International Journal of Multidisciplinary Research and Growth Evaluation.

Power production planning and operation in Nigeria using unit commitment technique

Chinedu James Ujam [1*], **Adebayo Adeniyi D** [2]

[1] Department of Mechatronics Engineering, Federal University Otuoke, Bayelsa State, Nigeria

[2] Department of Electrical and Electronic Engineering, Federal University, Otuoke, Bayelsa State, Nigeria

* Corresponding Author: **Chinedu James Ujam**

Article Info

ISSN (online): 2582-7138
Volume: 04
Issue: 01
January-February 2023
Received: 17-01-2023;
Accepted: 04-02-2023
Page No: 460-467

Abstract

Unit commitment is one of the serious major problems encountered in power system operation, control and coordination. It is a complex non-linear problem used in the schedule of operation of generating units at minimum operating cost. The study is aimed at using unit commitment in generation planning and operation in Nigeria for the best utilization of available energy resources to meet the varying load demand. In the study, the two objective functions formulated are minimization of total production cost and maximization of the energy consumption. To effectively deal with the constraints of the problem, the difficult minimum up/down-time constraints of thermal generation units and the turbine operating constraint of hydropower stations are embedded in the binary strings that are coded to represent the on/off-states of the generating units. The Nigeria 330kV power system containing four thermal and three hydropower plants is studied under different scenarios for a 24h horizon to show the effectiveness of the proposed algorithm. Although the approach is not really computationally efficient compared to some methods, a high accuracy of the optimal solution is guaranteed. The results obtained in the study are compared with the ones reported in the literature, which confirm the effectiveness of the proposed technique.

Keywords: Unit commitment, optimization, power system, dispatch, transmission

1. Introduction

The electricity firm suffers from the fact that electricity cannot be stored (apart from the limited storage available in pumped - storage plants), but must be produced when required. In addition, a requirement of rate and electrical energy stability makes necessary a rather precise matching amid load (the demand on the system from the consumer) and production (the supply from the power station). Moreover, recent public outcry for environmental safety makes it essential for a power system to make available adequate and reliable electricity not only at the cheapest possible cost, but also at the least echelon of pollution of the atmosphere. Therefore, electric power system operation is among the most important and complex tasks in today's civilization. It has to involve many considerations. The basic requirement is to produce adequate electricity to meet continuously changing customer load demand at the lowest possible cost (Ibitoye & Adenikinju, 2017) [15]. Of equal significance is the need to reduce the pollution impact on the environment which is mainly from thermal plant fuel emission. System security and reliability constraints also have to be taken into account to make available high standards of electrical energy stability and continuous supplies of electricity. Though interconnection of power scheme has improved the continuity of service and reliability, it has added further constraints and complication related to stability and security. These considerations form various improvement issues for a power system engineer to deal with (Oseni, 2016) [27]. The typical issues comprise fiscal dispatch, reactive power scheduling and allocation, maximum interchange, hydrothermal UC and dispatch, production, transmission and distribution expansion planning, maintenance scheduling, and many others. These issues become progressively more complicated due to ever growing system size, stricter governmental and environmental regulations, and augment requirement of system integration. Power industries face great pressure to better utilize the existing network so as to defer power system reinforcement. As a result, improved operation strategies are in great demand.

Due to heavy consumption of industrial loads the network is heavily loaded through the day and early in the evening and in contrast, it experiences much lower load late at night and early in the morning when most of the lights are out. The power consumption is periodic throughout the week. In a way that through the working days it is higher than holidays. But the question is, if it is reasonable or not to enter enough components into the network and keep them active in order to supply the peak demand? It is obvious that UC with large numbers of components is not fiscal and will result in a costly schedule, but it would save a lot of money if unnecessary components are turned off.

Power utilities in many countries around the world are shifting their attention to toward more energy efficient and renewable electric power source (Adebayo and Christian 2021) [21].

Unit Commitment (UC) in power system comprises the determination of planning the components to be on and off in order to supply the forecasted load in a period of time. Constraints such as load balance, system spinal reserve, component production limit and pollution are included in this planning schedule which is going to minimize the cost of power system operation (Palmintier, 2016) [30]. There are two processes ahead in solving the UC issues. First is to determine the components to be on or off. The numbers “1” and “0” show the condition of the components, whether it is on or off respectively. In the other process the fiscal dispatch should be analyzed, in other words, how much power should be allocated to each component from whole produced power in a period of time which the component is on. But solving the UC issues alone is not acceptable, since the network security constraints are not considered. Production configuration is considered in power system and a security constraint is determined for UC operation function. Transmission lines overload which is known as “Security Constrained UC (SCUC)”. The goal of SCUC is production configuration planning with the lowest cost and reliability. Large modern components are equipped with multi-valves turbines, which by opening the valves one after the other more steam will pass through the turbine blades and the production capacity will augment and therefore the component output would have a waveform curve which is called valve point effect. By considering this form of output the issues will be so complicated. It is at the backdrop that the researcher wishes to analyze the fiscal power production planning and operation in Nigeria using UC procedure in other to proffer solution to issues.

2. Review of Related Literatures

In recent years, because of strict environmental and governmental regulations, the development of electrical power facilities has been restricted. As a result, optimal fiscal operation and planning of power scheme becomes increasingly difficult (Bavafa *et al*, 2019) [7]. Issues such as fiscal dispatch, emission dispatch, reactive power scheduling and allocation, maximum interchange, UC and dispatch, production, transmission and distribution expansion planning, maintenance scheduling as well as many other matters, are so diverse that fiscal operation of power scheme becomes a sophisticated and very difficult task. It is made even more formidable with multi-objective improvement issues which consist of several objectives and are subjected to a number of constraints in one issues formulation. Yet, multi-objective formulation expresses complex and highly interactive power issues in a more realistic way. The followings are brief descriptions of some power system improvement issues.

Fiscal Dispatch (ED) is among the most important issue in power system operation (Revathy & Nithiyanandham, 2016). The goal of ED is that of scheduling the echelon of power output on the preselected components to match the customer load demand in order to achieve minimum operating cost. When excess production is available in a system such that an fiscal choice of components can be made, UC should be employed to determine the on or off schedule of generating components within a system to make available dispatchable components.

UC and power dispatch are so much coupled that they tend to be solved simultaneously in recent research. With the increasing concern about environmental safety, alternative operational strategies are required. Emission Dispatch (EMO) which aims to reduce pollution from power plants while meeting the system's energy demand has gained ever growing attention. The goal of reactive power scheduling and allocation is to make available a system with enough reactive power (VAR) sources for the system to operate in an fiscal manner, while load constraints and operational constraints, with respect to credible contingencies, are met. Maximum interchange is a means for utilities to decide the maximum interchange with the neighboring interconnected scheme ahead of time in case transmission contingencies occur. Optimal switching can be set up to minimize the number of switching operations for intermediate and low-electrical energy substations which link the high-electrical energy transmission system and the distribution networks of local loads, in order to alter the configuration of the substation for system reliability and safety purposes. This is the case when devices need to undergo maintenance or when emergency situations occur, which results in the need for configuration changes. Among these power improvement issues, this thesis mainly deals with fiscal dispatch, emission dispatch and their extensions and combinations. UC will be an extension of the current research work.

3. Methodology

Numerically, UC issues has been detailed as a non-curved, enormous scope, non-direct and Mixed Integer Programming (MIP) combinatorial improvement issues with requirements. The non-convexity is brought about by the twofold idea of UC choice (ON/OFF). Non-linearity occurs because of non-straight creation cost bends and non-direct transmission requirements. The presence of a blend of the paired and non-straight factors requires the issues to be detailed as a MIP issues. The numerical detailing for the issues is logically portrayed in the accompanying sections.

3.1. Deterministic formulation of UC issues

The deterministic definition of the UC issues can be considered as an exceptional instance of the separate stochastic plan, where just a solitary situation involving the conjecture estimations of the arbitrary segment and framework boundaries is thought of. The Mixed Integer Linear Programming (MILP) approach has been proposed since the 1970s as a practicable and proficient elective model for tackling different improvement issues identified with transient activity of electrical plan, specifically UC issues. Truth be told, most investigates in this field have perceived that basic choices related with the activity of force creation can be successfully appeared by whole number (parallel as a rule) factors. Hence, traditional straight programming approaches can't obviously display and settle such muddled issues. In MILP definitions, the responsibility choices demonstrating the ON/OFF status of the creating parts in different working stages (disconnected, fire up, dispatch, and closure) are displayed utilizing paired factors, while the force yield, save commitment, and stream choices are showed utilizing ceaseless factors.

3.2 Mixed Integer Linear Programming formulation (MILP)

The MILP detailing returned to in this paper depends on a solitary paired variable to portray the UC status and the relating hourly change of producing segments. On the other hand, a three-paired variable definition, thinking about UC status and start-up/closure markers has been proposed in a few works. The MILP deterministic UC issues can be defined as:

Limit Operational Cost (OC)

$$OC = \sum_{i=1}^{N} \sum_{t=1}^{T} FC_{it}(P_{it})I_{it} + NL_i I_{it} + ST_{it} + SD_{it} \qquad 3.1$$

Where,

OC = operating cost,

N = generating components,

T = time horizon, which is 24 h, and is a binary variable modeling UC

i = decision of component

t= hour,

$FC_{it}(P_{it})$ = the input/output curve that is modeled with a quadratic function of the power output,

$FC_{it}(P_{it}) = a_i P_{it}^2 + b_i P_{it} + c_i$ where,

a_i , b_i and $c_i$are the cost coefficients.

For all intents and purposes this expense is displayed as a piecewise-straight capacity. A tight detailing for this piecewise-direct guess is given in the condition above. is the expense for restarting a de-submitted warm segment, which is depended to the temperature of the evaporator. The quantity of the beginning up and closure and their sort (hot or cold) changes is an element of the ON/OFF status of the segments. It is communicated as follows 3.2

$$ST_{it} = \begin{cases} HSN_i, & if \quad MDT_i \leq T_{off,i}(t) \leq MDT_i + T_{cold,i} \\ CSN_i, & if \quad T_{off,i}(t) > MDT_i + T_{cold,i} \end{cases}$$

3.3 UC constraints

In limiting OC, the UC issues arrangement should regard both generator actual requirements and framework operational imperatives. These limitations can be producing limit requirements where each creating segment has least and most extreme cutoff points. The force yield can't surpass these cutoff points.

$$P_{it}(min) < P_{it} < P_{it}(max)$$

Where $P_{it}(min)$ and $P_{it}(max)$ are respectively the minimum and maximum real power output of component i at hour t.

Power balance constraint is the equilibrium amid load demand and power output in each hour and is given by

$$D_t = \sum_{i=1}^{N} P_{i(max)}(t).I_i(t) \quad 3.3$$

Where D_t = total demand at hour t.

3.5 Minimum up /down time constraints

Minimum up-time is the minimum number of hours of operation at or above the minimum production capacity. It is expressed as follows:

$T^{on}_i > MUT_i$

Where T^{on}_i and MUT_i are the total up-time and the minimum up-time of component i. Minimum downtime is the minimum number of hours once the generator is shut down before it can be brought online again to produce power.

4. Result and Discussion

The proposed calculation is tried on a framework consolidating hydro and warm turbines. The Nigerian 330 kV, 57-transport power framework appeared in Figure 1 sourced from (Akorede *et al*, 2009) [4] comprises of 7 segments involving 3 hydro and 4 warm segments. A quadratic expense work model was utilized for the warm segment, however the water transport and other hydro factors were excluded from this model as the hydro parts are utilized at the pinnacle request period. The activity information which sums up segments' properties appear in Table 1. The expense capacities utilized in this investigation are acquired from (Li, Pedroni, and Zio, 2013).

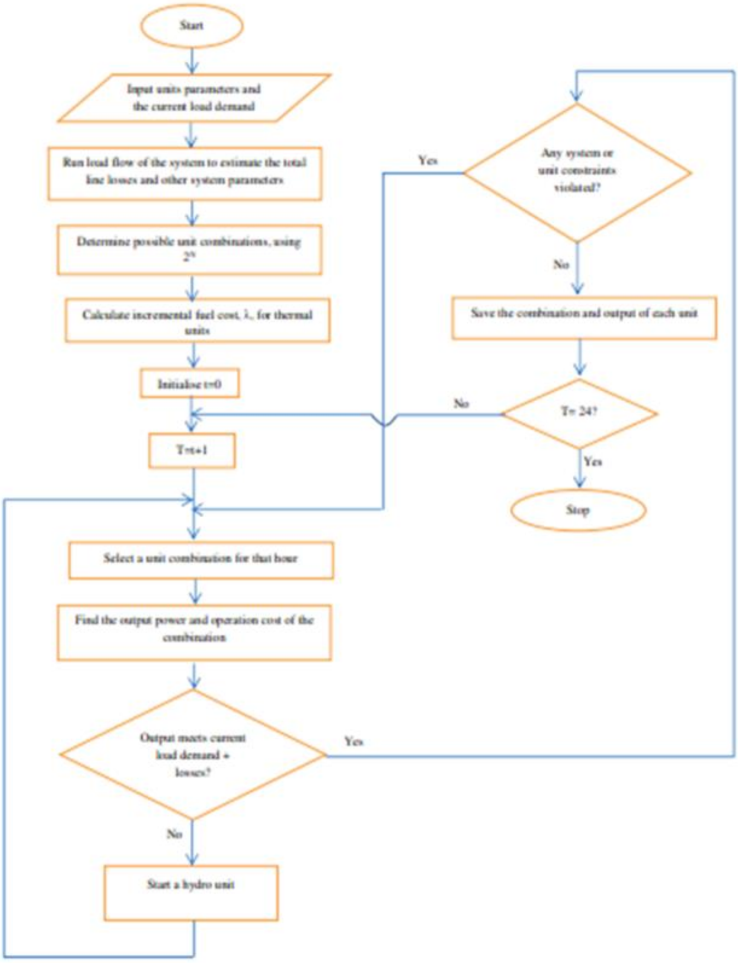

Fig 1: The proposed UC flowchart

Table 1: Operation data for the 7-Component case study system

COMPONENT	1(Hy)	2(Hy)	3(Hy)	4(Th)	5(Th)	6(Th)	7(Th)
P_{max}(MW)	150	260	450	445	445	130	162
P_{min}(MW)	10	35	125	150	150	20	25
α	0	0	0	1,000	970	700	450
B	0	0	0	16.19	17.26	16.60	19.70
Y	0	0	0	0.00048	0.00031	0.002	0.00398
On time	15	15	15	8	8	5	6
Off Time	3	3	3	8	8	5	6
Hot starts(s)	0	0	0	4,500	5,000	550	900
Cold starts	0	0	0	9,000	10,000	1,100	1,800
Initial state	0	0	0	8	8	-5	-6

4.1. Load demand pattern

The interest for power of the contextual investigation increases in a differing way, because of monetary and social turn of events. Since power can't be put away, it should be delivered and provided at the place of need day or night, top or off top period. It is a typical information that heap request relies upon the sort of client's (for example homegrown, business, modern, agrarian, and so forth) hardware like warming component, lighting, and so on climate conditions (for example outside temperature, light), and human variables in types of utilization designs, propensities, and so on The heap request hence differs radically inside a given period. The day by day load request profile for 24 h utilized in this examination is introduced in Fig 2. In this investigation, a consistent state examination of the electrical force framework which make availables electrical energy, flows, genuine and receptive force streams, line misfortunes, among others in a framework under a given burden condition, was done. This is to prepare and represent theoretical circumstances in power framework arranging, activity and control (Kuo, 2017)). All segments of the contextual investigation electric force framework were demonstrated and the heap stream examination was completed in MATPOWER (Sayah and Zehar, 2018)) to gauge the all-out framework power misfortunes.

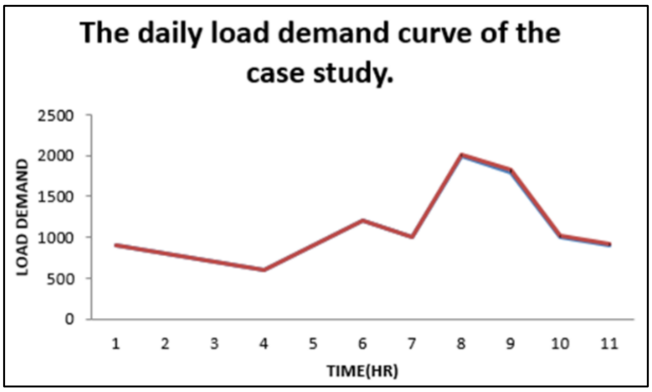

Fig 2: The daily load demand curve of the case study

4.2 Results and discussion

The proposed calculation is tried looking into it study framework recently portrayed with 24h skyline. The hydro segment is locked in at the pinnacle time frame to satisfy the need. The consequence of the aqueous framework tackled with EEA is contrasted and another model utilized in making arrangements for a framework to supply a similar burden. Three arrangements that fulfill the force needs are treated under various situations depicted as Case I–II. In all cases, the all out day by day energy delivered is assessed at 33,600MWh.

Case I

The ideal timetable that satisfied the heap need at the base expense, without disregarding any imperative with the base number of advances from ON to OFF and the other way around is the timetable alluded to as Case I. The segments mix uncover the must-run normal for parts 4 and 5, while complying with the base all over occasions. Anyway a little startup cost was caused by the warm parts, though the hydro segments just brought about the group cost since they don't run on any fuel. Table 2 presents the segments submitted and the heap distribution for Case I. As the heap request increases the absolute yield from the parts likewise expands either through expand in power yield of component(s) effectively dedicated or submitting other component(s) once more. Absolute change of the relative multitude of parts from OFF to ON and the other way around is only eight. Subsequently, less beginning up and shut down costs were brought about. This particular certainty upholds the decision of Case I being the expense ideal mix

Table 2: Daily optimal component schedule and load allocation for Case I

Hour(hr)	1(MW)	2(MW)	3(MW)	4(MW)	5(MW)	6(MW)	7(MW)	Load	Fuel cost	Start up cost	Prod cost
1	0	0	0	425	425	0	0	850	14,960		14,950
2	0	0	0	425	325	0	0	750	13,200		13,400
3	0	0	0	425	305	0	0	730	12,848		12,800
4	60	0	0	425	275	0	0	700	17,300		12,500
5	130	0	0	425	425	0	0	850	19,450		11,400
6	130	0	0	445	445	130	0	950	20,702	1,100	18,600
7	130	0	0	445	445	130	100	1,150	20,100	1,800	17,550
8	130	0	100	445	445	130	162	1300	21,200		20,400
9	130	0	188	445	445	130	162	1400	20,400		18,200
10	130	0	238	445	445	130	162	1500	22,500		20,210
11	130	0	338	445	445	130	162	1550	23,780		16,540
12	130	0	450	445	445	130	162	1600	20,600		15,508
13	130	38	450	445	445	130	162	1700	19,500		12,700
14	130	88	450	445	445	130	90	1850	18,750		16,250
15	130	260	450	445	445	130	140	1900	20,800		20,310
16	130	260	450	445	445	130	150	1950	13,600		10,502
17	130	260	450	445	445	130	90	2000	14,670		8,600
18		260	450	445	445	70	0	2010	9,600		9,500
19		260	450	445	315	0	0	1950	12,500		10,200
20	0	260	450	445	295	0	0	1800	17,900		11,400
21	0	260	450	220	220	0	0	1450	20,850		12,400
22	0	260	450	100	100	0	0	1310	12,500		3,500

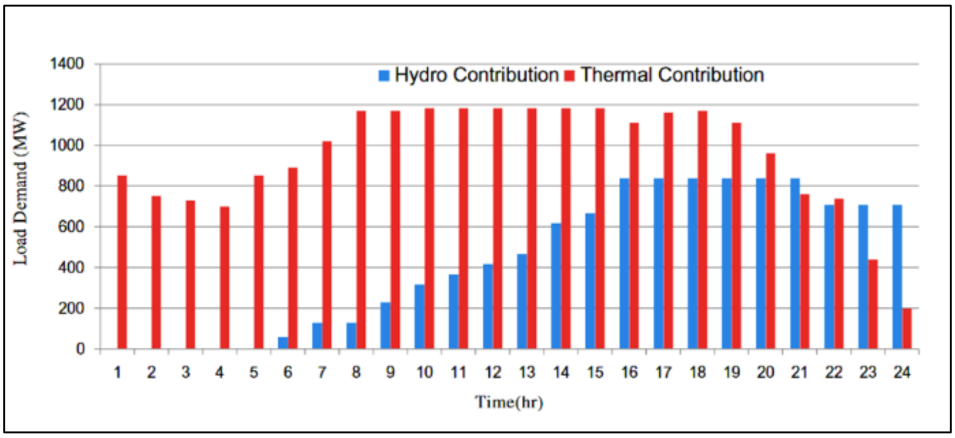

Fig 3: Presents the contribution of hydro and thermal components which met the total load demand

It is seen that warm segments were all ON all through the time frame viable while the responsibility of hydro segments began at the 6th hour when the submitted warm parts (segments 4 and 5) could not, at this point satisfy the necessary burden need. The submitted warm parts contributed a similar measure of force from the 10th to fifteenth hour. This is on the grounds that beginning one more warm segment at that specific time will prompt bringing about more expense because of cold startup since any remaining accessible warm segments have lost their working temperature.

Case II

In this situation introduced in Table 3, the parts booked can create the necessary force at a cheaper when contrasted with Case I. It is expected here that none of the segments delivered past either the base or greatest breaking point. Nonetheless, a lot of different imperatives were abused. The must-run normal for part 5 was ventured down and there are more advances of segments from ON to OFF and the other way around in 26 distinct occasions. This makes the parts abuse least up and least personal time imperatives as in segments 1, 2, 6 and 7. The startup cost caused is high a result of the quantity of changes. The segment shaded red shows the territory where either least up time or/and least vacation requirements were disregarded, while the blue segment demonstrates infringement of the must-run attributes.

Table 3: Component schedule and load allocation for Case II

Hour(hr)	1(MW)	2(MW)	3(MW)	4(MW)	5(MW)	6(MW)	7(MW)	Load	Fuel cost	Startup cost	Prod cost
1	125	0	0	425	425	125	140	850	12,960	3,100	14,950
2	25	0	0	425	325	125	140	750	15,200		13,400
3	10	0	0	425	305	125	140	730	14,848		12,800
4	0	0	0	425	275	125	140	700	14,300		12,500
5	125	0	0	425	425	125	140	850	16,450		11,400
6	125	217	0	445	445	125	140	950	16,702	-	18,600
7	130	250	0	445	445	125	0	1,150	22,100	1,900	17,550
8	130	250	440	445	445	125	162	1300	19,200		20,400
9	130	250	440	445	445	125	0	1400	22,400		18,200
10	130	250	440	445	445	125	0	1500	18,500		20,210
11	120	250	425	445	445	125	0	1550	16,780		16,540
12	120	0	425	445	445	0		1600	21,500		15,508
13	130	0	440	445	445	0	140	1700	16,500		12,700
14	130	0	440	445	445	0	140	1850	19,750	1,900	16,250
15	130	260	425	445	445	0	140	1900	21,500		20,310
16	125	260	440	445	445	0	140	1950	15,700		10,502
17	120	260	440	445	445	0	90	2000	13,870		8,600
18	125	0	425	445	445	125	0	2010	9,600		9,500
19	130	0	425	445	315	125	0	1950	16,500		10,200
20	125	0	425	445	295	125	0	1800	14,900		11,400
21	125	0	440	220	220	125	140	1450	19,850	650	12,400
22	130	208	420	100	100	0	0	1310	14,100		3,500

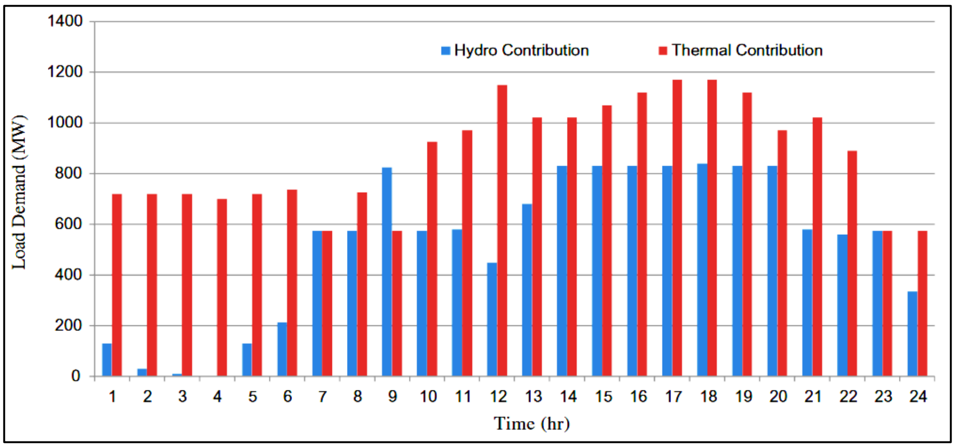

Fig 4: Commitments of hydro and warm segments for Case II.

Figure 4 shows the example of the commitments of the hydro and warm segments in fulfilling the heap need in Case II. The hydro segments were submitted directly from the primary hour notwithstanding the way that the must-run segments 4 and 5 can satisfy the heap need right now. All in all, the must-run condition was abused. Once more, it is seen that the figure shows a sporadic example that doesn't look like the heap request bend. This is on the grounds that segment 5, an unquestionable requirement run part, was not dedicated at the fitting time, which subsequently brings about high startup cost, even as the expense caused was decreased at the pinnacle time frame.

Case III

Notwithstanding the way that just a single imperative was disregarded in Case III and ten advances were recorded as introduced in Table 4, yet the expense of creation was the most elevated. The justification this is that the request by which the segments were submitted wasn't right. For instance, segment 1 was submitted right from the start. Accordingly it can't be fiscalal to receive such arrangement as an ideal mix. The commitments of hydro and warm parts towards the all out load request are introduced in Figure 5. Here the hydro parts are submitted all through the 24 h period, despite the fact that not ideally used. The unfiscalal dispatch from the warm parts brings about a high absolute creation cost.

Table 4: Component schedule and load allocation for Case III

Hour (h)	Components committed and fiscal dispatch (MW)							Load (MW)	Fuel cost ($)	Startup cost ($)	Prod. cost ($)
	1	2	3	4	5	6	7				
0	100	0	0	400	350	0	0	850	13,200.00	–	13,200.00
1	50	0	0	400	300	0	0	750	12,320.00	–	12,320.00
2	30	0	0	400	300	0	0	730	12,320.00	–	12,320.00
3	30	0	0	400	270	0	0	700	11,792.00	–	11,792.00
4	100	0	0	400	350	0	0	850	13,200.00	–	13,200.00
5	60	0	0	445	445	0	0	950	15,664.00	–	15,664.00
6	130	0	0	445	445	130	0	1,150	17,952.00	1,100.00	19,052.00
7	130	0	0	445	445	130	150	1,300	20,592.00	1,800.00	22,392.00
8	130	100	0	445	445	130	150	1,400	20,592.00	–	20,592.00
9	130	188	0	445	445	130	162	1,500	20,803.20	–	20,803.20
10	130	238	0	445	445	130	162	1,550	20,803.20	–	20,803.20
11	130	0	288	445	445	130	162	1,600	20,803.20	–	20,803.20
12	130	0	388	445	445	130	162	1,700	20,803.20	–	20,803.20
13	130	88	450	445	445	130	162	1,850	20,803.20	–	20,803.20
14	130	138	450	445	445	130	162	1,900	20,803.20	–	20,803.20
15	130	188	450	445	445	130	162	1,950	20,803.20	–	20,803.20
16	130	238	450	445	445	130	162	2,000	20,803.20	–	20,803.20

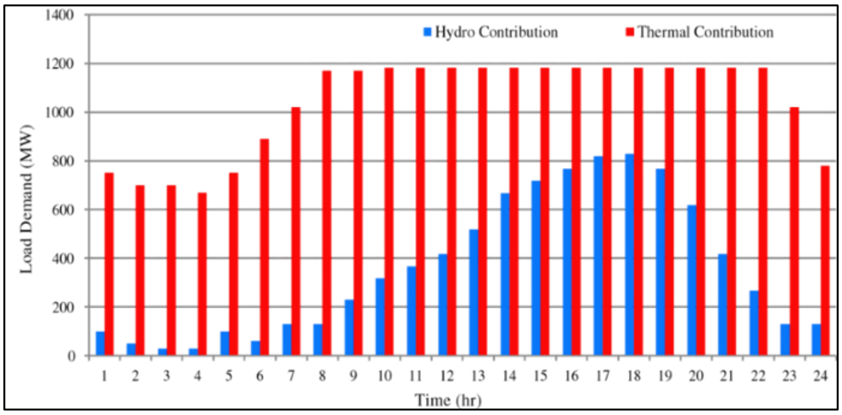

Fig 5: Contributions of hydro and thermal component for Case III

Refernces

1. Abido MA. Multi-Objective Evolutionary Algorithms for Electric Power Dispatch Issues, Transaction on Evolutionary Computation. 2015; 10(3):315-329. IEEE2006.
2. Adebayo AD, Christian A. Frequency Control for Hybrid Stand-Alone Power Systems For Isolated Communities, Advance Journal of Science, Technology and Engineering. 2021; 1(1):8-26
3. Ajenikoko GA, Olabode OE. Optimal Power Flow with Reactive Power Compensation for Cost and Loss Minimization on Nigerian Power Grid System. Indonesian Journal of Electrical Engineering and Informatics. 2017; 5(3):236-247.
4. Akorede MF, Hizam H, Aris I, AbKadir MZA. Contingency evaluation for electrical energy security assessment of power scheme. In IEEE 2009 Student Conference on Research and Development. Serdang: Universiti Putra Malaysia, 2009, 345-348.
5. Aoki K, Satoh T. New algorithms for classic fiscal load dispatch," IEEE Transactions on Power Apparatus and Scheme. 2017; 103(6):1423-1431.
6. Bai Q. Analysis of PSO algorithm. Computer and Information Science. 2016; 3:180-184.
7. Bavafa M, Monsef H, Navidi N. A new hybrid approach for UCusing Langrange relaxation combined with evolutionary and quadratic programing. University of Tehran, Tehran, 2019, 1-6.
8. Belegundu AD, Chandrupatla TR. Improvement Concepts and Applications in, 2016.
9. Devi AL, Krishna OV. Combined fiscal and emission dispatch using evolutionary algorithms: A case study, ARPN Journal of Engineering and Applied Sciences. 2017; 3(6):28-35.
10. Devi AL, Krishna OV. Combined Fiscal and Emission Dispatch using Evolutionary Algorithms-A Case Study, ARPN Journal of Engineering and Applied Science. 2018; 3(6):28-34.
11. Engineering Upper Saddle River, NJ, Prentice Hall, Gaing ZL. Particle swarm improvement to solving the fiscal dispatch considering the generator constraints," IEEE Transactions on Power Scheme. 2017; 18:1187-1195.
12. Habachi R, *et al*. Eagle Strategy Based Crow Search Algorithm for Solving UC Issues in Smart Grid System, Indonesian Journal of Electrical Engineering and Computer Science. 2018; 12(1):17-29.
13. Habachi R, *et al*. Resolution of Fiscal Dispatch Issues of

the moroccan Network Using Crow Search Algorithm. Indonesian Journal of Electrical Engineering and Computer Science. 2019; 13(1).
14. Hemamalini S, Simon SP. Dynamic Fiscal Dispatch Issues with Valve Point Effects using Maclaurin Series Based Lagrangian Model, International Journal of Computer Applications (0975-8887). 2016; 1(17):71-77.
15. Ibitoye FI, Adenikinju A. Future demand for electricity in Nigeria. Appl. Energy. 2017; 84:492-504.
16. Jeong YW, Park JB, Jang SH, Lee KY. A new quantum-inspired binary PSO: Application to UCissuesfor power scheme. IEEE Transactions on Power Scheme. 2010; 25:1486-1495.
17. Jeong YW, Park JB, Jang SH, Lee KY. A new quantum-inspired binary PSO: Application to UC issues for power scheme. IEEE Transactions on Power Scheme. 2016; 25:1486-1495
18. Kluabwang J. Fiscalal operation of hydro-thermal power system based on multi-path adaptive Tabu-search. International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering. 2018; 6:477-479.
19. Kumar C, Alwarsamy T. Dynamic Fiscal Dispatch –A Review of Solution Modelologies, European Journal of Scientific Research. 2015; 64(4):517-537, 2011.
20. Kuo CC. A Novel Coding Scheme for Practical Fiscal Dispatch by Modified Particle Swarm Approach, Transactions on Power Scheme. 2017; 23(4):1825-1835, IEEE.
21. Mishra SK, Mishra SK. A comparative study of solution of fiscal load dispatch issues in power scheme in the environmental perspective, Procedia Computer Science. 2016; 48:96-100.
22. Moradi-Dalvand M, B Mohammadi-Ivatloo, A Najafi, A Rabiee, Continuous quick group search optimizer for solving non-convex fiscal dispatch issues. Electric Power Scheme Research. 2018; 93:93-105.
23. Najafi S, Pourjamal Y. A new heuristic algorithm for UC issues using a two-echelon improvement model. Energy Procedia. 2016; 14:2005-2011.
24. Noman N, Iba H. Differential Evolution for Fiscal Load Dispatch Issues, Journal of Electric Power Scheme Research. 2018; 78(3):1322-1331.
25. Obioma DD, Izuchukwu AM. Comparative analysis of procedures for fiscal dispatch of produced power with modified lambda-iteration model, in Proceedings of the 2013 IEEE International Conference on Emerging Sustainable Technologies for Power ICT in a Developing Society (NIGERCON), 2018, 231-237.
26. Orike S, Corne DW. Improved Evolutionary Algorithms for Fiscal Load Dispatch Optimisation Issues, in Proceedings of 12thUK Workshop on Computational Intelligence (UKCI), Edinburgh, IEEE, 2018.
27. Oseni MO. Improving households' access to electricity and energy consumption pattern in Nigeria: Renewable energy alternative. Renew. Sustain. Energy Rev. 2016; 16:3967-3974.
28. Osman MS, Abo-Sinna MA, Mousa AA. A Solution to the Optimal Power Flow using Genetic Algorithm, Applied Mathematics and Computation. 2016; 155:391-405.
29. Ouyang Z, Shahidehpour SM. An intelligent dynamic programming for UC application. IEEE Transactions on Power Scheme. 1991; 6:1203-1209.
30. Palmintier B. Incorporating operational flexibility into electric production planning: Impacts and models for system design and policy analysis. PhD thesis in Engineering scheme: Technology, management and policy. Massachusetts Institute of Technology, Cambridge, MA, 2016.
31. Pothiya S, Ngamroo I, Kongprawechnon W. Application of Multiple Tabu Search Algorithm to solve Dynamic Fiscal Dispatch considering Generator Constraints, Journal of Energy Conversion and Management. 2017; 49(4):506-516.
32. Puri V, Narang N, Jain SK, Chauhan YK. UCusing particle swarm optimisation. BIOINFO Computational Optimisation. 2016; 2:9-16
33. Rao SS. Engineering Improvement: Theory and Practice, Third Edition, John Wiley and Sons Inc., 2017.
34. Revathy K, Nithiyanandham C. Fiscal dispatch using PSO. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 2014; 3:59-66
35. Sayah S, Zehar K. Using Evolutionary Computation to Solve the Fiscal Load Dispatch Issues, Leonardo Journal of Sciences. 2018; 12:67-78.
36. Sreenivasan GCH, Saibabu CH, Sivanagaraju S. Solution of Dynamic Fiscal Load Dispatch Issues with Valve Point Loading Effects and Ramp Rate Limits using PSO," International Journal of Electrical and Computer Engineering. 2017; 1(1):59-70.
37. Uyar AS, Turkay B. Evolutionary Algorithms for the UCIssues, Turk Journal of Electrical Engineering. 2018; 16(3):239-255.
38. Vanitha M, Thanushkodi K. Solution to Fiscal Dispatch Issues by Differential Evolution Algorithm Considering Linear Equality and Inequality Constraints, International Journal of Research and Reviews in Electrical and Computer Engineering. 2017; 1(1):21-26.
39. Xia X, Elaiw AM. Optimal Dynamic Fiscal Dispatch of Production: A Review, Journal of Electrical Power Scheme Research. 2018; 80:975-986.