient than AC distribution buildings. With the increase of distribution generation penetration coefficient, DC distribution network has been gradually considered due to higher quality, lower losses and larger distributed energy compared to AC distribution network. The DC distribution system has the potential to eliminate many of the conversion losses in AC building distribution networks, which include photovoltaic and DC end-uses. This means that AC / DC converters can be eliminated using the DC distribution system, which reduces losses. In this paper, we examine the development of direct current (DC) networks from a technical and economic point of view using domestic and commercial loads. A review of the achievements achieved in this regard and a sample of work done in this regard is provided.

Keywords: Technical and economic analysis, direct current distribution networks, domestic and commercial loads

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Introduction

Global challenges such as climate change, energy security and environmental pollution have prompted research into different types of alternative energy sources. Electric energy is the most common type of energy in our daily lives, but its production is often achieved by burning fossil fuels, which have many limitations. In the old structure of the electricity industry in developed countries and the current situation of many countries, the tasks of production, transmission and distribution have been the responsibility of integrated electricity companies [1]. The increase in power demand in recent years in many countries has caused these companies to not be able to effectively meet this high demand, resulting in blackouts, power outages and equipment failure, etc [2]. in many countries. As a result, prices soared during the peak period. In addition, the oil crisis has led many countries that depended on fossil fuels in their industry to find suitable alternatives to these fuels. It also became more important to find a suitable alternative to fossil fuels as public awareness of environmental issues increased. [3]

To evaluate the cost-effectiveness of a DC distribution, its economic performance is compared with a corresponding AC distribution system. This comparison considers the incremental cost difference between the two systems, assuming that AC and DC buildings are the same except for their distribution systems; Therefore, TEA is limited to capital differences and operating costs due to different system components in AC and DC distribution systems. The methodology and criteria (LCC and PBP) used in this TEA are consistent with what the DOE standard uses to determine the economic impact of the consumer on energy saving standards in home appliances. The DOE uses LCC and PBP as part of a set of criteria used to determine regulation [4-12]. [12-23-9]. In general, a technical and economic evaluation of DC direct current distribution in highly efficient commercial and residential buildings with DC loads is provided [24]. Previous studies have shown that buildings with high capacity PV and high battery storage are more cost-effective; Otherwise, DC systems would not be cost-effective, so a battery-free building would hardly benefit from DC distribution. Finally, using a large capacity battery can help with beneficial distribution. The analysis also shows that the simultaneous load and production of PV saves productivity and economic benefits. Perhaps one of the most important factors in saving energy and cost is the DC system configuration. Simpler systems with fewer energy conversion steps have fewer components and suffer less losses.

It should be noted that the current markets for DC systems are in their infancy, and most analyzes take into account installation costs and design costs, and are expected to be comparable to AC networks with increasing developments. While other potential benefits of DC can translate into additional cost savings for DC distribution; Flexibility, ease of communication, controls, and increased reliability of simpler devices can actually be more important motivating factors for using DC power in buildings [25]. Environmental concerns as well as rising fossil fuel prices are among the main reasons for the growing trend towards renewable energy. All over the world due to the growth of industries and increasing and limited use

End-of-life fossil fuels, as well as low-efficiency energy converters that pollute the environment, alter ecosystems, and upset nature, produce energy at low voltage levels and at the point of use, from renewable sources and microgrids [26]. Used. Due to the high costs of investment and maintenance, etc., optimal energy management in these systems is very important.

In this paper, an optimization model for optimal power planning in the distribution network with the presence of renewable resources and VSCs added to the network was expressed.

The optimization problem is a nonlinear multi-objective problem of mixed integers and a 24-hour planning horizon. The problem includes distribution network power dissipation constraints, network losses, converter constraints, renewable generation constraints and losses, and finally constraints on VSCs added to the system.

In general, the results obtained in this article are summarized as follows:

- Minimize the reduction of renewable energy production
- Minimize the cost of operating renewable energy sources, fuel cells and diesel generators
- Optimal distribution power distribution distribution planning in the presence of renewables and VSCs

Objectives and formulation functions:

The intended objective functions meet the following objectives, which are:

Minimizing the production of renewable resources

This goal minimizes the overall limitation of renewable energy on the optimization horizon, which is formulated as follows:

$f_1 = min \sum_{t=1}^{t_n} PCUR(t) \Delta T$
1

Here t is the time step, PCUR (t) is the limit of the renewable generation at each time step. t is the number of time steps ΔT is the length of each time step.

Minimizing the cost of operating renewable energy sources, fuel cells and diesel generators

The objective functions of the problem are expressed as relation (1):

)2$(f_2 = \sum_{t=1}^{t_n} (C_f\,(t) P_f(t) \Delta T + \sum_{K=1}^{K} C_K(t) P_{DER-K}(T) \Delta T) + \sum_{\mathrm{l}\,\epsilon\, r} C_{\mathrm{l}}$

Where k is the number of DERS; C_F (t) and C_K (t) are the electricity price and DER operating cost at each stage, respectively. Pf is the power purchased from the external network. P_{DER-k} is the active power generation of DER-K. C is the cost of flexible load I, T is the set of flexible load.

The objective function is related to the first goal and the other expresses the second goal.

Problem constraints

Active and reactive power balance constraints in relation 3:

AC grid power balance equations

)3 $(P_{Gi} - P_{Di} - V_i \sum_{j \in N_{AC}} V_j \left(G_{ij} cos\theta_{ij} + B_{ij} sin\theta_{ij}\right) = 0. \forall_i \in N_{AC}$

$Q_{Gi} - Q_{Di} - V_j\left(G_{ij} sin\theta_{ij} - B_{ij} cos\theta_{ij}\right) = 0. \forall_i \in N_{AC}$

Where P_{Gi} and Q_{Gi} are the injection of active and reactive power in the passage i, respectively. P_{Di} and Q_{Di} are active and reactive loads at bus i. V_i and V_j are the junction voltages of bus and bus j, respectively B_{ij} and G_{ij} are, respectively, the electrical conductivity sensitivity and the phase angle difference between bus i and bus j.

Network security restrictions

Network security constraints, including bus voltage limits and line loads, are expressed in Equations 4 and 5:

)4 $(V_{min}(i) < V(i.t) < V_{max}(i)$

Where, V (i.t) is the voltage of the bus node i at time t 〖V_max (i) and V〗 _min (i) are the low and high voltage ranges of the bus i, respectively. It is assumed that the low and high voltage ranges remain constant on the optimization horizon. Line loading restrictions are formulated as follows.

) 5 $(\quad -S_{max}(m) < |S(m.t)| < S_{max}(m)$

Where $S(m.t)$ represents the apparent power current of the m line, $S_{max}(m)$ represents the maximum allowable power current.

5Restrictions on the production of dispersed generators

Constraints on the production of distributed generators include the following equations:

)6 $(0 \leq P_{DG}(nf.t) \leq P_{DG.max}(nf.t) \quad \forall nf.t \in T$

)7 $(P_{DG}(nf.t) - P_{DG.\mathrm{max}}(nf.t+1) \leq R_{down} \quad \forall nf.t \in T$

)8 $(P_{DG}(nf.t+1) - P_{DG}(nf.t) \leq R_{up} \quad \forall nf.t \in T$

P_DG is the active power generation of DG and R_{down} and Rup are related ramp-down and ramp-up rates, respectively.

energy storage constraints

ESS can absorb energy during periods of low demand and sell power during peak hours. This reduces the need for conventional peak power plants. ESSS restrictions apply to maximum capacity and charge mode (SOC). For simplicity, it is assumed that the charging power and discharging power are constant at any time interval. Equations (9) and (10) present the ESS charge and discharge constraints. Equation (11) ensures that charging and discharging do not occur simultaneously.

The following restrictions apply to energy storage and charging and discharging:

(9)$O \leq P_{charge}(t) \leq X_{charge}\,(t) \times P_{charge.max}(t)$

)10 $(\; O \leq P_{dis}(t) \leq X_{dis}(t) \times P_{dis.max}(t)$

)11 (

$X_{charge}(t) + X_{dis} \leq 1$

Where P_{dis} and P_{charge}charge are the ESS charge and discharge power. $P_{charge.max}$ and $P_{dis.max}$ Are the corresponding restrictions. 1 =X_{charge} و 0 = X_{dis} dis indicate the ESS charge and discharge mode. If 1 X_{charge} و 0 = X_{dis} dis, ESS is in charge mode. Otherwise, if0 = $X_{charge}$and 1= X_{dis} is in discharge mode. In short, X is a binary variable for charging and discharging storage and describes how to charge and dis charge.

Storage charge modes and related limitations

)12 $$(SOC_{min} \leq SOC(t) \leq SOC_{max}$$

)13 $$(SOC(t+1) = SOC(t) + \frac{\varepsilon_{charge} P_{charge}(t) - \varepsilon_{dis} P_{dis}(t)}{S_{ESS}} \Delta t$$

)14 $$(SOC(t_0) = SOC(t_n)$$

Converter constraints

The constraint constraints are according to the following equations:

)15 $$(P_{inj} = V_i^2 G_C - V_i V_c [G_c \cos(\theta_i - \theta_c) + B_c \sin(\theta_i - \theta_c)]$$

)16 $$(Q_{inj} = -V_i^2 B_C - V_i V_c [G_c \sin(\theta_i - \theta_c) - B_c \cos(\theta_i - \theta_c)]$$

)17 $$(P_{AC-cov} = V_c^2 G_C - V_c V_i [G_c \cos(\theta_c - \theta_i) + B_c \sin(\theta_c - \theta_i)]$$

)18 $$(Q_{AC-cov} = -V_c^2 B_c - V_c V_i [G_c \sin(\theta_c - \theta_i) - B_c \cos(\theta_c - \theta_i)]$$

)19 $$(I_c = \frac{\sqrt{P_{AC-cov} + Q_{AC-COV}}}{\sqrt{3} V_c}$$

)20 $$(P_{loss-con} = a + b \cdot I_c + c \cdot I_c^2$$

)21 $$(\sqrt{P_{AC-cov}^2 + Q_{AC-cov}^2} \leq S_{con}$$

)22 $$(V_{AC-con} \leq \bar{V}_{AC-con}$$

)23 $$(V_{DC-con} \leq \bar{V}_{DC-con}$$

Where P_{inj} و $Q_{inj}$are the active power and reactive power from the AC network to the transformer, respectively. V_i و $V_c$are the voltage values of node i and the AC terminal, and θ_i وθ_c Are the corresponding voltage angles. S_{son} is the capacity of the converter.

Distribution network power exchange

The power exchange of the distribution network with the external network is established through the following equations:

)24 $$(0 \leq PG_{in}(t) \leq (t) \times PG_{in-max}$$

)25 $$(0 \leq PG_{out}(t) \leq X_{out}(t) \times PG_{out-max}$$

)26 $$(X_{in}(t) + X_{out}(t) \leq 1$$

10 load related restrictions

27 $$(\underline{p_{\mathrm{l}}}(t) \leq p_{\mathrm{l}}(t) \leq \overline{p}_{\mathrm{l}}(t) \quad . \ \forall t \in T$$

)28 $$(\underline{E_{\mathrm{l}}}(t) \leq \sum_{t \in T} p_{\mathrm{l}}(t) \Delta t \leq \overline{E}_{\mathrm{l}}(t)$$

)29 $$(C_{\mathrm{l}}(P_{\mathrm{l}}) = \sum_{t \in T} \alpha_{\mathrm{l}} \left(\min\left(p_{\mathrm{l}}(t) - p_{\mathrm{l}}^{f}(t).0\right)\right)^2$$

Constraints related to both VSCs including active and reactive power, losses, etc. are defined in the following equations:

)30 $$(P_{AC1}(t) + P_{AC2}(t) + P_{AC-loss}(t) = 0$$

)31 $(P_{AC-loss}(t) = \eta_{AC1}\left|P_{AC1}(t)\right| + \eta_{AC2}\left|P_{AC2}(t)\right|$

)32 $(V_{AC1}(t) \leq \overline{V_{AC1}}$

)33 $(V_{AC2}(t) \leq \overline{V_{AC2}}$

)34 $(\sqrt{P_{AC1}(t)^2 + Q_{AC1}(t)^2} \leq S_{AC1}$

)35 $(\sqrt{P_{AC2}(t)^2 + Q_{AC2}(t)^2} \leq S_{AC2}$

)36 $(P_{DC1}(\mathrm{t}) + P_{DC2}(t) + P_{DC-loss}(t) = 0$

)*37* $(P_{DC-loss}(\mathrm{t}) = \eta_{DC1}\left|P_{DC1}(t)\right| + \eta_{DC2}\left|P_{DC2}(t)\right.$

)38 $(\left|P_{DC1}(t)\right| \leq \overline{P_{DC1}}$

)39 $(\left|P_{DC2}(t)\right| \leq \overline{P_{DC2}}$

)40 $(V_{DC1} \leq \overline{V_{DC1}}$

)41 $(V_{DC2} \leq \overline{V_{DC2}}$

3: case studies

As mentioned in the previous section, the problem data presented in the previous chapter is such as network data, contours, and VSCs. The network used is the 33-bus IEEE network. The nominal voltage of the mentioned network is 12.66 kV and its nominal power is 1 MVA. In this network, the minimum and maximum voltage values of the buses are equal to 0.94 and 1.06 kV, respectively. GAMS software was used to simulate the case studies. Because the problem model is a nonlinear integer (MINLP) optimization model, the solvers related to this solver are used in the software. Simulation data is also relevant to the problem of network data, contours and VSCs. Case studies include 5 scenarios. For this purpose, five different studies were conducted in this article:

- •Optimal AC power distribution planning
- •Optimal scheduling of AC and DC power distribution simultaneously
- •Optimal AC and DC power distribution planning designed to add contour simultaneously
- •Optimal AC and DC power distribution planning at the same time to add the designed contour with AC constraints, distributed VSCs
- •Optimal AC and DC power distribution planning at the same time to add the designed contour along with AC and DC constraints, distributed VSCs

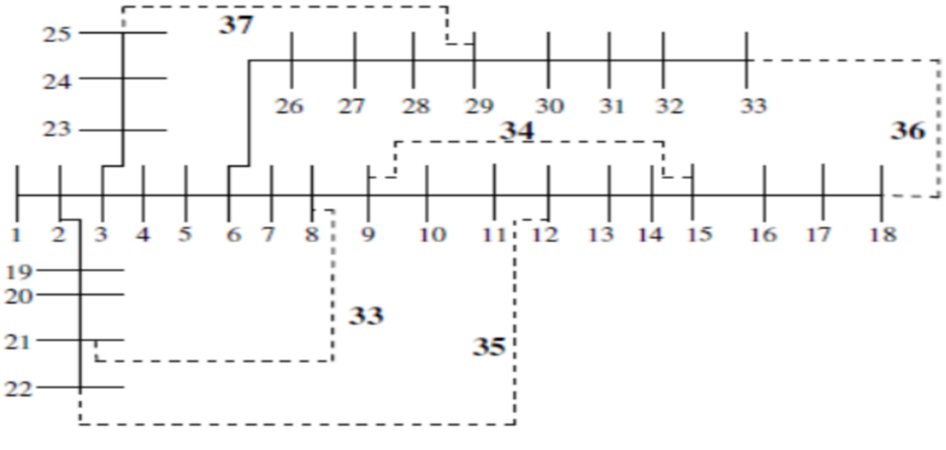


Figure (1) : 33-bus IEEE network

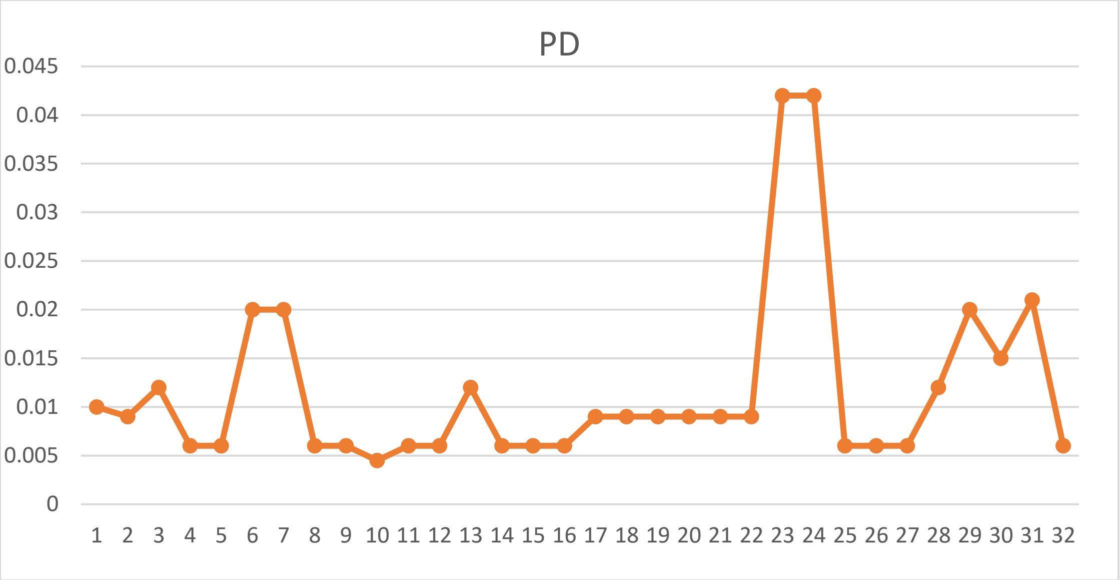


Figure (2) Active load power

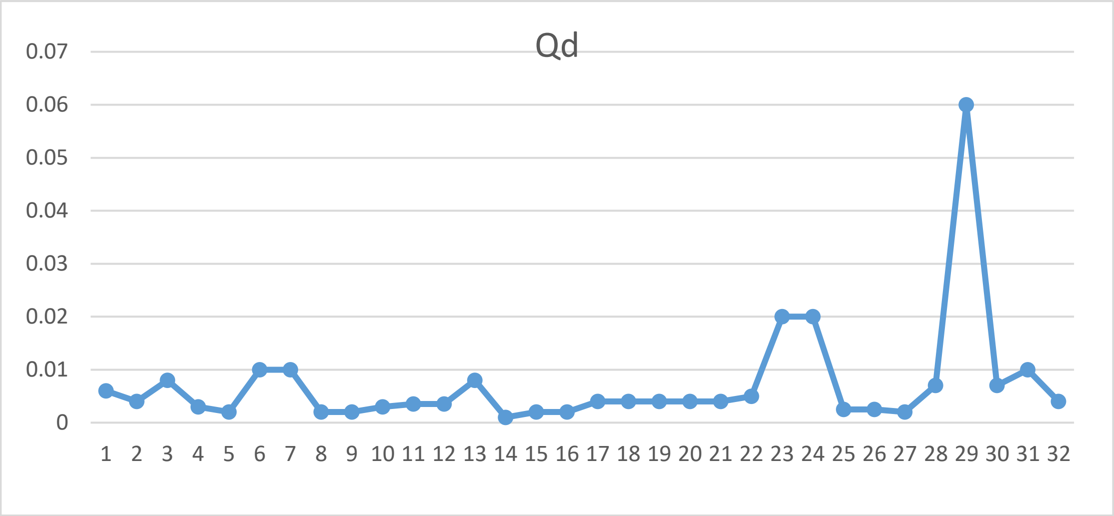


Figure (3) Reactive power of the load

Figures (4), (5) and (6) show the power generation diagrams of solar panels, wind generators and their sum of renewable power, respectively:

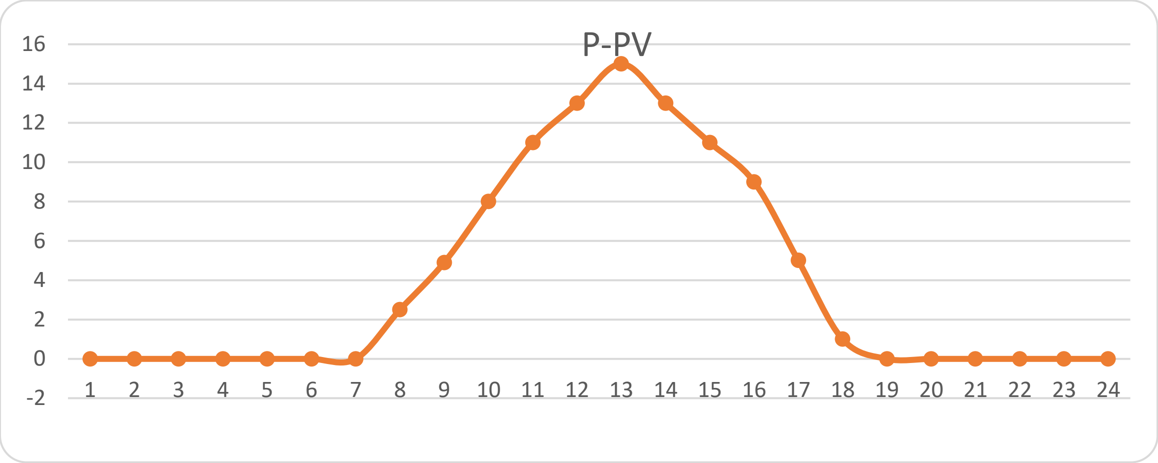


Figure (4) Production capacity of solar panels

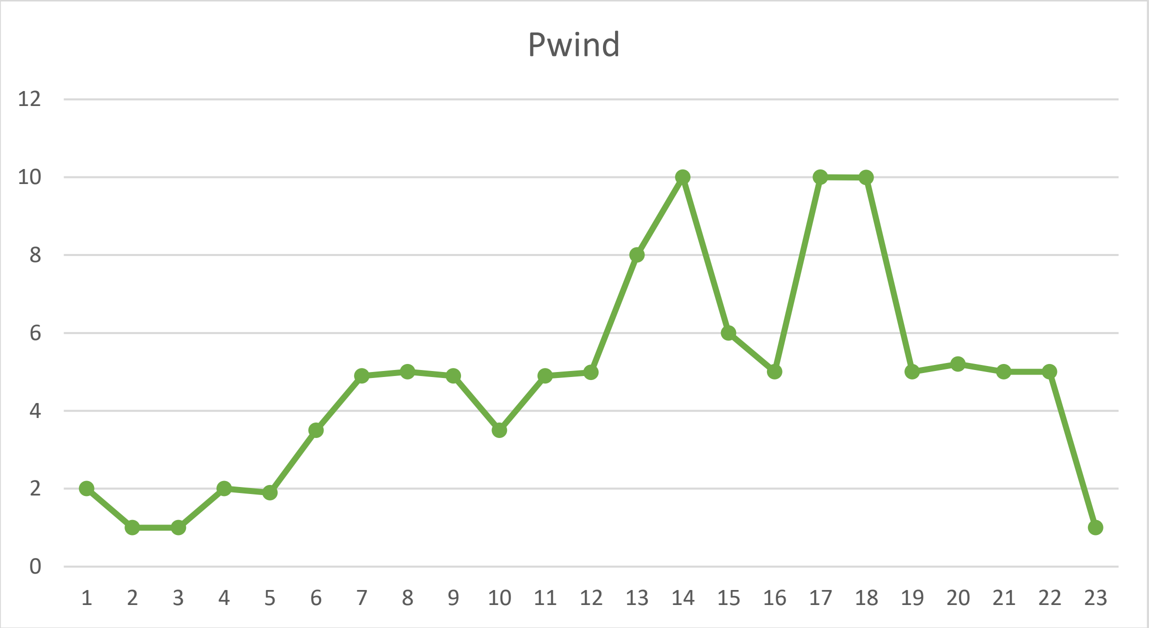


Figure (5) Wind generators

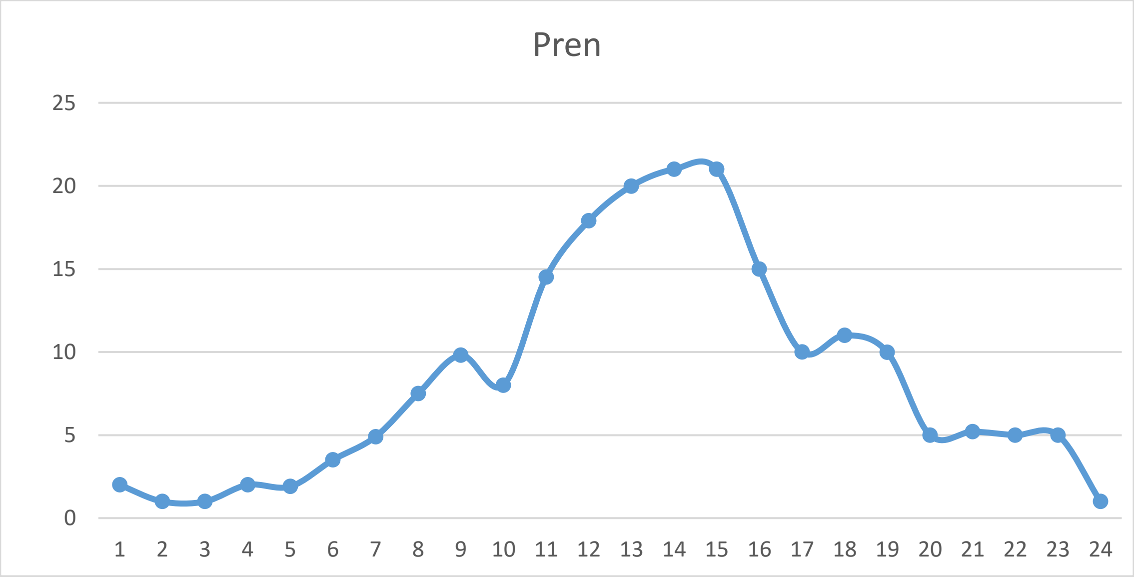


Figure (6) Total renewable production capacity

Simulation:

To simulate and evaluate the results, the case studies are divided into 5 different scenarios and the results are discussed and evaluated in the section related to each.

Scenario One

In the first and second scenarios, there is no mention of contour and VSC constraints. Also, the part of the load done in the power distribution network is AC power and its related restrictions are considered. The optimal values of the objective function are given in the table below as well as the results obtained in the first scenario as diagrams in Figures (7) and (8).

Table (1) optimal values of objective functions

4- Funtot	5- -2.69060E+7
6- Fun1	7- -1.0000E+10
8- Fun2	9- .05541E+9

Diagram of active power output from AC power distribution in the first scenario:

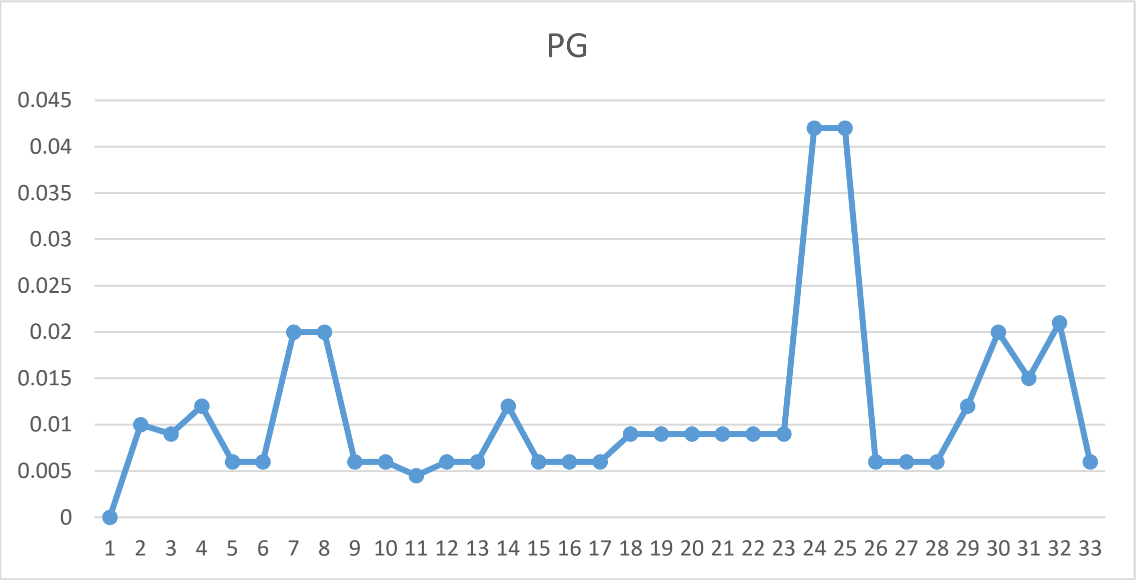


Figure (7) Active load power diagram

Diagram of reactive power generated from AC power distribution in the first scenario: In this scenario, power distribution is not done between DC buses and power generation is used using the AC network in the presence of renewable sources.

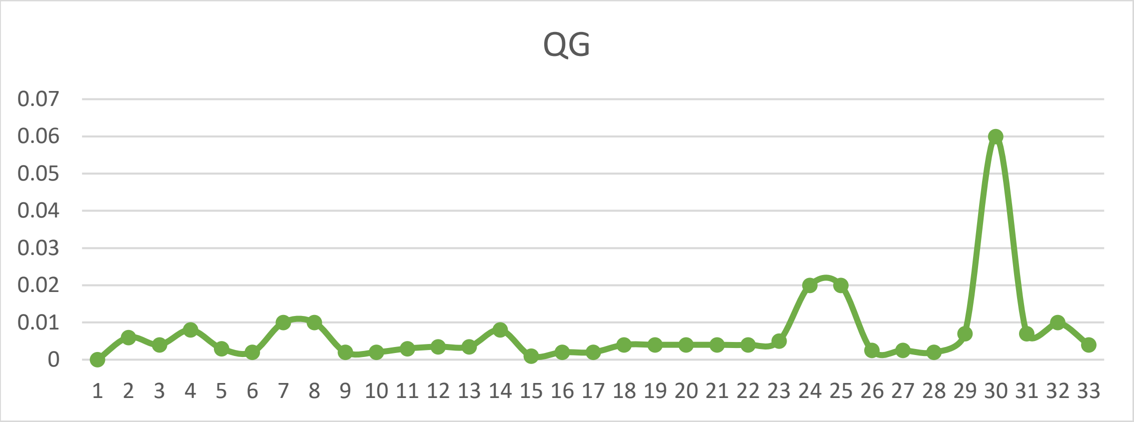


Figure (8) Production reactive power

Scenario II

In the second scenario, the trend changes with the addition of energy constraints to the distributed generators.

Table (2) optimal values of objective functions of the second scenario

11- Fun1	10- -10000000000
13- Fun2	12- 055412486

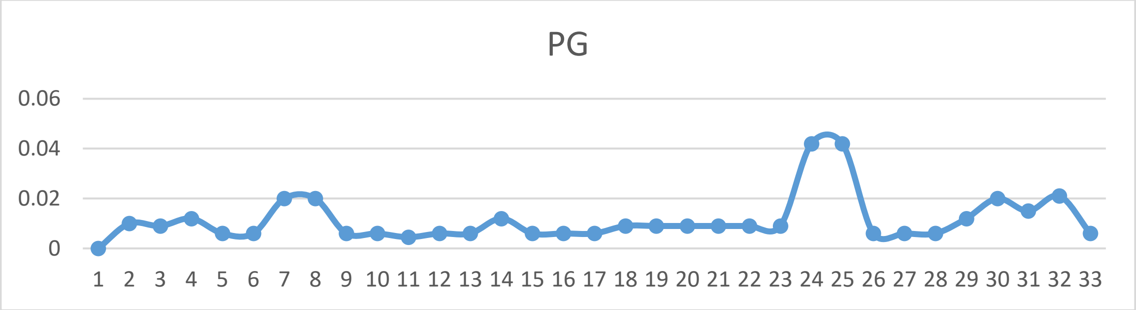


Figure 9 Active generating power

Also, the load supply program is similar to the first scenario. Because AC subnet and DC subnet are independent. Graph of active power output from AC power distribution in the second scenario: Diagram of reactive power generated from AC power distribution in the second scenario:

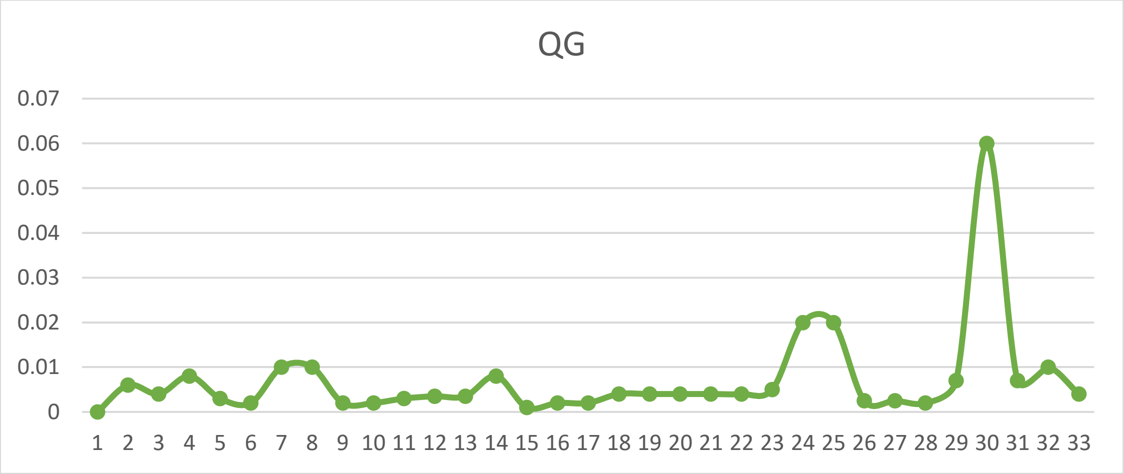


Figure 10) Reactive power generation

As can be seen, the load supply program is similar to the first scenario.

Third scenario

In the third scenario, constraints related to the contour are added to the model. These constraints include AC and DC modes. Also, the output losses of the converter, its active and reactive power and voltage are added to the model of this scenario as constraints and constraints.

Table (4) optimal values of objective functions of the third scenario

15- Fun1	14- -1E+10
17- Fun1_star	16- 203.18
19- Fun2	18- 3.1E+09
21- Fun2_star	20- 664.985
23- Funtot	22- 2.7E+07

In this scenario, a two-way AC / DC converter is used to connect the AC subnet and the DC subnet. The converter also absorbs reactive power, which reduces the increase in voltage under the AC mains during peak hours. The table below shows the active and reactive power and the losses of the converter:

Table (4) the active and reactive power and the losses of the converter

Inc.	-2500.22
PAC_cov	0.014142
PLoss_cov	-18965.6
QAC_cov	-0.01414

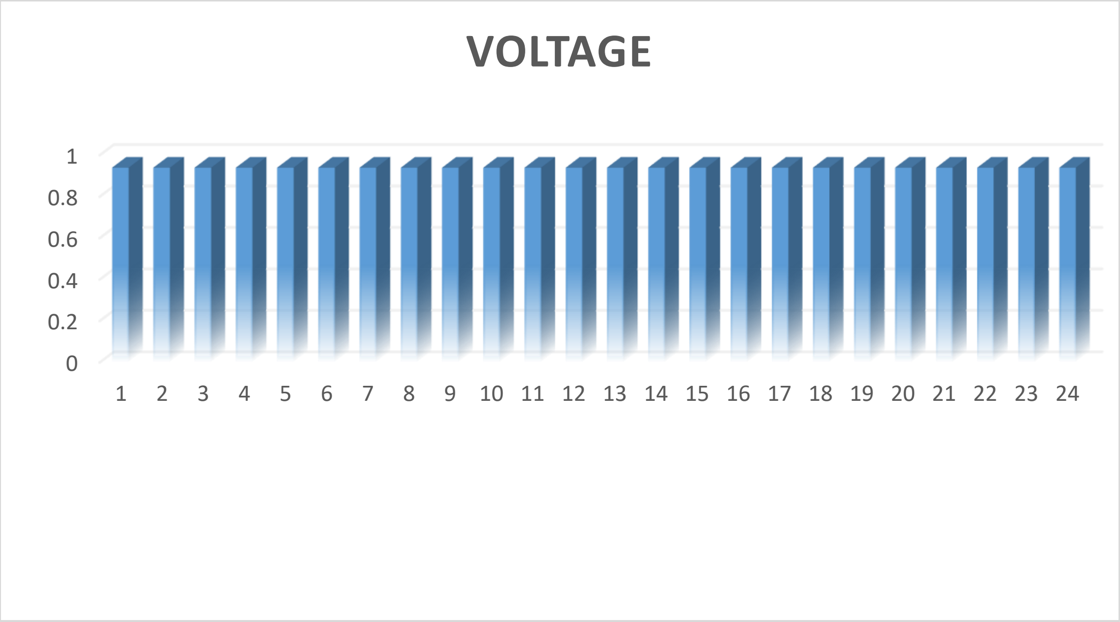


Figure (11) The first bus voltage

The fourth scenario

In Scenario 4, in addition to having contour constraints, VSC constraints are added to the code. Of course, DC mode is added in the next scenario. In this scenario, it is AC mode.

Table (4) optimal values of objective functions of the fourth scenario

25- Fun1	24- -2.0318E+10
27- Fun1_star	26- 203.180
29- Fun2	28- -6.6499E+10
31- Fun2_star	30- 664.985
33- Funtot	32- -1.00000E+8

As expected, it has no quantities and no power is produced. Because the limitations of the two prove this.

The power diagram of the first VSC reactive power diagram shows:

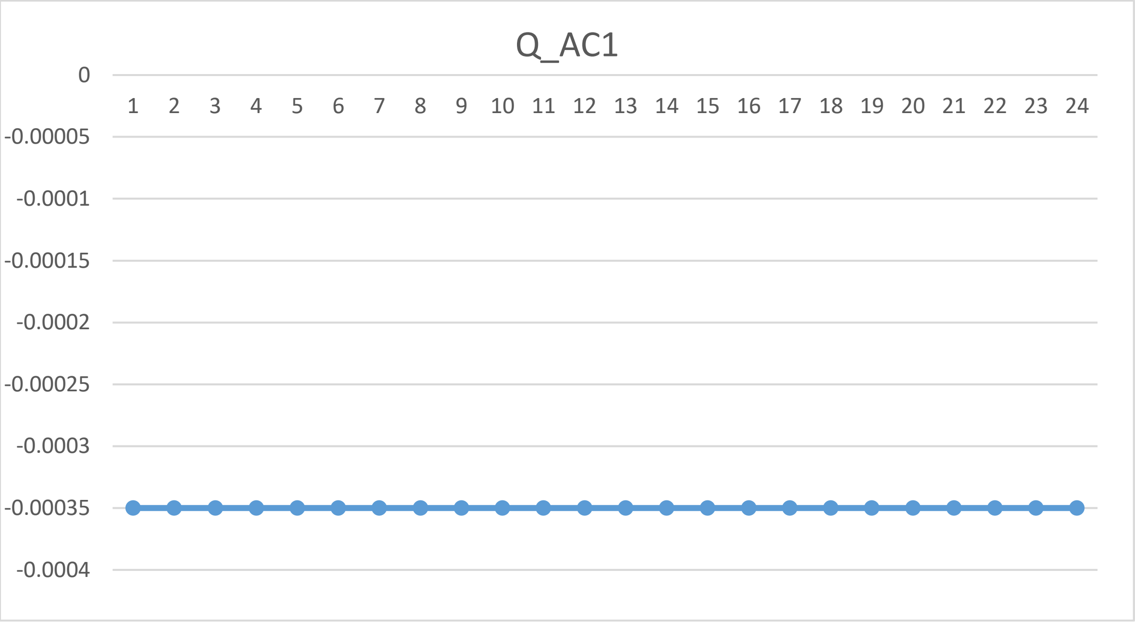


Figure (12) VSC reactive power first

The power diagram of the second VSC reactive power diagram shows:

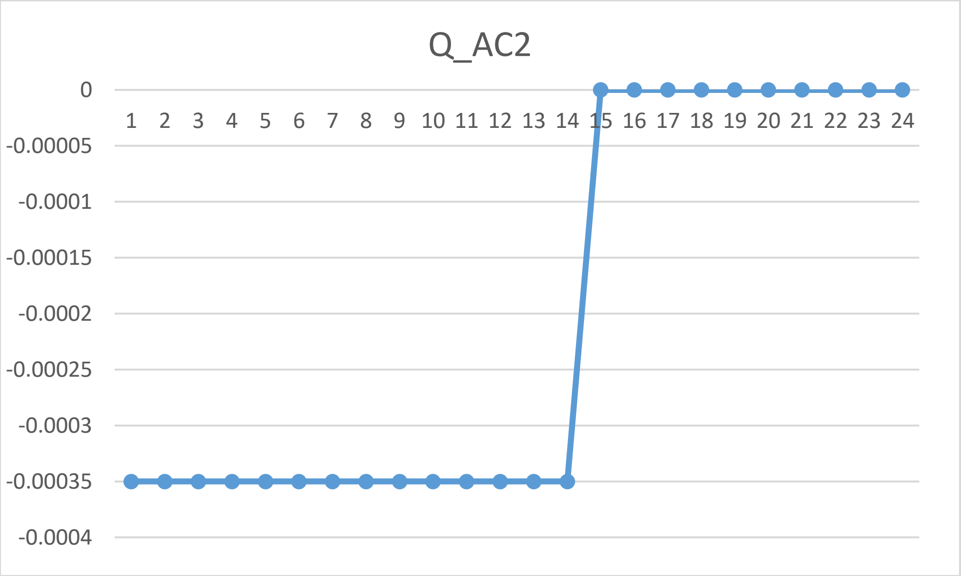


Figure (13) VSC Reactive Power II

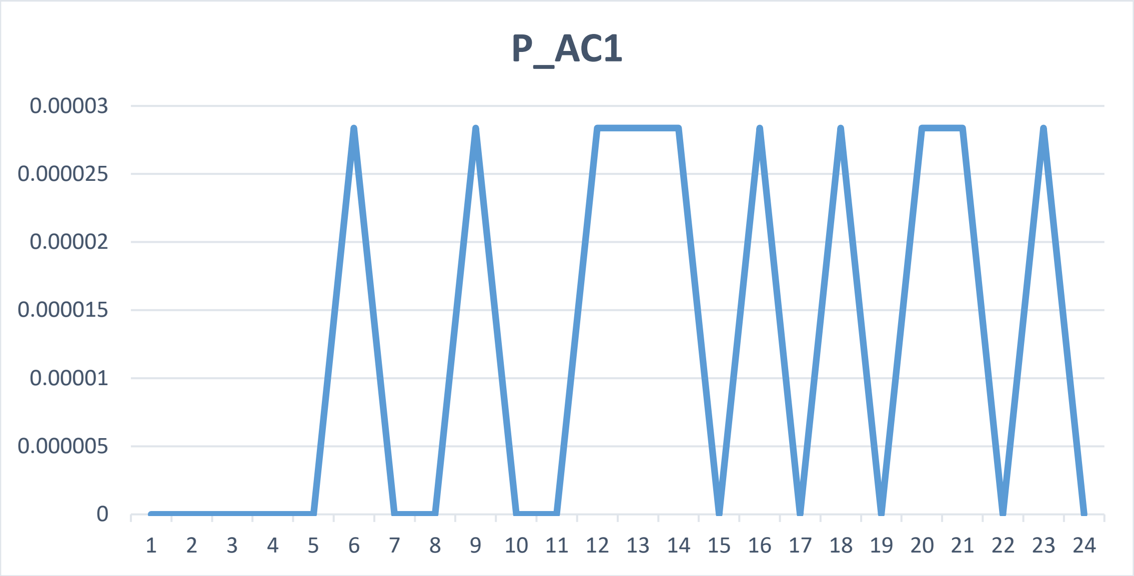
Scenario Five

In the scenario, all the equations in the mathematical model are entered into the modeling and the results are evaluated.

Table (4) optimal values of the objective functions of the fifth scenario

35- Fun1	34- -20318050000
37- Fun1_star	36- 203.180
39- Fun2	38- -66498550000
41- Fun2_star	40- 664.985
43- Funtot	42- -100000000

Figures 4-14 and 4-15 show the VSC Active



Power Chart:

Figure (14) Active VSC power first

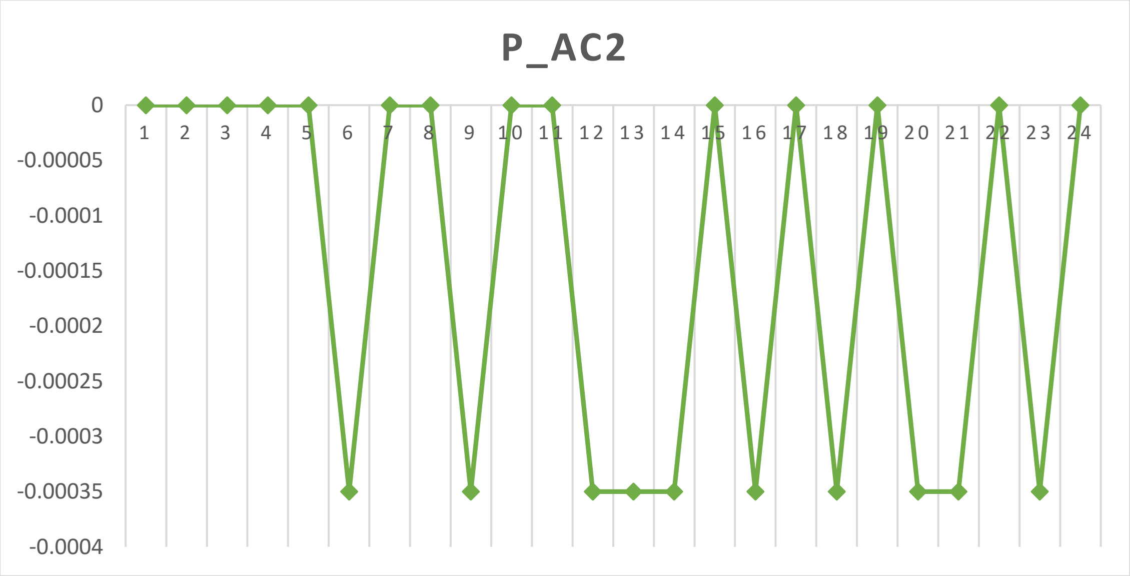


Figure (15) VSC Active Power II

As it is clear, similar to the previous scenario, the sum of the production of this zero does not lead to the production of power. The AC power loss diagram for the two VSCs is shown in Figure

(16):

Figure (15) VSC Active Power II

As it is clear, similar to the previous scenario, the sum of the production of this zero does not lead to the production of power. The AC power loss diagram for the two VSCs is shown in Figure (16):

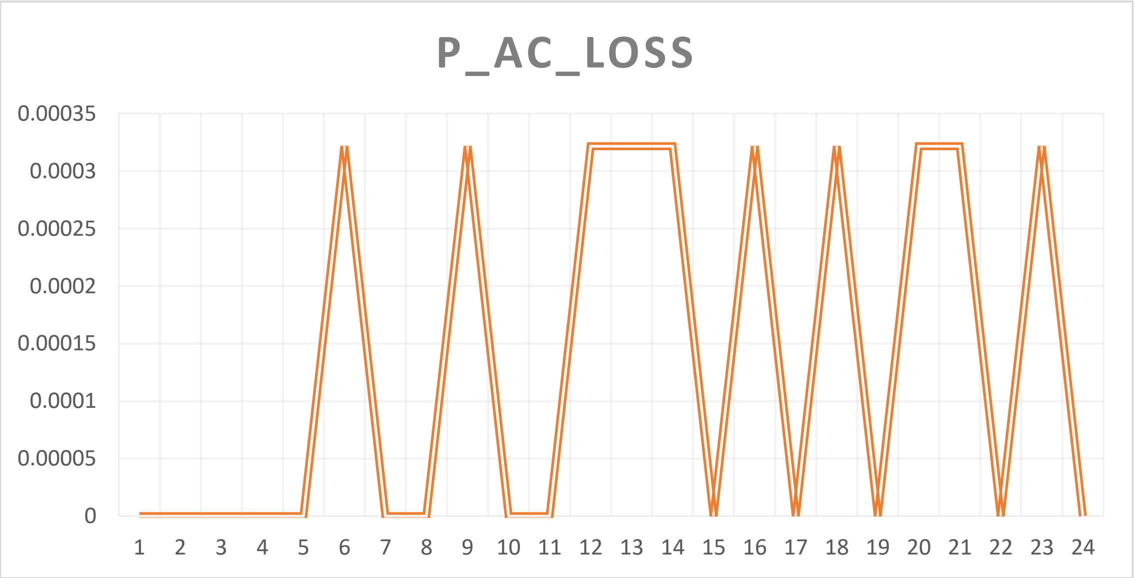


Figure (16) AC loss power for two VSCs

The DC active powers of the VSCs are shown in Figures (17) and (18):

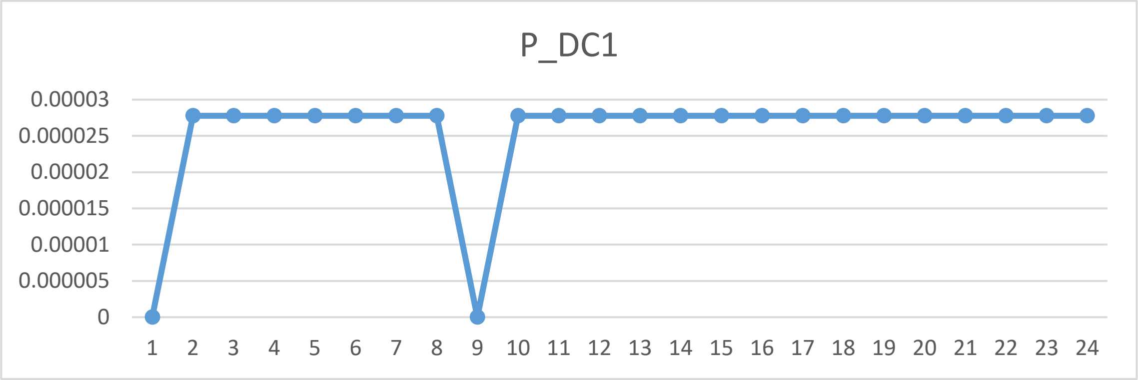


Figure (17) DC active power corresponding to the first VSC

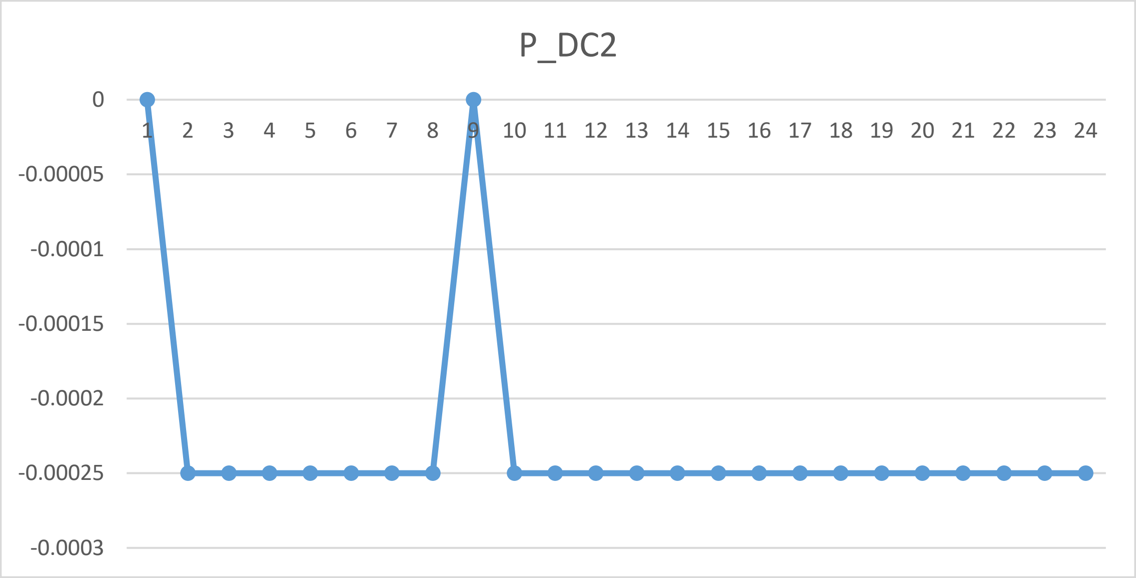


Figure (18) DC active power corresponding to the second VSC

Conclusion

1. In this paper, an optimization model for optimal power planning in the distribution network with the presence of renewable resources and VSCs added to the network was expressed.
2. The optimization problem is a nonlinear multi-objective problem of mixed integers and a 24-hour planning horizon. The issue includes distribution network power distribution constraints, network losses, converter constraints, renewable generation constraints and their losses, and finally constraints related to VSCs added to the system.
3. In general, the results obtained in this article are summarized as follows:
4. •Minimize the reduction of renewable energy production
5. •Minimize the cost of operating renewable energy sources, fuel cells and diesel generators
6. •Optimal distribution power distribution distribution planning in the presence of renewables and VSCs
7.

Appendix

The explanation of parameters and indices associated with equations:

Table 5. the explanation of parameters associated with equations

i,j	*Index of the number of nodes*
k	*Index of the number of number of DERs*
l	*Index of the number of loads*
m	*Index of the number of lines*
t	*Index of the number of time periods*
nf	*Index of the number of number of nonfirm generators*
c	*Index of the number of number of converters*
Ppv(t)	*PV Power*
Pwind(t)	*Wind Power*
Cf(t)	*Operation costs PV and Wind*
G(c)	*Condoctance converter*
B(c)	*Suspension converter*
teta(c)	*angle converter*
G(i,j)	*Condoctance bus*
B(i,j)	*Suspension bus*
teta(i,j)	*angle bus*
DT	*The length of each time step*
PD(i)	*Active Power load*
QD(i)	*Reactive Power load*
lambda1, lambda2	*Weighting coefficients*
epsilon_ch, epsilon_dch	*Charging and discharging efficiency*
Beta,a,b,c	*Cost coefficients*
etaAC, etaDC	*Efficiency VSC*
Pcur(t)	*Renewable power generation*
Pf	*Power purchased from external gird*
PDER(k)	*Active power generation DER*
Pren(t)	*renewable power generation including wind and solar energy*
PG(i), QG(i)	*Injection of active and reactive power in the bus*
V(i)	*Voltage bus*
Vmin(i) ,Vmax(i)	*Voltage limit*
S(m,t)	*Apparent power of the line*
PDG	*Power DG*
Rdown,Rup	*maximum down/up rates*
Pcharge,Pdis	*ESS charging and discharging power*
Xcharge,Xdis	*Indicates ESS charge and discharge mode*

	(0 or 1)
SOCmin,SOCmax	*Lower and upper range of SOCs*
Pinj,Qinj	*Active power and reactive power of AC network to transformer*
Scon	*Capacity converter*
PACcon	*Active power injected into the connector converter on the AC side*
Qac-cov	*The reactive power absorbed by the converter*
Ploss_con	*Ploss converter*
PGin	*Power purchased from external network*
PGout	*Power exported to the external network*
pl(t)	*Predicted load*
PAC(t)	*Active power VSC*
QAC(t)	*Reactive power VSC*
PAC-loss (t)	*Ploss VSC*

References

[1] Ayboğa MH, Ganii F. The Covid 19 Crisis and The Future of Bitcoin in E-Commerce. J Organ Behav Res. 2022;7(2):203-13

[2] Irhan HB, Oran IB. Value Changes in National Currency in Foreign-Dependent Economies & Turkey Example in The Context of Crises. J Organ Behav Res. 2022;7(2):82-94.

[3] Mohammad E. Khodayar, Mohammad Ramin Feizi, Ali Vafamehr" Solar photovoltaic generation: Benefits and operation challenges indistribution networks. Available online 30 April 2019 1040-6190/ © 2019 Published by Elsevier Inc. https://doi.org/10.1016/j.tej.2019.03.004

[4] . Hamed Ahmadi-Nezamabad, et al. "Multi-objective optimization based robust scheduling of electric vehicles aggregator." Sustainable Cities and Society vol. 47,101494, 2019.

[5] Zand, Mohammad; Nasab, Morteza Azimi; Sanjeevikumar, Padmanaban; Maroti, Pandav Kiran; Holm-Nielsen, Jens Bo: 'Energy management strategy for solid-state transformer-based solar charging station for electric vehicles in smart grids', IET Renewable Power Generation, 2020, DOI: 10.1049/iet-rpg. 2020.0399.

[6] Rezaeimozafar, M.; Eskandari, M.; Amini, M.H.; Moradi, M.H.; Siano, P. A Bi-Layer Multi-Objective Techno-Economical Optimization Model for Optimal Integration of Distributed Energy Resources into Smart/Micro Grids. Energies 2020, 13, 1706. https://doi.org/10.3390/en13071706

[7] M. Eskandari, F. Blaabjerg, L. Li, M. H. Moradi, P. Siano, "Optimal Voltage Regulator for Inverter Interfaced DG Units-Part II: Application," IEEE Transactions on Sustainable Energy, vol. 11, no. 4, pp. 2812824, Oct. 2020.

[8] M. Eskandari, L. Li, M. H. Moradi, P. Siano, F. Blaabjerg, "Optimal Voltage Regulator for Inverter Interfaced DG Units-Part I: Control System" IEEE Transactions on Sustainable Energy, vol. 11, no. 4, pp. 2825-2835, 2020.

[9] M. H. Moradi, M. Eskandari, and S. M. Hosseinian, "Cooperative control strategy of energy storage systems and micro sources for stabilizing microgrids in different operation modes," Int. J. Electr. Power Energy Syst vol. 6, pp. 390–400, Jun. 2016.

[10] Ghasemi M, et al. (2020). An Efficient Modified HPSO-TVAC-Based Dynamic Economic Dispatch of Generating Units, Electric Power Components and Systems

doi.org/10.1080/15325008.2020.1731876.

[11] Nasri, Shohreh, et. al. Maximum Power Point Tracking of Photovoltaic Renewable Energy System Using a New Method Based on Turbulent Flow of Water-based Optimization (TFWO) Under Partial Shading Conditions. 978-98136-456-1.

[12] Tetteh, Nathan, and Owusu Amponsah. “Sustainable Adoption of Smart Homes from the Sub-Saharan African Perspective.” Sustainable Cities and Society (2020): 102434.

[13] Javed, Abdul Rehman, et al. “Automated cognitive health assessment in smart homes using machine learning.” Sustainable Cities and Society 65 (2021): 102572.

[14] Xia, Dong, Shusong Ba, and Ali Ahmadpour. “Non–intrusive load disaggregation of smart home appliances using the IPPO algorithm and FHM model.” Sustainable Cities and Society 67 (2021): 102731.

[15] Iqbal, Javed, et al. “A generic internet of things architecture for controlling electrical energy consumption in smart homes.” Sustainable cities and society 43 (2018): 44450.

[16] Babar Muhammad, Muhammad Usman Tariq, and Mian Ahmad Jan. “Secure and resilient demand side management engine using machine learning for IoT-enabled smart grid.” Sustainable Cities and Society 62 (2020): 102370.

[17] Zafar, Usman, Sertac Bayhan, and Antonio Sanfilippo. “Home Energy Management System Concepts, Configurations, and Technologies for the Smart Grid.” IEEE access 8 (2020): 119271-119286.

[18] Anvari-Moghaddam, Amjad, Hassan Monsef, and Ashkan Rahimi-Kian. “Optimal smart home energy management considering energy saving and a comfortable lifestyle.” IEEE Transactions on Smart Grid 6.1 (2014): 32432.

[19] M. Zand, M. A. Nasab, A. Hatami, M. Kargar and H. R. Chamorro, "Using Adaptive Fuzzy Logic for Intelligent Energy Management in Hybrid Vehicles," 2020 28th ICEE, pp. 1-7, doi: 10.1109/ICEE50131.2020.9260941.

[20] M. H. Moradi and M. Eskandari, “A hybrid method for Simultaneous optimization of DG capacity and operational strategy in microgrids considering uncertainty in electricity price forecasting,” Renew. Energy, vol. 68, pp. 697–714, 2014.

[21] Golmohamadi, Hessam, et al. “Optimization of power-to-heat flexibility for residential buildings in response to day-ahead electricity price.” Energy and Buildings 232 (2021): 110665.

[22] Ragimov RM, Zakaev CT, Abdullaeva NM, Esiev RK, Pushkin SV, Nauruzova DM, et al. Analysis of effectiveness of the use of multifunctional biopolymers of chitosan and alginate in dentistry. J Adv Pharm Educ Res. 2022;12(3):21-7.

[23] Oran İB, Ayboğa MH, Erol M, Yildiz G. The Necessity of Transition from Industry 4.0 To Industry 5.0: SWOT Analysis of Turkey’s SCM Strategy. J Organ Behav Res. 2022;7(2):1-17.

[24] Gazafroudi, Amin Shokri, et al. “Stochastic interval-based optimal offering model for residential energy management systems by household owners.” International Journal of Electrical Power & Energy Systems 105 (2019): 201-219.

[25] Rashid, M. M. U., et al. “Home Energy Management for Community Microgrids Using Optimal Power Sharing Algorithm. Energies 2021, 14, 1060.” (2021).

[26] Rohani A, et al, “Three-phase amplitude adaptive notch filter control design of DSTATCOM under unbalanced/distorted utility voltage conditions,” Journal of Intelligent & Fuzzy Systems, , 2020, 10.3233/JIFS-201667.