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Generator Capability Curve Approaches for Optimal Power Flow

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***Abstract*— Involving the generator capability curves intactly will make the optimal power flow problem more complicated. If the constraints of inequality increase, the system of linear equations in the optimization settlement becomes larger. But for the power systems that do not require much reactive power, each generator will operate on a high power-factor, either the leading or lagging conditions, so the excitation limits are impossible to be violented. This paper approaches on the excitation limits with the minimum and maximum reactive power limits to obtain simpler generator capability curves so a number of the inequation constraints will significantly be reduced. Through this approach will be obtained an optimal power flow problem is smaller when compared to involve the excitation limits. Thus, the proposed methodology will be able to reduce computation time and more effective for large power systems. From several simulations show that the proposed method can work very well with the satisfactory results.**

Keywords-inequality contraints; reactive power; smaller; effective; computation time.

I. INTRODUCTION

In operating a power system, fuel-mix costs should be kept as low as possible. This is given that the fuel-mix costs in the power system can reach more 60% of the total costs. For that the experts should focus on efforts to optimize the fuel-mix. Where they have developed research on optimal power flow, OPF, [1] - [6], to get optimum of the fuel-mix costs. Efforts optimize the fuel-mix will be faced with complex problems on a large scale so that program will run more slowly. This is closely related to the many constraints of lines, bus voltages and generators on the power system.

Solving the OPF problem through the calculus calculations will be faced to completion of the system of nonlinear equalities, which it is expressed by (1).

$$\nabla L_y(y) = \begin{bmatrix} s\pi - \mu e \\ z(\pi + \nu) - \mu e \\ s + z - \hat{h} + \breve{h} \\ h(x) + z - \hat{h} \\ J_f - J_g^{\mathrm{T}}\lambda + J_h^{\mathrm{T}}\nu \\ -g(x) \end{bmatrix} = 0 \tag{1}$$

Where *L(y)* is LaGrange function, *s, z* and *x* are primal variables, *μ, λ, π* and *ν* are dual variables, *h(x)* is a function of inequality constraints, $\breve{h}$ and $\hat{h}$ are limits minimum and maximum, g(x) is a function of equality constraints, *e* is identity matrix and *J* is Jacobian matrix.

Efforts to speed up computation time through the interior point method have been developed by [7], [8]. With results that can significantly decrease computation time. While efforts to solve OPF problem with involving GCCs have been studied by [9], i.e. through particle swarm optimization, PSO. But there is no guarantee that PSO can solve the optimization problem with the large-scale in fast time. Another [10] have intactly involved GCCs, but every iteration step should be specified which curve will be used. This is determined by active power, P_c in Fig.1, i.e. the cross point between the upper excitation and stator current curves. If the active power of generator less than P_c, then is used the upper excitation curve, and vice versa. This can affect the computing time, i.e. the program runs more slowly.

To reduce the the system of nonlinear equalities, this paper proposes an approach to the GCCs, i.e. excitation limits are represented by minimum and maximum reactive power limits. Through this approach, it is expected that computing time can be faster. While to see the performance of the proposed methodology has been done case studies and the results compared with the method in [10].

II. RESEARCH METHOD

A. Capabillity Curve

The operation of a generating unit is determined by its GCCs. The GCCs consist of the operation constraints of a generator. Fig. 1 is a GCCs that has mentioned before, it is limited by four constraints, namely:

1) Maximum ability of prime mover. Generally, smaller than the maximum active power that is limited by stator current of the generator.
2) Maximum ability of the excitation of the generator.
3) Maximum ability of the armature current of the generator to produce power.
4) The minimum limit in conditions less excitation.

The existence of these constraints makes the generators no longer operate freely within the half-circular curve on the radius

$\hat{S} = \sqrt{3}\, V\, \hat{I}$ or the maximum apparent power limit of the stator, as shown in Fig. 1.

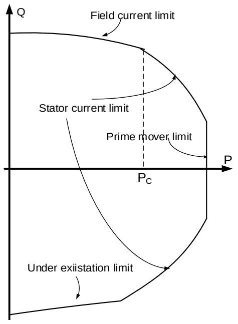

Figure 1. Generator capability curves

B. Capabillity Curve Approach

In Fig. 1 above, the prime mover and stator current limits can be easily applied to optimization, active power is less than or equal to the maximum limit of the prime mover and the output power of the generator is limited by the maximum stator current. However, application of the excitation limit curves is very difficult applied into the OPF problem. In the paper is taken an approach, i.e. excitation is limited by the maximum and minimum reactive powers, as shown in Fig. 2. Through the approach, the GCCs can be formulated with the three equations below.

$$P \le P_{PM} \tag{2}$$

$$\breve{Q} \le Q \le \widehat{Q} \tag{3}$$

$$\hat{S} = \sqrt{P^2 + Q^2} \tag{4}$$

Equation (2) is to implement the prime mover limit, where the active power of a generator cannot be operated the exceeding P_{PM}. Equation (3) is the approach taken to realize the excitation limits, both upper and under limits. These will limit the operation of the reactive power of the generator. While (4) is to realize the limits of the output power of generators in the form a half-circle diagram with radius maximum is an apparent power of the generator.

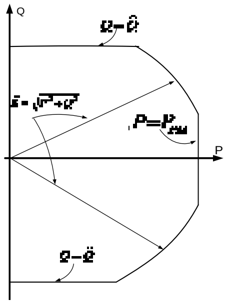

Figure 2. Generator Capability curve approaches

C. OPF Problem

1) Objective function

In the paper, the objective function of OPF is fuel costs of generator units expressed by (5).

$$\text{Min}\ \ f(x) = \sum_{i=1}^{m} c_i + b_i P_{Gi} + a_i P_{Gi}^2 \tag{5}$$

Where *f(x)* is a function of fuel-mix costs in *R* currency, m is a number of generator units, *c, b* and *a* are constants and *P* is active power in MW.

2) Constraint functions

- *Equality constraints*

These constraints consist of active and reactive power-balances on each node expressed by (6).

$$g(x) = \begin{cases} P_{Gi} - P_{Di} - \sum Y_{ij} V_i V_j Cos(\delta_i - \delta_j - \theta_{ij}) = 0 \\ Q_{G1} - Q_{D1} - \sum Y_{ij} V_i V_j Sin(\delta_i - \delta_j - \theta_{ij}) = 0 \end{cases} \tag{6}$$

Where *g(x)* is an equality function, *P* and *Q* are active and reactive powers, $Y_{ij} \angle \theta_{ij}$ is an element of bus admittance matrix and $V \angle \delta$ is bus voltage.

- Inequality constraints

For OPF problem involving the fully GCCs, inequality constraints consist of,

1) Bus voltage: $V \le \hat{V}$
2) Line flow: $S_{ij} \le \hat{S}_{ij}$
3) Stator apparent power: $P^2 + Q^2 \le \hat{S}_s$
4) Prime mover: $P \le \hat{P} = P_{PM}$
5) Over excitation: $P^2 + (Q_o + Q)^2 \le \hat{S}_o$
6) Under excitation: $Q - kP \le \breve{Q}$

The last four are constraints derived from GCCs based on Fig. 1. Where over excitation is assumed as a cycle curve and under excitation is assumed as a linear curve. Through the proposed approaches, the inequality constraints will significantly be lessened, namely:

1) Bus voltage: $V \le \hat{V}$
2) Line flow: $S_{ij} \le \hat{S}_{ij}$
3) Stator apparent power: $P^2 + Q^2 \le \hat{S}_s$
4) Prime mover: $P \le \hat{P} = P_{PM}$
5) Reactive power: $\breve{Q} \le Q \le \hat{Q}$

Furthermore, these five inequality constraints above have been put in (7).

$$h(x) = \begin{cases} \breve{V}_i \le V_i \le \widehat{V}_i \\ 0 \le S_{ij}^2 \le \widehat{S}_{ij}^2 \\ \breve{P}_{Gi} \le P_{Gi} \le \widehat{P}_{Gi} \\ \breve{Q}_{Gi} \le Q_{Gi} \le \widehat{Q}_{Gi} \\ 0 \le P_{Gi}^2 + Q_{gi}^2 \le \widehat{S}_{Gi}^2 \end{cases} \tag{7}$$

Where $\breve{V}_i$ & $\hat{V}_i$ are minimum and maximum voltages, $\breve{P}_{Gi}$ & $\hat{P}_{Gi}$ are minimum and maximum active powers, $\breve{Q}_{Gi}$ & $\hat{Q}_{Gi}$ are minimum and maximum reactive powers, and $\hat{S}_{ij}$ & $\hat{S}_{Gi}$ are maximum apparent powers of line and generator.

D. Flow Chart

Fig. 3 is a flowchart of the proposed method for solving the OPF problem. Step by step the proposed methodology will follow the following procedures.

1) Start with input data of the OPF problem with GCCs approach.
2) Do initial solution through load flow calculation based on economic dispatch, ED.
3) Check constraints: If there is no violation then write the results and stop; Otherwise continue to step 4.
4) Determine the violated constraints.
5) Set the inequality function is based on the violated constraints.
6) Run interior point program to get results of the OPF problem.
7) Check again constraints: If there is no violation then write the results and stop; Otherwise continue step 4.

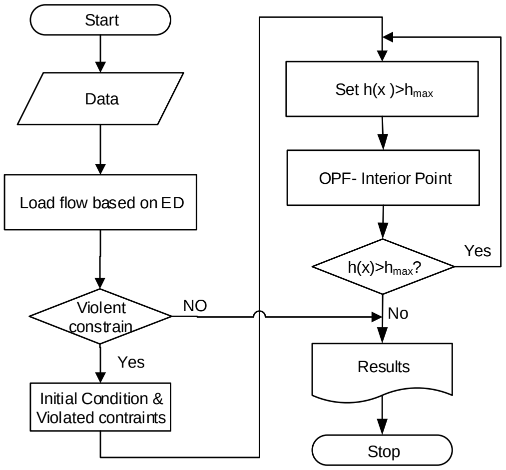

Figure 3. Flow chart diagram of the reduction technique

III. SIMULATION AND ANALYSIS

A. Simulation

Fig. 4 below is the 4-bus power system consisting of two generating units on bus1 and 2, and the total system load is 495 MW. While Tables 1a, 1b and 1c contain data of the generating units, bus loads and line characteristics in per-unit, pu, on the base 100 MVA and 20 kV.

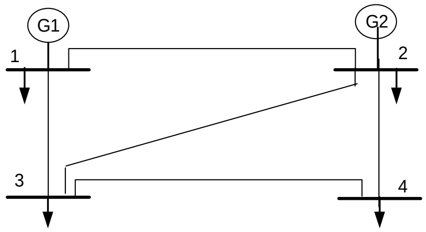

Figure 4. 4-bus system

TABLE Ia. VOLTAGE CONSTRAINTS AND LOADS

Bus	V_{min}(pu)	V_{max}(pu)	P_d(pu)	Q_d(pu)
1	0.9	1.05	0.75	0.65
2	0.9	1.05	0.60	0.30
3	0.9	1.05	1.85	1.15
4	0.9	1.05	1.75	1.10

TABLE Ib. DATA OF GENERATOR UNITS

Gen	c	b	a	$\breve{P}_g$ (MW)	$\hat{P}_g$ (MW)	$\breve{Q}_g$ (MVar)	$\hat{Q}_g$ (MVar)	$\hat{S}_g$ (MVA)
1	200	12.8	0.008	30	240	-200	200	250
2	200	12.2	0.012	50	360	-320	320	400

TABLE Ic. IMPEDANCE AND POWER LIMIT OF LINE

Line	R(pu)	X(pu)	Y_{sh}(pu)	$\hat{S}_{ij}$ (pu)
1-2	0.0546	0.2112	0.0572	0.9
1-3	0.0126	0.0439	0.60	1.6
2-3	0.0218	0.0845	0.0229	1.8
2-4	0.0218	0.0845	0.0229	1.8
3-4	0.0218	0.0845	0.0229	1.8

Whereas Table 2a and 2b contain a base case as an initial solution that is obtained from the converged Newton-Rapson load flow solution based on ED. The base case cannot be applied to system/grid due to any violations, i.e. line 1-3 is over load, which the maximum limit of the line 1-3 is 1.600 pu while it is loaded 2.026 pu (see Table 2b), and Stator limit of generator 1, G_1, is over, which the apparent power limit of generator 1 is 2.50 pu while the generator 1 is loaded 2.941 pu.

TABLE IIa. VOLTAGE AND POWER BASED ON ED

Bus	V(pu)	δ(rad)	P_g(pu)	Q_g(pu)
1	1.050	0.000	2.400	1.700
2	1.030	0.002	2.674	1.372
3	0.982	-0.055	0.000	0.000
4	0.935	-0.092	0.000	0.000
Total			5.074	3.072

TABLE IIb. POWER FLOWS BASED ON ED

Line	P(pu)	Q(pu)	S(pu)	Remarks
1-2	0.014	0.096	0.097	-
1-3	1.636	1.194	2.026	Over
2-3	0.788	0.042	0.885	-
2-4	1.299	0.873	1.565	-
3-4	0.511	0.420	0.662	-

While Tables 3a and 3b contain the results of OPF without GCCs. From these tables can be seen that all constraints have been met, except for the stator power limit of generator 1, which G_1 will be loaded 2.640 pu.

TABLE IIIa. VOLTAGE AND POWER BASED ON OPF WITHOUT GCCS

Bus	V(pu)	δ(rad)	P_g(pu)	Q_g(pu)
1	1.032	0.000	2.400	1.101
2	1.050	-0.010	2.672	1.971
3	0.981	-0.061	0.000	0.000
4	0.945	-0.100	0.000	0.000
Total			4.950	3.200

TABLE IIIb. POWER FLOWS BASED ON OPF WITHOUT GCCS

Line	P(pu)	Q(pu)	S(pu)	Remarks
1-2	0.028	-0.096	0.100	-
1-3	1.622	0.780	1.600	Max
2-3	0.789	0.675	1.039	-
2-4	1.310	1.010	1.654	-
3-4	0.502	0.288	0.578	-

The complete results of the proposed method are shown in Tables 4a and 4b. From the tables can be shown that all constraints have been met, which generator 1 will be loaded less than maximum stator limit (2.50 pu), i.e. 2.4822 pu.

TABLE IVa. RESULTS BASED ON PROPOSED METHOD

Bus	V(pu)	δ(rad)	P_g(pu)	Q_g(pu)
1	1.044	0.000	2.083	1.350
2	1.050	0.015	2.986	1.705
3	0.988	-0.049	0.000	0.000
4	0.949	-0.080	0.000	0.000
Total			5.069	3.055

TABLE IVb. POWER FLOWS ON PROPOSED METHOD

Line	P(pu)	Q(pu)	S(pu)	Remarks
1-2	-0.082	-0.009	0.083	-
1-3	1.416	0.946	1.703	-
2-3	0.930	0.555	1.084	-
2-4	1.373	0.953	1.671	-
3-4	0.439	0.347	0.560	-

The calculation results of the methods for the 4-bus system above were shown in Table 5. It provides a description of the losses, total generation costs and constraints violated from the three methods were observed.

TABLE V. COMPARISON BETWEEN ED AND PROPOSED METHODS

Item	Based on ED	OPF without GCCs	Proposed Method
1. Losses (MW)	12.4	12.2	11.9
2. Total cost ($)	775.17	778.03	783.40
3. Violent constraints			
3.1. Line	L13	-	-
3.2. GCCs	S_{G1}	S_{G1}	-

Fig. 5 and 6 below is a plot of the GCCs for G_1 and G_2 respectively. Three cross signs in the figures show the results of three methods. Where X_1 comes from ED results, X_2 comes from OPF without GCCs and X_3 comes from the proposed method. In the Fig. 5, X_1 and X_2 fall out of GCCs, and X_3 falls inside of GCCs. Whereas GCCs of G_2 can be met by the results of the thee methods, see Fig.6. From the figures can be seen that reactive power of each generator always much smaller than the active power so it is not possible to violate the upper and under limits of excitation.

Meanwhile, Table 6 contains computation time of proposed and OPF with GCCs intactly methods for a few case studies. Data of the case studies are not included in this paper because there are too much, but the data 24 bus Jawa-Bali system is contained in the appendix. Simulations are realized through a program created using Fortran Power Station. Whereas that program is executed by a Laptop of the Core-i3 Asus.

TABLE VI. COMPARISON OF COMPUTATION TIME OF TWO METHOD

Power System	Iteration Step	Computation Time in seconds		Delta time in seconds
		Proposed Method	OPF Method with GCCs Intactly	
3 buses	14	0.33	0.36	0.03
4 buses	15	0.34	0.39	0.05
5 buses	16	0.38	0.45	0.07
9 buses	19	0.43	0.54	0.11
24 buses	18	0.74	1.26	0.52

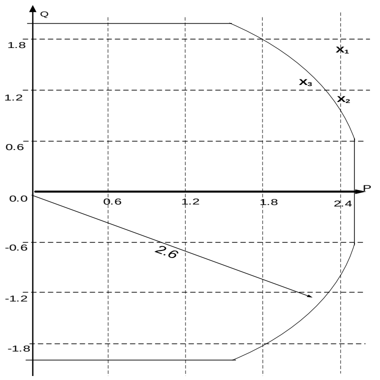

Figure 5. Plot results in the GCCs of G_1

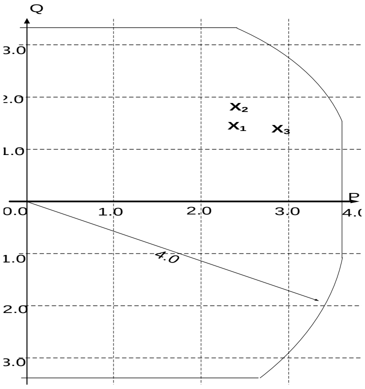

Figure 6. Plot results in the GCCs of G_2

B. Analysis

From Table 5 shows the differences in the calculation results of the three optimization methods that have been studied. The calculation results of the ED method yield a total cost of the generator units is cheapest, 775.17 $, but the losses are biggest. It cannot be applied directly to the grid yet because there are L13 and GCCs of G_1 constraints violated. OPF without GCCs yields the total cost is more expensive and the losses are bigger. However, there is a violation of the GCCS of G_1. So, these results cannot also be applied directly to the grid. If there is a constraint violated, it is necessary to adjust the result in order to meet all the constraints. The adjustments of the results will be able to take a long time, so it can influence the scheduling of the generators that were planned one hour ahead. The long time depends on the experience of the operator in handling the operating system. In addition, the results after adjustments are not assured fall at the optimal point. It will cause operating costs to be more expensive. While the calculation results of the proposed method have met all the constraints, so they can be applied directly to the grid. The results showed that total cost is the biggest, but losses are the smallest.

From Fig. 5 and Fig. 6 show that the reactive power consumption assumption of the system is relatively small so that each generator unit can be assured will not violate the upper and under limits of its excitation.

The proposed method is significantly able to reduce the number of inequalities constraints so the system of linear equation, see (1), to be smaller. It will cause faster running program if compares to involve GCCs intactly, see Table 6. Difference time of two methods, Delta-Time, is enough significant, where for a larger system will be having the big Delta-Time. So, the proposed method will be more effective and efficient for the large system.

I. Conclusion

The method that the results can be applied directly to the system/grid had been proposed in this paper. This method has been tested with several case studies with very satisfactory results. The simulation results show that it can work faster so it is suitable to be applied to large systems. Therefore, the proposed method needs to be considered in determining the scheduling of power plants or to determine energy price in the present restructured electricity markets.

References

[1] Gonen T., "Electrical power distribution system engineering," McGrow-Hill, 1986.

[2] Andersen ED, Gondzio J, Meszaros C and Xu X. (1996), "Implementation of interior point methods for large-scale linear programming," Technical Report 1996.3, Logilab, Section of Management Studies, University of Geneva, Switzerland, 1996.

[3] Dommel HW and Tinney WF, "Optimal power flow solutions," IEEE Transaction on Power System, vol.87, pp.1866-1876, 1968.

[4] Quintana VH, Torres GL and Medina PJ., "Interior-point methods and their applications to the power system," IEEE Transaction on Power System, vol.15, pp.170-176, 2000.

[5] Wei H, Sasaki H, Kubokawa J and Ykoyama R., "An interior point Nonlinear programming for optimal power flow problems with a novel data structure," IEEE Transaction on Power System, Vol.13, pp.870-877, 1998.

[6] Yan X and Quintana VH., "Improving an interior point based OPF dynamic adjustments of step sizes and tolerance," IEEE Transaction on Power System, Vol. 14, pp. 709-717, 1999.

[7] Carpenter TJ, Lustig IJ, Mulvey JM and Shanno DF., "Higher-order predictor-corrector interior point methods with applications to quadratic objectives," SIAM Journal on Optimization, Vol. 3, pp. 696-725, 1993.

[8] Z. Hermagasantos, "Reduksi Langkah Dalam Metoda Interior Point Untuk Aliran Daya Optimal dan Metoda Baru Pemisahan Rugi-Rugi Dalam Struktur Kompetisi Bisnis Tenaga Listrik," Dissertation doctor, Sekolah Teknik Elektro dan Imformasi, Institut Teknologi Bandung, 2005.

[9] Mat S, Adi S and Takashi H., "Generator Capability Curve Constraint for PSO Based Optimal Power Flow," International Journal of Electrical and Electronics Engineering, Vol. 4 no.6, 2010.

[10] Z. Hermagasantos, S. Yusra, "Involving generator capability curves in optimal power flow," IEEE Xplore, pp. 347 – 351, Publication Year: 2015.

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Appendix: Data of 500 kV Jawa-Bali System

TABLE VII. Voltage limits and load data in pu

Bus	Name	V_{min}	V_{max}	P_d	Q_d
1	Slaya	0.9	1.10	0.26	0.16
2	Cwang	0.9	1.10	0.74	0.21
3	Bkasi	0.9	1.10	0.12	0.06
4	Sglng	0.9	1.10	0.00	0.00
5	Bdsln	0.9	1.10	0.51	0.22
6	Grsik	0.9	1.10	0.15	0.10
7	Srbrt	0.9	1.10	0.68	0.34
8	Braja	0.9	1.10	0.00	0.00
9	Clgon	0.9	1.10	0.76	0.20
10	Cibng	0.9	1.10	0.58	0.17
11	Depok	0.9	1.10	0.01	0.00
12	Crata	0.9	1.10	0.36	0.20
13	Mdrcn	0.9	1.10	0.33	0.06
14	Uagrn	0.9	1.10	0.19	0.06
15	Tjjti	0.9	1.10	0.00	0.00
16	Grati	0.9	1.10	0.25	0.14
17	Kmbgn	0.9	1.10	0.66	0.26
18	Gndul	0.9	1.10	0.55	0.12
19	Mtwar	0.9	1.10	0.00	0.00
20	Cbatu	0.9	1.10	0.70	0.28
21	Tasik	0.9	1.10	0.19	0.04
22	Pedan	0.9	1.10	0.35	0.16
23	Kdiri	0.9	1.10	0.24	0.09
24	Paiton	0.9	1.10	0.37	0.06

TABLE VIII. Generator data

Bus	a	b	c	P_{min}	P_{max}	Q_{min}	Q_{max}	S_a
1	200.0	400.0	1.0110	200.0	3400.0	-3400.0	3400.0	4000.0
4	200.0	500.0	0.0000	30.0	650.0	-750.0	650.0	700.0
6	200.0	400.0	1.0220	900.0	2300.0	-2300.0	2300.0	2600.0
12	200.0	500.0	0.0000	300.0	900.0	-900.0	900.0	1000.0
15	200.0	410.0	1.0140	50.0	2500.0	-2500.0	2500.0	2800.0

16	200.0	500.0	1.0300	375.0	1400.0	-1400.0	1400.0	1600.0
19	200.0	550.0	1.0210	400.0	2000.0	-2000.0	2000.0	3000.0
24	200.0	400.0	1.0310	200.0	3000.0	-3000.0	3000.0	3500.0

Note: P in MW, Q in MVar and Cost in $ currency.

TABLE IX. LINE DATA IN PU

No	**Fram**	**To**	***R***	***X***	***y/2***	S_m
1	Slay	Braja	0.0024	0.0224	0.0040	0.60
2	Slaya	Clgon	0 .0007	0 .0070	0.0013	4.41
3	Cwang	Bkasi	0.0058	0.0538	0.0024	1.98
4	Cwang	Mtwar	0.0020	0.0188	0.0009	1.98
5	Bkasi	Cibng	0.0046	0.0425	0.0019	1.98
6	Sglng	Bdsln	0.0022	0.0210	0.0038	4.41
7	Sglng	Cibng	0.0048	0.0450	0.0081	3.97
8	Sglng	Depok	0.0015	0.0141	0.0025	3.97
9	Bdsln	Mdrcn	0.0072	0.0668	0.0121	4.41
10	Grsik	Srbrt	0.0014	0.0134	0.0024	3.97
11	Srbrt	Uagrn	0.0303	0.2827	0.0127	3.98
12	Srbrt	Grati	0.0048	0.0445	0.0080	3.97
13	Braja	Gndul	0.0043	0.0398	0.0072	3.97
14	Clgon	Cibng	0.0157	0.1465	0.0066	2.17
15	Cibng	Depok	0.0007	0.0062	0.0011	4.41
16	Cibng	Mtwar	0.0064	0.0594	0.0027	1.98
17	Depok	Gndul	0.0013	0.0119	0.0021	4.41
18	Depok	Tasik	0.0028	0.0263	0.0048	4.41
19	Crata	Cbatu	0.0028	0.0262	0.0047	4.41
20	Mdrcn	Uagrn	0.0135	0.1256	0.0226	3.97
21	Uagrn	Tjjti	0.0162	0.1512	0.0068	3.98
22	Uagrn	Pedan	0.0090	0.0844	0.0038	1.98
23	Grati	Paiton	0.0053	0.0496	0.0090	4.41
24	Kmbgn	Gndul	0.0018	0.0169	0.0030	3.97
25	Mtwa	Cbatu	0.0029	0.0270	0.0049	3.97
26	Tasik	Pedan	0.0184	0.1712	0.0309	4.41
27	Pedan	Kdiri	0.0122	0.1136	0.0205	4.41
28	Kdiri	Paiton	0.0128	0.1194	0.0216	4.41