IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 9 (September. 2018), ||V (IV) || PP 01-10

Building software for optimal calculation of electricity system and results of optimal calculation and operation of Vietnam's electricity system

LUONG Ngoc Giap[*1,3], VU Huu Hai[*1], NGO Van Dung[*2]
NGUYEN Binh Khanh[*3], TRAN The Vinh[*3], LE Tat Tu[*3]
*[*1] National University of Civil Engineering,*
No. 55 Giai Phong str., Hai Ba Trung dist., Hanoi, Vietnam
*[*2] University of Science and Technology - The University of Da Nang*
*[*3] Institute of Energy Science, Vietnam Academy of Science and Technology*
A9 Building, 18, Hoang Quoc Viet str., Cau Giay dist., Hanoi, Vietnam
Corresponding Author: LUONG Ngoc Giap

Abstract: This article introduced the program to optimize the developement and operation of Vietnam’s power system based on the previously developed models and methods of calculating the optimal development and optimal operation of Vietnam's power system ([1]). The program solves the problem of optimal development and operation of large and complex electrical systems with any number of nodes. The results from a calculation to optimize Vietnam’s power system until 2030 with 3, 5 or 8 nodes shows that the program is built in accordance with the practical operation of Vietnam’s power system and can be applied to solve the optimal problem of developing large power system complex.

Keywords: Optimizing power system program, Vietnam power system; power source characteristics; transmission line; optimal operation

---

Date of Submission: 08-09-2018 Date of acceptance: 26-09-2018

I. INTRODUCTION

Vietnam power system has developed into a large complex system with multiple power sources (coal and gas thermal power, hydropower and renewable energy ...) together with the national transmission grid from North to South. The formation of key economic zones and industrial parks has led to the rapid increase of load centers and the increasing disparity between the high and low points of the regional load as well as the whole country. To ensure reliability and reduce the cost of power supply, an optimizing operation of power plants in Vietnam power system to meet the demand for the load graph’s peaks is being investigated.

The research team has successfully built the optimal model of Vietnam power system taking into account the characteristics of power sources and transmission lines ([1]). The model has described all characteristics of power sources (scale, energy characteristics, power mobility, power, location, etc...) and transmission lines between load nodes of a complex power system. In order to determine the objective function and constrains of the optimal model of Vietnam power system and to assert the nature of an optimization problem is to find the minimum cost to supply electricity (power) for a load demand in reviewing stage, satisfying the constrains of sources and transmission lines. In an optimal model, objective functions and constraints are nonlinear mathematical relationships.

Based on the research results ([1]), the authors have used the linearization solution to build optimal calculation software for the development and the operation of Vietnam power system by linear planning method ([2],[3]) and this software is used to calculate and to verify the actual operating results at the National Load Dispatch Centre A0 ([5],[12],[13]) .

II. BUILDING AN OPTIMAL CALCULATION SOFTWARE FOR THE DEVELOPMENT AND THE OPERATION OF AN COMPLEX POWER SYSTEM WITH A NUMBER OF NODES (THE NUMBER OF NODES IS A VARIABLE)

2.1 Block diagram of the software

The objective function and constrains are solved by linear planning method with the block diagram shown in figure 1. From figure 1, the main program consists of 8 steps with 14 blocks.

Step 1: Start the software, the main screen is opened; the software shall update the prepared database. The database contains data from power sources, 500 kV and 220 kV transmission grids that are in operation as of 2016 as well as the sources and transmission grids that will be available before 2030. Load data are load charts of nodes corresponding to load regions with 3 levels: high, medium and low during the calculating period from 2015 to 2030. The database can be managed from the main screen.

Step 2: Select the calculation method. The parameters for selection are: number of regions or nodes (n), load level (high, medium, low), hydropower frequency (p%), calculation length: year, month.

Step 3: Construct data for selected calculation method. Once a method is selected, the software shall access the database to get data for power sources, grid and corresponding loads.

Step 4: Cover the peaks of load chart. Medium-ans small-sized hydropowers in each region are used to cover the peaks of load chart of that region first. A hydropower station is able to provide cover if satisfying several conditions such as limied power set and to ensure the number of steps to cover.

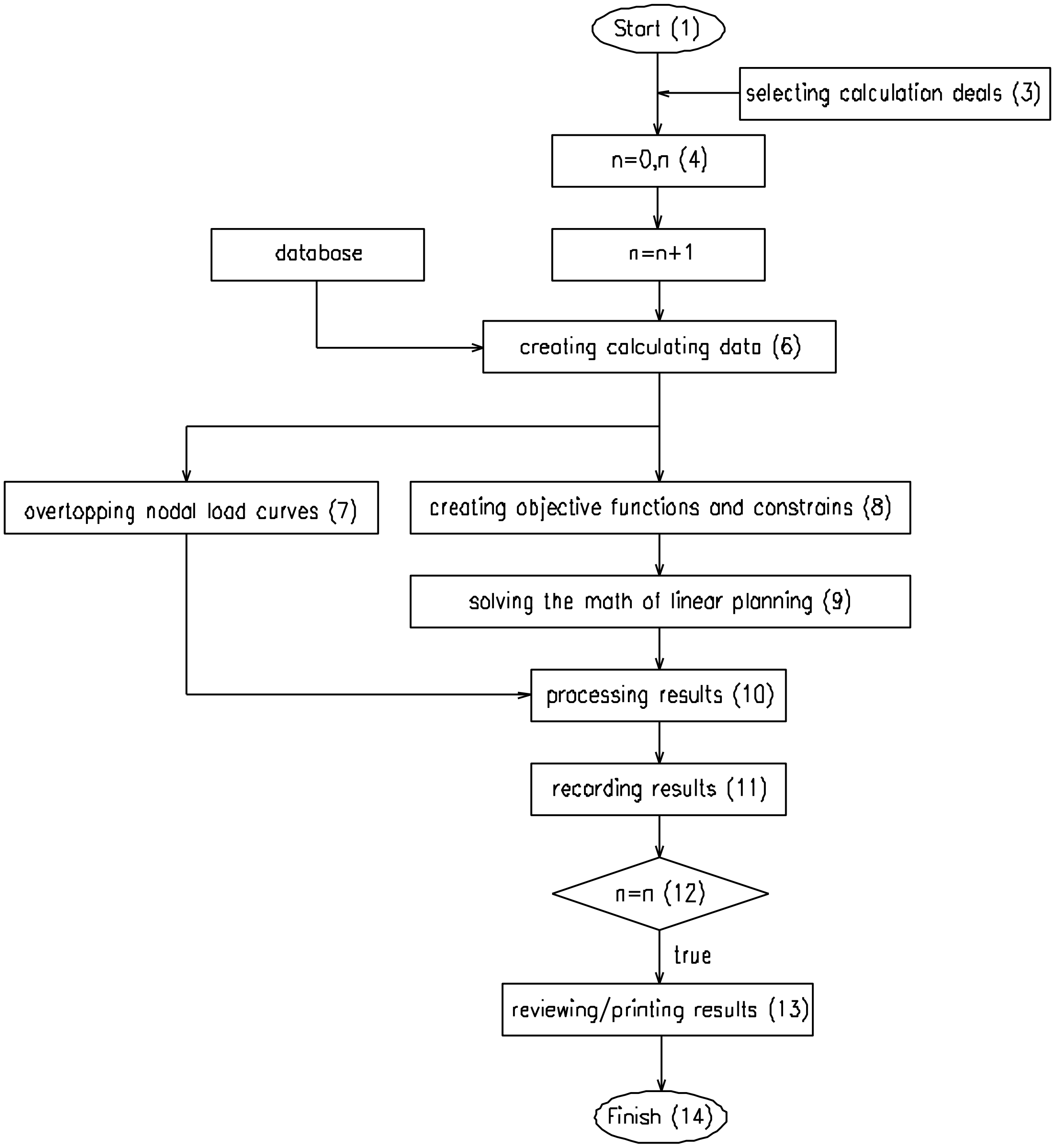

Figure 1: Optimal block diagram of power system program with any number of nodes

Step 5: Construct the objective function and constrains in accordance with the selected method of calculation: The set of objective functions and constrains will be automatically completed by the program. This set describes the supply-demand balancing of a power system with a purpose of minimum calculation costs.

Step 6: Solve the linear planning problem: The objective function and constrains shall be solved by Lpsolve program. The results are charts, tables and figures containing the variables.

Step 7: Process the results: This is a step to reverse the intermediate variables to give the operation results of the power system in 24 hours.

Step 8: Show the results: The results are given in documents, figures and tables in order to print, read or save and are automatically done.

The 8 steps above are processed automatically to supply a complete solution to problems of optimizing development or operation of a power system. The differences between the optimal development problem and the optimal operation problem are in the input data. The input data for the optimal operation problem are set according to the known characteristics of actual power sources and transmission lines of a power system. The objective of this problem is the minimum total cost of power supply for load demands of selected calculating nodes. The calculation length is often in days, weeks, months or a typical year according to requests. In contrast, the optimal development problem is to find the minimum total cost of power supply for the forecasted demand (often in years) and a result is a plan or a set of structural plans of the power system that have total cost close to one another. Depending on the number of nodes, the simulation model of the power system will be set up automatically and solved to balance the supply and demand of the power system corresponding to the objective function and the constraints of the problem.

2.2 Program interfaces

The interface of the software is shown in figure 2.

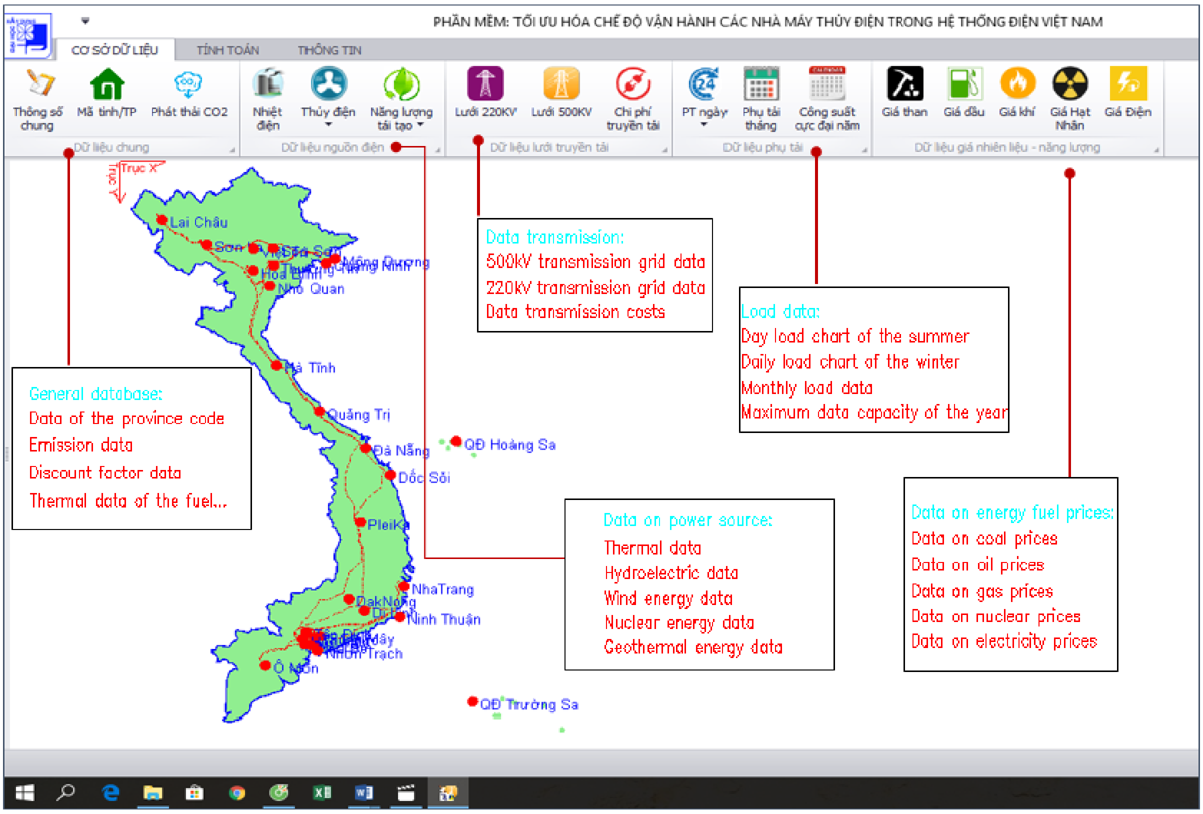

Figure 2: Main interface of the software to optimize Vietnam power system with any number of nodes

From Figure 2, we can see that input data have 5 main parts: General database (provice and city code, emission, discount rate, heat values of fuel ...); Data about power sources (hydropower, thermal power, renewable energy sources, ...); Data about the power transmission lines (500 kV, 220 kV, cost of power transmission, ...); Data about loads (typical daily load charts for summer, winter, week, month, year ...); Data about fuel cost).

Data about the power sources: Power sources of the power system in the optimal operation problem are taken in reallife or according to plans in the approved master power planning 7 ([6], [7], [8]).

Data about thermal power plants include: Name, type, operation years, installed power, type of fuel, consumption rate, operation and maintenance costs etc... Heat properties of the generators are linearized in 4 phases: peak, half-peak, half-bottom, bottom of the load chart. The emission shall be calculated based on the norms set for 2015

Data about hydropower plant include: Name, type, operation years, installed power, monthly actual power and average power corresponding to annual hydrological frequency p=50%, p=75% and p=90%; Cost of power generation inlcudes: Return on capital and O&M operating and management costs and economic lifespan of hydropower projects;

Tax and environmental costs, operation costs, power self-consumption rate,... are taken according to current regulations of Vietnam.

Data about power from renewable energy sources (solar and winds include: Name, type, investment, O&M cost, installed power, self-consumption rate, years in operation) are updated according to the approved planning.

Data about pumped storage hydropower plant include: Name, type, years in operation, installed power, cost of power generation, O&M costs, cost of daily water pumping calculated with low power cost... according to the power planning 7 ([6], [13]).

Imported power is updated according to actual documents including: Name, exporting sources, years in operation, power taken from parameters in the power planning 7. Power generation cost includes import power cost and import location.

Data about the power transmission lines are updated according to total power and equivalent length of 500 kV lines, 220 kV lines connecting between regions as approved in ([6], [13]). The equivalent transmission cost is the weighted average of the 220 kV and 500 kV lines for each link line between the two load nodes. Total cost of unit transmission on line segments (Cddtt) is calculated according to the formula:

$$C_{ddtt} = L_{tt} \text{ x } K_{tt} \text{ (USD/MWh)} \quad (1)(2)$$

With: L_{tt}: Transmission length is the length of the equivalent line connecting two regions (km); K_{tt}: The cost of transmission is regulated by year (USD/MWh.km);

Applying formula (1) will calculate the equivalent transmission cost C_{dd220} and C_{dd500} of corresponding 220kV and 500kV transmission line. The total power of all lines is P_{dd220} and P_{dd500}. The general transmission cost (C_{dd}) is calculated according to the following formula:

$$C_{dd} = \frac{C_{dd500} * P_{dd500} + C_{dd220} * P_{dd220}}{P_{dd500} + P_{dd220}} \text{ (USD/MWh)} \quad (2)$$

In addition, to find the solution to the optimal problem in the load chart covering process, we need to determine the direction of power transmission on the grid. Conventionally, when considering a node, only the source of that node is considered the power source, the sources of other nodes are considered as loads and the direction of transmission is considered from the power source in question. By specifying the beginning and end points of the transmission grid for each node, we shall determine the direction of transmission on the grid.

Data about loads: Load database include load charts for all cities and provinces. Load charts are built based on the typical daily load chart (in summer and in winter) and the annual load chart (for 12 months) published for the time of calculation. Maximum annual power P_{max} forecasted for cities and provinces with high, medium and low load demands are collected from power planning 7 ([6], [13]).

Data about fuel cost, electricity cost: costs of coal, oil and gas... are taken from domestic costs and imported costs at 3 regions North, Centre and South as specified in the power planning 7 ([6], [7], [8], [13]). Average yearly increase in cost of fuel is 2%. Electricity price in the problem is the average yearly price, this price in 2015 is 75,6 USD/MWh; in 2017 is 75,8 USD/MWh and the average increase in price is 0.1% according to the Vietnam announcement.

III. CALCULATION RESULTS AND DISCUSSION

3.1 Optimal operation calculation of Vietnam power system using 3-node-model: North, Centre and South

The 3-node model of the Vietnam power system is shown in Figure 3. The input data is as described above for the power sources, transmission lines and load demand in practice in January 2017 and phase 2020, 2025 and 2030 under the approved power plan ([6], [13]).

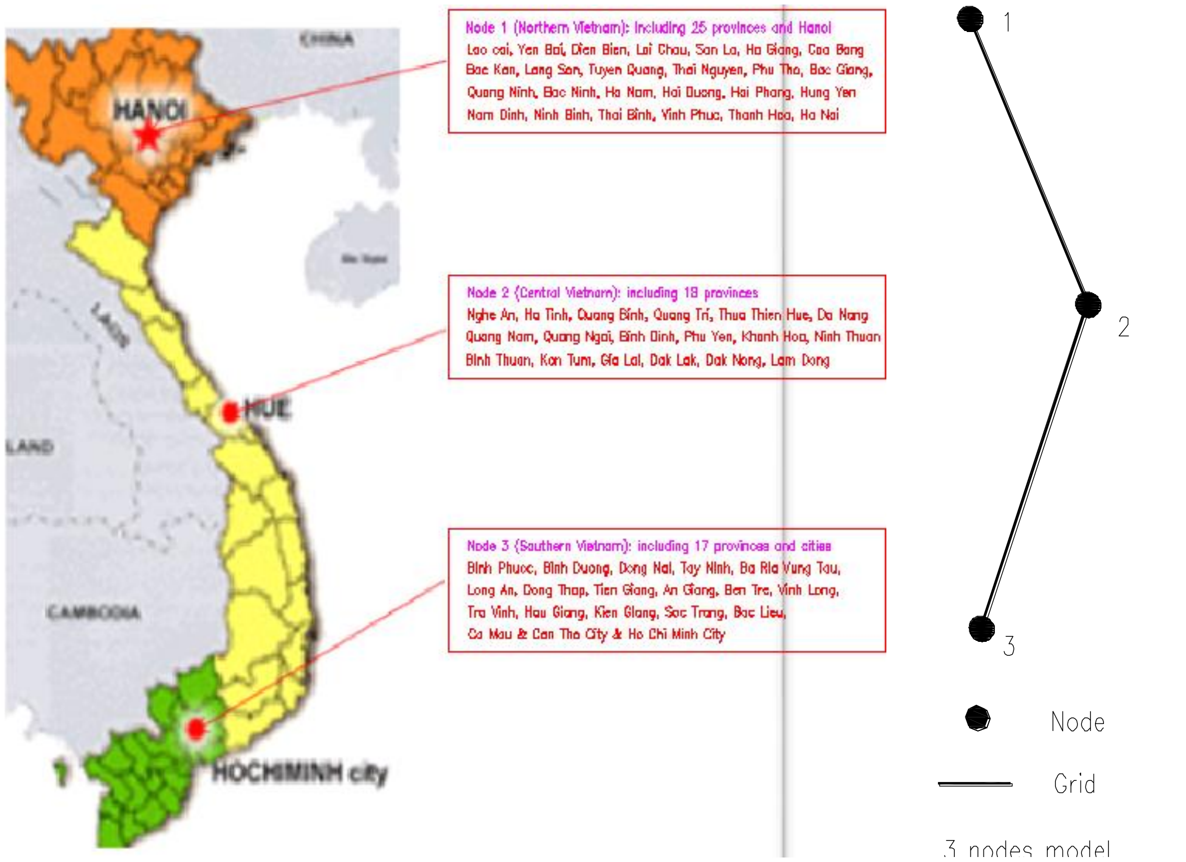

Figure 3: The three-node model of Vietnam power system

Calculation results with a low load scenario and a 50% hydropower frequency are shown in Figures 4. The results are compared with the results of the National Load Dispatch Centre A0 ([6],[12]) in Table1.

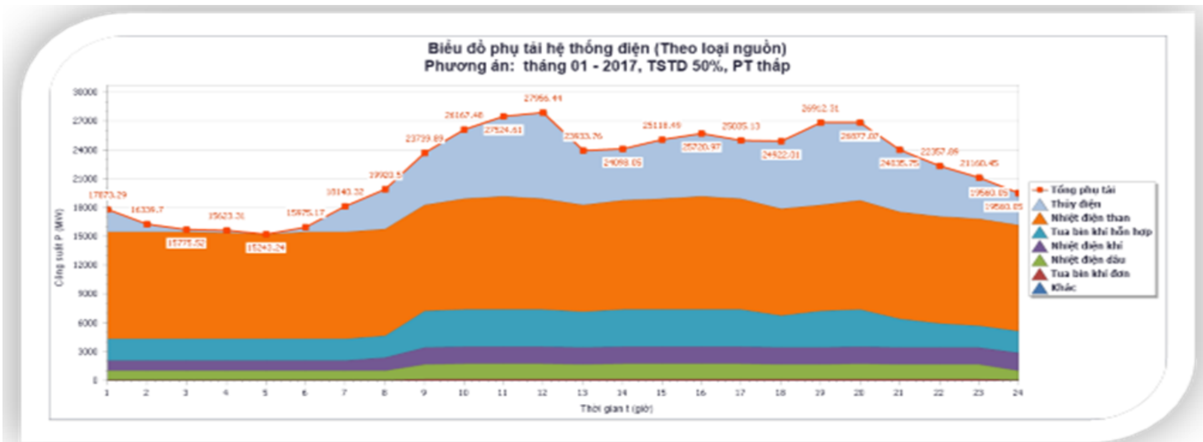

Figure 4: Result of the covering load chart of Vietnam power system Jan-2017

Table 1: Calculated results in comparison with Decision No. 4711-BCT & Power planning 7

Year	Energy $E_{năm}$ (10^3MWh)	Energy $E_{Tháng\ 1}$ (10^3MWh)		Error (%)	Energy $E_{Tháng\ 4}$ (10^3MWh)		Error (%)	Energy $E_{Tháng\ 8}$ (10^3MWh)		Error (%)	Energy $E_{Tháng\ 11}$ (10^3MWh)		Error (%)
		Soft-ware	QHĐ 7&Ao		Soft-ware	QHĐ7 &Ao		Soft-ware	QHĐ7 &Ao		Soft-ware	QHĐ7& Ao	
Năm 2017	204.387	3512	3636	3.40	4625	4505	2.66	7534	7796	3.36	5372	5214	3.03
Năm 2020	288.873	3477	3658	4.95	4668	4577	1.99	8795	8466	3.89	5510	5297	4.02
Năm 2025	433.053	4056	3899	-4.03	5353	5108	4.80	8795	9025	2.55	5988	5806	3.13

Năm 2030	624.123	4076	4047	-0.72	5365	5302	1.19	8806	9087	3.09	6051	6027	0.40

From Table 1, it can be seen that the calculation results are consistent with the optimal operating scenario of A0 and the calculation result of Power Plan 7 (maximum error of 4.95%).

3.2 Modeling Vietnam power system with 5 nodes:

Based on 5 management and operation sub-zones of 5 power corporations: Northern Power Corporation consists of 27 (provinces); Central Power Corporation consists of 13 (provinces); Southern Power Corporation consists of 21 (provinces); Hanoi Power and HoChiMinh City Power Corporation. The location diagram is shown in Figure 5. Geographical location, parameters and characteristics of power sources at each node is determined according to actual situation and power planning 7. Only 500 kV and 220 kV transmission line system (as specified) between nodes are consider.

3.3 Modeling Vietnam power system with 8 nodes

Developed and calculated based on 10 large river basins to serve the purpose of determining the optimum operating regime for hydropower plants in Vietnam power system. In 10 large river basins in Vietnam, there are several neighboring basins and hydropower plants sharing the transmission system, which has been transformed into 08 main nodes as shown in Figure 6. All operational or expected to be operational by 2030 hydropower plants on considering river basins are included in the calculation.

Table 2 summarizes results of the covering typical daytime load chart according to the optimal model of the Vietnam power system with 5 nodes. Table 3 summarizes the results for the 8-node model. For the convenience of discussion and comment, Table 4 summarizes the results of calculation of total electricity supply cost, total emission and some other indicators according to the model of 3 nodes, 5 nodes and 8 nodes.

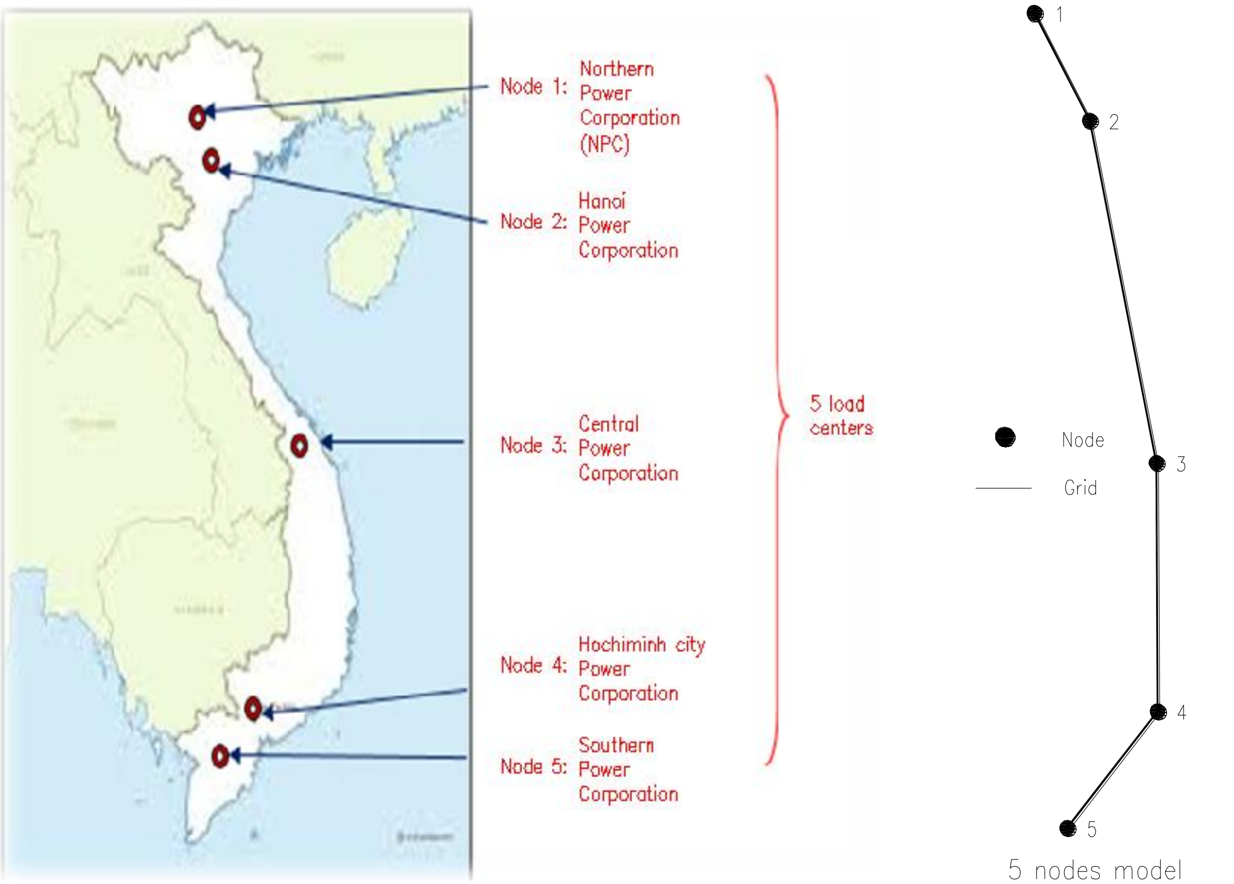

Figure 5: Current node descriptions under the management model of Vietnam Electricity Corporation

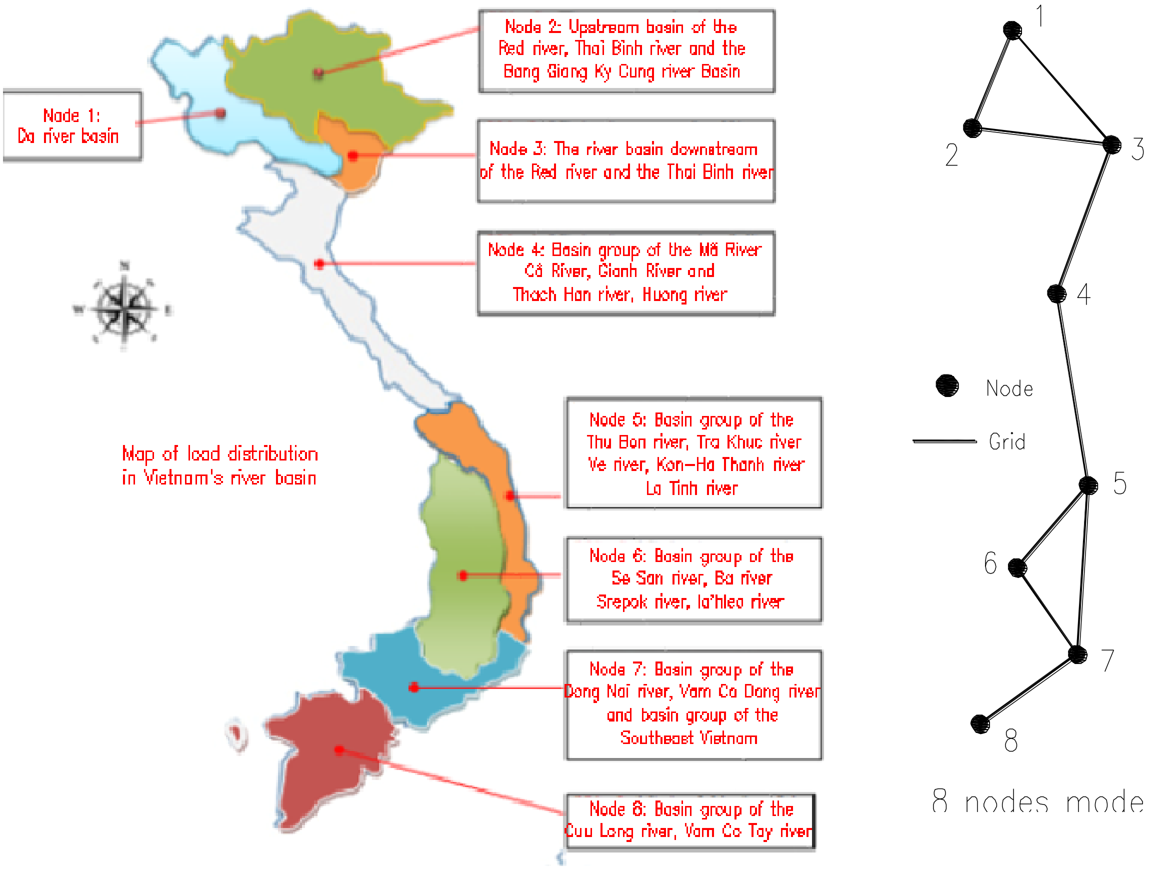

Figure 6: Zoning load nodes in accordance with Vietnam's river basins

Table 2: Summary results of covering load charts of Vietnam power system with 5 node approach (MW)

Hour	Total demands (MW)	Hydro-power (MW)	Thermal power (MW)	DD0104 (MW)	DD0102 (MW)	DD0203 (MW)	DD0205 (MW)	DD0305 (MW)	Total losses (MW)
1	17,873	1,551	16,322	1,693	674	-376	99	895	45
2	16,340	659	15,681	1,530	674	-376	0	895	43
3	15,776	440	15,336	1,474	674	-376	0	867	42
4	15,623	221	15,402	1,448	674	-376	0	895	42
5	15,243	220	15,023	1,413	636	-376	0	838	40
6	15,975	685	15,290	1,500	674	-376	0	838	42
7	18,140	2,201	15,939	1,836	674	-376	0	895	45
8	19,921	3,149	16,771	2,029	674	-376	257	895	50
9	23,740	5,554	18,186	2,253	674	-376	1,020	895	63
10	26,167	7,981	18,186	2,423	674	-356	1,387	895	70
11	27,525	9,338	18,186	2,601	674	-252	1,484	895	73
12	27,956	9,770	18,186	2,919	674	-356	1,331	895	72
13	23,934	5,748	18,186	2,274	674	-376	984	895	62
14	24,098	5,912	18,186	2,125	674	-376	1,286	895	66
15	25,118	6,932	18,186	2,227	674	-356	1,404	895	69
16	25,721	7,535	18,186	2,283	674	-252	1,480	895	71
17	25,035	6,849	18,186	2,096	674	-356	1,379	895	67
18	24,922	6,736	18,186	2,458	674	-376	859	895	62
19	26,912	8,726	18,186	2,755	674	-376	1,056	895	67
20	26,877	8,691	18,186	2,577	674	-376	1,262	895	69
21	24,036	5,993	18,042	2,338	674	-376	778	895	60
22	22,358	4,722	17,635	2,102	674	-376	628	895	56
23	21,160	3,578	17,583	1,912	674	-376	568	895	54
24	19,560	2,452	17,108	1,740	674	-376	394	895	50
Energy (MWh)	530,011	115,644	414,367	50,005	16,132	-8,702	17,657	21,340	1,380

Table 3. Summary results of covering load charts of Vietnam power system with 8 node approach (MW)

Hour / Total demands (MW)		Hydro-power (MW)	Thermal power (MW)	DD0103 (MW)	DD0102 (MW)	DD0203 (MW)	DD0304 (MW)	DD0405 (MW)	DD0506 (MW)	DD0507 (MW)	DD0607 (MW)	DD0708 (MW)	Total losses (MW)
1	17,873.3	1,681.1	16,192.2	493.5	-134.7	1,888.4	52.9	313.2	0.0	0.0	0.0	-91.3	20.6
2	16,339.7	874.3	15,465.4	63.1	-134.7	1,896.5	52.9	313.2	0.0	0.0	0.0	-91.3	18.4
3	15,775.5	632.4	15,143.2	-122.2	-134.7	1,900.0	14.7	313.2	0.0	0.0	0.0	-91.3	16.9
4	15,623.3	414.0	15,209.3	-190.1	-134.7	1,900.0	14.7	313.2	0.0	0.0	0.0	-91.3	16.6
5	15,243.2	402.7	14,840.6	-182.2	-134.7	1,900.0	0.0	313.2	0.0	0.0	0.0	-59.7	15.9
6	15,975.2	897.3	15,077.9	-12.4	-134.7	1,896.5	52.9	313.2	0.0	0.0	0.0	-91.3	18.1
7	18,140.3	2,407.2	15,733.2	935.3	-134.7	1,816.4	52.9	313.2	0.0	0.0	0.0	-91.3	23.1
8	19,920.5	3,049.0	16,871.5	1,433.1	-134.7	1,816.4	52.9	313.2	0.0	0.0	0.0	-91.3	25.6
9	23,739.9	5,588.9	18,151.1	2,057.3	-134.7	1,794.6	74.4	313.2	0.0	120.6	929.8	334.5	49.6
10	26,167.5	8,016.4	18,151.1	2,537.3	-134.7	1,786.3	108.5	313.2	0.0	216.0	1,251.7	733.9	63.2
11	27,524.6	9,373.6	18,151.1	3,002.8	-134.7	1,786.3	114.0	313.2	0.0	216.0	1,413.4	839.3	69.4
12	27,956.4	9,805.4	18,151.1	3,824.8	-134.7	1,786.3	114.0	313.2	0.0	216.0	1,179.3	672.5	67.9
13	23,933.8	5,782.7	18,151.1	2,132.5	-134.7	1,786.3	88.4	313.2	0.0	120.6	929.8	295.0	49.7
14	24,098.1	5,947.0	18,151.1	1,725.5	-134.7	1,794.6	74.4	313.2	0.0	216.0	1,179.3	624.2	56.2
15	25,118.5	6,967.4	18,151.1	1,989.5	-134.7	1,794.6	74.4	313.2	0.0	216.0	1,277.4	751.5	60.6
16	25,721.0	7,569.9	18,151.1	2,175.3	-134.7	1,786.3	108.5	313.2	0.0	216.0	1,349.4	834.9	64.2
17	25,035.1	6,884.1	18,151.1	1,662.5	-134.7	1,816.4	108.5	313.2	0.0	216.0	1,251.7	725.2	58.6
18	24,922.0	6,771.0	18,151.1	2,633.3	-134.7	1,786.3	114.0	313.2	0.0	120.6	548.4	158.9	45.1
19	26,912.3	8,761.3	18,151.1	3,402.5	-134.7	1,786.3	114.0	313.2	0.0	120.6	1,152.6	374.0	60.7
20	26,877.1	8,726.0	18,151.1	2,942.5	-134.7	1,786.3	114.0	313.2	0.0	216.0	1,152.6	597.9	62.1
21	24,035.8	5,884.7	18,151.1	2,324.1	-134.7	1,786.3	114.0	313.2	0.0	0.0	548.4	71.1	41.3
22	22,357.9	4,206.9	18,151.1	1,681.9	-134.7	1,812.0	108.5	313.2	0.0	0.0	0.0	-91.3	27.7
23	21,160.5	3,198.9	17,961.6	1,167.2	-134.7	1,816.4	88.4	313.2	0.0	0.0	0.0	-91.3	24.8
24	19,560.1	2,281.5	17,278.5	614.1	-134.7	1,888.4	52.9	313.2	0.0	0.0	0.0	-91.3	21.2
Energy (MWh)	530,011	116,124	413,888	38,291	-3,233	43,808	1,865	7,516	0	2,211	14,164	6,040	977

Table 4: Comparing the optimal operation calculation results of Vietnam power system with approaches of 3, 5 and 8 nodes

Number of nodes	Total calculated costs, USD	Emission CO_2, ton
3	17.444.022,15	818.927,57
5	17.444.183,72	927.365,22
8	17.624.323.45	1.028.125,50

Table 5: Balancing daily power supply-demand (MWh) according to optimal operation model of Vietnam power system with approaches of 3, 5 and 8 nodes

Approach (number of nodes)	Total demand HT	Supply from hydropower	Supply from thermal power	Power on 500 kV and 220 kV lines	Total losses
3	530.011,0	113.405,0	416.606,0	42.034,3	533,8
5	530.011,0	115.644,0	414.367,0	96.432,0	1380,0
8	530.011,0	116.124,0	413,888	110.659,0	977,0

Based on the results of solving the optimal operation of Vietnam power system with the model of 3, 5 and 8 nodes with low load demand, in January 2017 and the frequency of hydroelectric power is 50%, several comments are :

- The selection of the number of nodes in the model affects the optimal results. As the number of nodes increases, the total cost of electricity supply increases as well as the transmission line between the nodes and the total transmission power. The change in the proportion of power generated from hydropower and thermal power in the 3-node, 5-node and 8-node model has changed toward a closer approach to reality. It is noteworthy that the mobilization capacity to cover the load chart from 8-node hydroelectric plants increased compared to the 3-node and 5-node schemes. This shows that, when modeling the power system with more nodes, the transmission line is more realistic, the advantage of fast power mobility with the low cost of the hydropower plant to cover peaks is used more effectively.

- The selection of the number of nodes should be based on the results of the analysis of the current state of the source and the grid diagram in order to meet the objective of the problem and the appropriate distribution of the elements in the power system, so that the individual characteristics of the power supply and transmission grid between nodes are fully present, close to reality. Note that, as the number of nodes increases, the portion of transmission power in the local area tends to decrease. At that point, the transmission capacity between the nodes may increase and the total cost of power supply to the overall load of the power system increases.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusion

The program of optimizing the operation of the power system in Vietnam presented above is based on the optimal model, which fully describes the specific characteristics of Vietnam power system - a large, complex system, diversified sources with multi-level power grid, stretching from North to South. The program has been calibrated with data of the 3-node Vietnam power system with small deviation, to the extent permitted;

Computation results with 5-node and 8-node power system confirmed the rationality and suitability with the reality of Vietnam power system development. The program allows the research for the optimal development and optimal operation of Vietnam power system, meeting all the requirements of the current and future planned power system of Vietnam.

4.2. Recommendations

In order to meet the actual needs of developing Vietnam power system in the future, the research on the development of pumped storage hydroelectric power and the power sources from the computational energy are being carried out by the research team and shall be presented in subsequent publications.

ACKNOWLEDGEMENT

This paper was supported by the Institute of Energy Science, Vietnam Academy of Science and Technology, the National University of Civil Engineering and the University of Science and Technology - The University of Da Nang. We would like to extend our gratitude to our colleagues and scientists for their excellent comments on this article and hope to continue to receive comments from these specialized experts in future articles.

REFERENCES

[1]. LUONG Ngoc Giap, VU Huu Hai, NGO Van Dung, NGUYEN Binh Khanh, TRAN The Vinh, LE Tat Tu: “Models and methods of calculating the optimal development and optimal operation of Vietnam's power system”, IOSR Journal of Engineering (IOSRJEN), ISSN (e): 2250-3021, ISSN (p): 2278-8719, Vol. 08, Issue 6 (June. 2018), ||V (II) || PP 01-07.

[2]. NGO Van Dung, Optimization of operation of hydro power plants in vietnam electric system, Ph.D. thesis, National University of Civil Engineering, Hanoi, 2018.

[3]. BUI The Tam, Tran Vu Thieu, Optimization methods, Transport Publishing House Ha noi, (TPH), 1998.

[4]. BUI Minh Tri, Mathematical program, Science and Technics Publishing House, Ha noi, 1999.

[5]. National Load Dispatch Centre (A0), Summing up the operation of the national electricity system 2016, Hanoi 2016.

[6]. Project: Adjusting National Power Development Plan for 2011-2020, with a vision to 2030, Institute of Energy, Ministry of Industry and Trade, 2017.

[7]. Project: Calculation of operating regime and role of Ialy Hydropower plant expansion in Vietnam Power System, Institute of Energy, Ministry of Industry and Trade, 2017.

[8]. Project: Calculation of operating regime and role of Hoa Binh Hydropower plant expansion in Vietnam Power System, Institute of Energy, Ministry of Industry and Trade, 2017.

[9]. NGO Van Dung, NGO Tuan Kiet, VU Huu Hai: The optimal development model of Vietnam's power system taking into account the regime of hydropower generation and transmission lines. Journal of Science and Technology, University of Da Nang - Journal 3 (88).2015 Page 15; ISSN 1859-1531, 2015.

[10]. NGO Van Dung, NGO Tuan Kiet, VU Huu Hai: Optimizing the operation of hydropower plants in the South Vietnam power system, taking into account transmission line losses. - Journal of Science and Technology, University of Da Nang - Journal 9 (118).2017 - Book 1, page 29;

ISSN 1859-1531.
[11]. NGO Van Dung, LE Tat Tu, VU Huu Hai: Study on the role of coal-fired thermal power in Vietnam's power system, Thermal energy magazine: 137-9 / 2017 * 25-29, ISSN 0868 -3336.
[12]. Decision No. 4711 / QD-BCT, Approving the plan on electricity supply and operation of the power system in 2017, Ministry of Industry and Trade, Hanoi, December 2012.
[13]. Decision No. 428 / QD-TTg of the Prime Minister dated 18 March 2016 Approving the Scheme on Adjusting the National Power Development Plan for the 2011-2020 period with a vision to 2030.

LUONG Ngoc Giap . "Building software for optimal calculation of electricity system and results of optimal calculation and operation of Vietnam's electricity system. " IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 9, 2018, pp. 01-10.