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# BIODATA

## A. IDENTITAS DIRI

| | | |
|---|---|---|
| Nama Lengkap | : | Haripuddin |
| Jenis Kelamin | : | Laki-Laki |
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| Telp./Faks. (0411)868794 | : | (0411)869834, 869854, 864935; Faks. |

## B. RIWAYAT PENDIDIKAN

| No | Tahun Lulus | Jenjang | Lokasi (Dlm/Luar Negeri) | Perguruan Tinggi | Program Studi |
|---|---|---|---|---|---|
| 1 | 2008 | Magister | Dalam Negeri | Universitas Hasanuddin | Teknik Elektro |
| 2 | 1996 | Sarjana | Dalam Negeri | Universitas Hasanuddin | Teknik Elektro |

## C. RIWAYAT PEKERJAAN

1. Site Electrical Engineering: PT. Semen Bosowa Maros, 1-05-1997 s/d 8-02-1998

2. Dosen tetap FT UNM: 2 Februari 1997 s/d Sekarang

# DAFTAR PUBLIKASI ILMIAH

## A. SEMINAR INTERNASIONAL

| | | | |
|---|---|---|---|
| 1. | Judul Publikasi | : | Dynamic Economic Dispatch for 150 kV Sulselbar Power Generation Systems Using Artificial Bee Colony Algorithm |
| | Nama Konferensi | : | 2019 International Conference on Information and Communications Technology (ICOIACT) |
| | DOI | : | 10.1109/ICOIACT46704.2019.8938474 |
| | ISBN | : | 978-1-7281-1654-9/CFP19L86-USB |
| | Penerbit | : | IEEE Explorer |
| | Tanggal | : | 24-25 July 2019, Yogyakarta |

## B. JURNAL INTERNASIONAL

| | | | |
|---|---|---|---|
| 1. | Judul Publikasi | : | Multi-objective dynamic economic dispatch using Fruit Fly Optimization method |
| | Nama Jurnal | : | Archives of Electrical Engineering |
| | Website | : | aee.put.poznan.pl |
| | DOI | : | 10.24425/aee.2021.136989 |
| | ISSN (Online) | : | 2300-2506 |
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| | Volume | : | 70 |
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| | Tahun | : | 2021 |

| | | | |
|---|---|---|---|
| 2. | Judul Publikasi | : | Hybrid Optimization Method for Thermal-Wind Integration with Multi Objective Dynamic Economic Dispatch |
| | Nama Jurnal | : | International Journal of Advanced Science and Technology |
| | Website | : | http://sersc.org/journals/index.php/ijast |
| | ISSN (Online) | : | 2207-6360 |
| | ISSN (Print) | : | 2005-4238 |
| | Volume | : | 29 |
| | Nomor | : | 3 |
| | Tahun | : | 2020 |

## DAFTAR PUBLIKASI ILMIAH

| | | | |
|---|---|---|---|
| 3. | Judul Publikasi | : | MFOA-ABC Hybrid Optimization Method for Dynamic Economic Dispatch of the 150 kV Sulselbar Electrical System |
| | Nama Jurnal | : | Prezeglad Electrotechniczny |
| | Website | : | http://pe.org.pl/index.php?lang=1 |
| | DOI | : | 10.15199/48.2021.08.13 |
| | ISSN (Online) | : | 2449-9544 |
| | ISSN (Print) | : | 0033-2097 |
| | Volume | : | R 97 |
| | Nomor | : | NR 8 |
| | Tahun | : | 2021 |

**Validasi Terbalik**

1. **Hasil simulasi rugi-rugi daya aktif sistem IEEE 30 bus, di mana data sistem IEEE 30 bus dijalankan dengan menggunakan metode Newton Raphson sebelum metode optimasi Hybrid diterapkan.**

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 0,000949095
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 176,127 | -16,681 | 0,000 |
| 2 | 1,038 | -3,689 | 21,700 | 12,700 | 48,840 | 24,956 | 0,000 |
| 3 | 1,011 | -10,475 | 94,200 | 19,000 | 21,510 | 27,282 | 0,000 |
| 4 | 1,019 | -8,285 | 30,000 | 30,000 | 22,150 | 28,385 | 0,000 |
| 5 | 1,091 | -8,732 | 0,000 | 0,000 | 12,140 | 14,197 | 0,000 |
| 6 | 1,091 | -10,218 | 0,000 | 0,000 | 12,000 | 5,891 | 0,000 |
| 7 | 1,008 | -9,564 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,021 | -6,898 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,064 | -9,978 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,062 | -11,661 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,027 | -5,742 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,083 | -11,032 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,020 | -8,038 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,072 | -11,954 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,070 | -12,182 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,069 | -11,591 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,062 | -11,895 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,059 | -12,740 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,055 | -12,892 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,059 | -12,700 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,054 | -12,194 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,055 | -12,186 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,063 | -12,716 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,050 | -12,770 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,047 | -12,526 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,029 | -12,922 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,053 | -12,129 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,018 | -8,557 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,048 | -13,691 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,031 | -14,333 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 292,767 | 84,029 | 45,000 |

# Lampiran B

## Validasi Terbalik

### Line Flow and Losses

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 1 | | 176,127 | -16,681 | 176,915 | | | |
| | 2 | 117,482 | -16,299 | 118,608 | 2,435 | 1,537 | |
| | 11 | 58,693 | -0,369 | 58,694 | 1,414 | 1,394 | |
| 2 | | 27,140 | 12,256 | 29,779 | | | |
| | 1 | -115,048 | 17,836 | 116,422 | 2,435 | 1,537 | |
| | 8 | 34,179 | -1,874 | 34,230 | 0,618 | -2,016 | |
| | 3 | 63,202 | 0,546 | 63,205 | 1,753 | 2,978 | |
| | 13 | 44,806 | -4,201 | 45,002 | 1,085 | -0,666 | |
| 3 | | -72,690 | 8,282 | 73,160 | | | |
| | 2 | -61,449 | 2,433 | 61,497 | 1,753 | 2,978 | |
| | 7 | -11,241 | 5,867 | 12,680 | 0,078 | -1,882 | |
| 4 | | -7,850 | -1,615 | 8,014 | | | |
| | 13 | -10,194 | 1,086 | 10,252 | 0,012 | -0,892 | |
| | 28 | 2,344 | -2,604 | 3,504 | 0,003 | -4,430 | |
| 5 | | 12,140 | 14,197 | 18,680 | | | |
| | 9 | 12,140 | 14,241 | 18,713 | 0,000 | 0,612 | |
| 6 | | 12,000 | 5,891 | 13,368 | | | |
| | 12 | 12,000 | 5,983 | 13,409 | 0,000 | 0,211 | |
| 7 | | -22,800 | -10,900 | 25,272 | | | |
| | 3 | 11,319 | -7,749 | 13,718 | 0,078 | -1,882 | |
| | 13 | -34,119 | -3,151 | 34,264 | 0,307 | -0,805 | |
| 8 | | -7,600 | -1,600 | 7,767 | | | |
| | 2 | -33,561 | -0,142 | 33,561 | 0,618 | - 2,016 | |
| | 11 | -54,501 | 3,168 | 54,593 | 0,378 | 0,205 | |
| | 13 | 47,048 | -10,831 | 48,279 | 0,265 | -0,014 | |
| | 12 | 33,414 | 6,205 | 33,985 | 0,000 | 2,465 | 0,932 |
| 9 | | 0,000 | 0,000 | 0,000 | | | |
| | 13 | -18,050 | 11,354 | 21,324 | 0,000 | 0,835 | |
| | 5 | -12,140 | -13,629 | 18,252 | 0,000 | 0,612 | |
| | 10 | 30,190 | 2,275 | 30,275 | 0,000 | 0,890 | |
| 10 | | -5,800 | 3,000 | 6,530 | | | |
| | 13 | -12,703 | 2,316 | 12,912 | -0,000 | 0,822 | |

## Validasi Terbalik

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 9 | | -30,190 | -1,385 | 30,222 | 0,000 | 0,890 | |
| | 20 | 8,791 | -2,138 | 9,048 | 0,068 | 0,152 | |
| | 17 | 4,909 | -1,414 | 5,108 | 0,007 | 0,020 | |
| | 21 | 15,803 | 4,091 | 16,324 | 0,082 | 0,177 | |
| | 22 | 7,589 | 1,530 | 7,742 | 0,039 | 0,080 | |
| 11 | | -2,400 | -1,200 | 2,683 | | | |
| | 1 | -57,279 | 1,762 | 57,306 | 1,414 | 1,394 | |
| | 8 | 54,879 | -2,962 | 54,959 | 0,378 | 0,205 | |
| | 12 | -11,200 | -2,500 | 11,476 | | | |
| | 8 | -33,414 | -3,740 | 33,623 | 0,000 | 2,465 | |
| | 6 | -12,000 | -5,772 | 13,316 | 0,000 | 0,211 | |
| | 14 | 7,824 | 1,083 | 7,899 | 0,065 | 0,136 | |
| | 15 | 18,713 | 1,728 | 18,793 | 0,199 | 0,392 | |
| | 16 | 7,676 | 4,200 | 8,750 | 0,062 | 0,130 | |
| 13 | | 0,000 | 0,000 | 0,000 | | | |
| | 2 | -43,721 | 3,535 | 43,863 | 1,085 | -0,666 | |
| | 8 | -46,783 | 10,817 | 48,017 | 0,265 | -0,014 | |
| | 7 | 34,426 | 2,346 | 34,506 | 0,307 | -0,805 | |
| | 4 | 10,207 | -1,978 | 10,397 | 0,012 | -0,892 | |
| | 9 | 18,050 | -10,519 | 20,891 | 0,000 | 0,835 | 0,978 |
| | 10 | 12,703 | -1,494 | 12,790 | -0,000 | 0,822 | 0,969 |
| | 28 | 15,118 | -2,706 | 15,359 | 0,038 | -1,216 | |
| 14 | | -6,200 | -1,600 | 6,403 | | | |
| | 12 | -7,759 | -0,947 | 7,817 | 0,065 | 0,136 | |
| | 15 | 1,559 | -0,653 | 1,690 | 0,005 | 0,005 | |
| 15 | | -8,200 | 2,500 | 8,573 | | | |
| | 12 | -18,514 | -1,336 | 18,562 | 0,199 | 0,392 | |
| | 14 | -1,553 | 0,658 | 1,687 | 0,005 | 0,005 | |
| | 18 | 6,239 | 2,416 | 6,690 | 0,042 | 0,085 | |
| | 23 | 5,629 | 0,762 | 5,680 | 0,028 | 0,057 | |
| 16 | | -3,500 | -1,800 | 3,936 | | | |
| | 12 | -7,615 | -4,071 | 8,634 | 0,062 | 0,130 | |
| | 17 | 4,115 | 2,271 | 4,700 | 0,016 | 0,037 | |
| 17 | | -9,000 | -0,800 | 9,035 | | | |
| | 16 | -4,099 | -2,233 | 4,668 | 0,016 | 0,037 | |
| | 10 | -4,901 | 1,433 | 5,106 | 0,007 | 0,020 | |

## Validasi Terbalik

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 18 | | -3,200 | -0,900 | 3,324 | | | |
| | 15 | -6,197 | -2,331 | 6,621 | 0,042 | 0,085 | |
| | 19 | 2,997 | 1,431 | 3,321 | 0,006 | 0,013 | |
| 19 | | -9,500 | -3,400 | 10,090 | | | |
| | 18 | -2,991 | -1,418 | 3,310 | 0,006 | 0,013 | |
| | 20 | -6,509 | -1,982 | 6,804 | 0,014 | 0,028 | |
| 20 | | -2,200 | 4,300 | 4,830 | | | |
| | 19 | 6,523 | 2,010 | 6,826 | 0,014 | 0,028 | |
| | 10 | -8,723 | 2,290 | 9,019 | 0,068 | 0,152 | |
| 21 | | -17,500 | -6,200 | 18,566 | | | |
| | 10 | -15,721 | -3,914 | 16,201 | 0,082 | 0,177 | |
| | 22 | -1,779 | -2,286 | 2,896 | 0,001 | 0,002 | |
| 22 | | 0,000 | 0,000 | 0,000 | | | |
| | 10 | -7,551 | -1,450 | 7,689 | 0,039 | 0,080 | |
| | 21 | 1,780 | 2,288 | 2,898 | 0,001 | 0,002 | |
| | 24 | 5,771 | -0,837 | 5,831 | 0,035 | 0,055 | |
| 23 | | -3,200 | 3,400 | 4,669 | | | |
| | 15 | -5,601 | -0,705 | 5,645 | 0,028 | 0,057 | |
| | 24 | 2,401 | 4,105 | 4,755 | 0,026 | 0,054 | |
| 24 | | -8,700 | -1,700 | 8,865 | | | |
| | 22 | -5,736 | 0,892 | 5,805 | 0,035 | 0,055 | |
| | 23 | -2,374 | -4,051 | 4,695 | 0,026 | 0,054 | |
| | 25 | -0,590 | 1,459 | 1,574 | 0,004 | 0,007 | |
| 25 | | 0,000 | 0,000 | 0,000 | | | |
| | 24 | 0,594 | -1,451 | 1,568 | 0,004 | 0,007 | |
| | 26 | 3,542 | 2,363 | 4,258 | 0,042 | 0,063 | |
| | 27 | -4,136 | -0,912 | 4,236 | 0,018 | 0,034 | |
| 26 | | -3,500 | -2,300 | 4,188 | | | |
| | 25 | -3,500 | -2,300 | 4,188 | 0,042 | 0,063 | |
| 27 | | 0,000 | 0,000 | 0,000 | | | |
| | 25 | 4,154 | 0,946 | 4,261 | 0,018 | 0,034 | |
| | 28 | -17,421 | 0,751 | 17,438 | 0,000 | 1,086 | |
| | 29 | 6,214 | -1,939 | 6,510 | 0,084 | 0,159 | |
| | 30 | 7,053 | 0,242 | 7,057 | 0,144 | 0,271 | |

**Validasi Terbalik**

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 28 | | 0,000 | 0,000 | 0,000 | | | |
| | 27 | 17,421 | 0,336 | 17,425 | 0,000 | 1,086 | 0,968 |
| | 4 | -2,341 | -1,826 | 2,969 | 0,003 | -4,430 | |
| | 13 | -15,081 | 1,490 | 15,154 | 0,038 | -1,216 | |
| 29 | | -2,400 | 4,100 | 4,751 | | | |
| | 27 | -6,130 | 2,097 | 6,479 | 0,084 | 0,159 | |
| | 30 | 3,730 | 2,003 | 4,234 | 0,039 | 0,074 | |
| | 30 | -10,600 | -1,900 | 10,769 | | | |
| | 27 | -6,909 | 0,029 | 6,909 | 0,144 | 0,271 | |
| | 29 | -3,691 | -1,929 | 4,164 | 0,039 | 0,074 | |

**Total lossess** **9,415**

Elapsed time is 0,237 seconds.

**2. Hasil simulasi rugi-rugi daya aktif sistem IEEE 30 bus, di mana luaran dari metode optimasi Hybrid FOA-ABC dimasukkan kembali ke metode Newton Raphson**

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 1,5153e-06
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 175,985 | -41,024 | 0,000 |
| 2 | 1,048 | -3,830 | 21,700 | 12,700 | 49,188 | 25,896 | 0,000 |
| 3 | 1,041 | -10,736 | 94,200 | 19,000 | 20,299 | 43,926 | 0,000 |
| 4 | 1,039 | -8,402 | 30,000 | 30,000 | 22,822 | 32,022 | 0,000 |
| 5 | 1,081 | -8,678 | 0,000 | 0,000 | 12,612 | 5,143 | 0,000 |
| 6 | 1,101 | -10,232 | 0,000 | 0,000 | 12,000 | 4,762 | 0,000 |
| 7 | 1,032 | -9,710 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,035 | -6,992 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,071 | -9,976 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,073 | -11,623 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,038 | -5,822 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,095 | -11,031 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,038 | -8,150 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,084 | -11,932 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |

## Validasi Terbalik

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 15 | 1,082 | -12,153 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,080 | -11,566 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,072 | -11,856 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,070 | -12,693 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,067 | -12,837 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,070 | -12,646 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,065 | -12,148 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,066 | -12,141 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,076 | -12,679 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,063 | -12,736 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,063 | -12,538 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,046 | -12,922 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,071 | -12,175 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,039 | -8,696 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,070 | -13,699 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,058 | -14,334 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 292,906 | 70,724 | 45,000 |

## Line Flow and Losses

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 1 | | 175,985 | -41,024 | 180,703 | | | |
| | 2 | 117,393 | -34,183 | 122,269 | 2,570 | 1,887 | |
| | 11 | 58,592 | -6,841 | 58,990 | 1,416 | 1,354 | |
| 2 | | 27,488 | 13,196 | 30,491 | | | |
| | 1 | -114,823 | 36,070 | 120,355 | 2,570 | 1,887 | |
| | 8 | 33,742 | -4,148 | 33,996 | 0,593 | -2,183 | |
| | 3 | 64,332 | -9,918 | 65,092 | 1,804 | 3,017 | |
| | 13 | 44,237 | -8,809 | 45,105 | 1,059 | -0,853 | |
| 3 | | -73,901 | 24,926 | 77,992 | | | |
| | 2 | -62,528 | 12,934 | 63,852 | 1,804 | 3,017 | |
| | 7 | -11,373 | 11,992 | 16,527 | 0,128 | -1,869 | |
| 4 | | -7,178 | 2,022 | 7,457 | | | |
| | 13 | -9,642 | 5,296 | 11,001 | 0,014 | -0,921 | |
| | 28 | 2,464 | -3,274 | 4,098 | 0,004 | -4,609 | |

## Validasi Terbalik

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 5 | | 12,612 | 5,143 | 13,620 | | | |
| | 9 | 12,612 | 5,143 | 13,620 | 0,000 | 0,330 | |
| 6 | | 12,000 | 4,762 | 12,910 | | | |
| | 12 | 12,000 | 4,762 | 12,910 | 0,000 | 0,192 | |
| 7 | | -22,800 | -10,900 | 25,272 | | | |
| | 3 | 11,500 | -13,861 | 18,010 | 0,128 | -1,869 | |
| | 13 | -34,300 | 2,961 | 34,428 | 0,299 | -0,902 | |
| 8 | | -7,600 | -1,600 | 7,767 | | | |
| | 2 | -33,149 | 1,965 | 33,207 | 0,593 | -2,183 | |
| | 11 | -54,398 | 9,576 | 55,235 | 0,377 | 0,181 | |
| | 13 | 46,504 | -20,910 | 50,989 | 0,287 | 0,031 | |
| | 12 | 33,443 | 7,769 | 34,334 | 0,000 | 2,448 | 0,932 |
| 9 | | 0,000 | 0,000 | 0,000 | | | |
| | 13 | -17,416 | 5,556 | 18,281 | 0,000 | 0,606 | |
| | 5 | -12,612 | -4,813 | 13,499 | 0,000 | 0,330 | |
| | 10 | 30,028 | -0,744 | 30,038 | 0,000 | 0,865 | |
| 10 | | -5,800 | 3,000 | 6,530 | | | |
| | 13 | -12,516 | 0,688 | 12,535 | -0,000 | 0,759 | |
| | 9 | -30,028 | 1,608 | 30,071 | 0,000 | 0,865 | |
| | 20 | 8,748 | -2,363 | 9,061 | 0,067 | 0,149 | |
| | 17 | 4,873 | -1,727 | 5,170 | 0,008 | 0,020 | |
| | 21 | 15,642 | 3,590 | 16,049 | 0,078 | 0,168 | |
| | 22 | 7,482 | 1,204 | 7,578 | 0,036 | 0,075 | |
| 11 | | -2,400 | -1,200 | 2,683 | | | |
| | 1 | -57,176 | 8,196 | 57,760 | 1,416 | 1,354 | |
| | 8 | 54,776 | -9,396 | 55,576 | 0,377 | 0,181 | |
| 12 | | -11,200 | -2,500 | 11,476 | | | |
| | 8 | -33,443 | -5,321 | 33,864 | 0,000 | 2,448 | |
| | 6 | -12,000 | -4,569 | 12,840 | 0,000 | 0,192 | |
| | 14 | 7,824 | 1,094 | 7,900 | 0,064 | 0,133 | |
| | 15 | 18,704 | 1,777 | 18,788 | 0,195 | 0,384 | |
| | 16 | 7,715 | 4,519 | 8,941 | 0,063 | 0,132 | |
| 13 | | 0,000 | 0,000 | 0,000 | | | |

## Validasi Terbalik

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| 2 | | -43,177 | 7,955 | 43,904 | 1,059 | -0,853 | |
| | 8 | -46,217 | 20,941 | 50,740 | 0,287 | 0,031 | |
| | 7 | 34,599 | -3,863 | 34,814 | 0,299 | -0,902 | |
| | 4 | 9,657 | -6,218 | 11,485 | 0,014 | -0,921 | |
| | 9 | 17,416 | -4,951 | 18,106 | 0,000 | 0,606 | 0,978 |
| | 10 | 12,516 | 0,071 | 12,517 | -0,000 | 0,759 | 0,969 |
| | 28 | 15,206 | -13,937 | 20,627 | 0,044 | -13,867 | |
| 14 | | -6,200 | -1,600 | 6,403 | | | |
| | 12 | -7,760 | -0,961 | 7,819 | 0,064 | 0,133 | |
| | 15 | 1,560 | -0,639 | 1,686 | 0,005 | 0,005 | |
| 15 | | -8,200 | 2,500 | 8,573 | | | |
| | 12 | -18,509 | -1,393 | 18,562 | 0,195 | 0,384 | |
| | 14 | -1,555 | 0,644 | 1,683 | 0,005 | 0,005 | |
| | 18 | 6,282 | 2,639 | 6,813 | 0,042 | 0,087 | |
| | 23 | 5,583 | 0,610 | 5,616 | 0,027 | 0,054 | |
| 16 | | -3,500 | -1,800 | 3,936 | | | |
| | 12 | -7,652 | -4,387 | 8,820 | 0,063 | 0,132 | |
| | 17 | 4,152 | 2,587 | 4,891 | 0,017 | 0,039 | |
| 17 | | -9,000 | -0,800 | 9,035 | | | |
| | 16 | -4,135 | -2,547 | 4,856 | 0,017 | 0,039 | |
| | 10 | -4,865 | 1,747 | 5,169 | 0,008 | 0,020 | |
| 18 | | -3,200 | -0,900 | 3,324 | | | |
| | 15 | -6,239 | -2,552 | 6,741 | 0,042 | 0,087 | |
| | 19 | 3,039 | 1,652 | 3,459 | 0,007 | 0,013 | |
| 19 | | -9,500 | -3,400 | 10,090 | | | |
| | 18 | -3,033 | -1,639 | 3,447 | 0,007 | 0,013 | |
| | 20 | -6,467 | -1,761 | 6,703 | 0,013 | 0,027 | |
| 20 | | -2,200 | 4,300 | 4,830 | | | |
| | 19 | 6,481 | 1,788 | 6,723 | 0,013 | 0,027 | |
| | 10 | -8,681 | 2,512 | 9,037 | 0,067 | 0,149 | |
| 21 | | -17,500 | -6,200 | 18.566 | | | |
| | 10 | -15,564 | -3,422 | 15.936 | 0,078 | 0,168 | |
| | 22 | -1,936 | -2,778 | 3.386 | 0,001 | 0,002 | |
| 22 | | 0,000 | 0,000 | 0,000 | | | |

## Validasi Terbalik

| --Line-- from | to | Power at bus & line flow MW | Mvar | MVA | --Line loss-- MW | Mvar | Transformer tap |
|---|---|---|---|---|---|---|---|
| | 10 | -7,445 | -1,130 | 7,531 | 0,036 | 0,075 | |
| | 21 | 1,937 | 2,780 | 3,388 | 0,001 | 0,002 | |
| | 24 | 5,509 | -1,651 | 5,751 | 0,033 | 0,052 | |
| 23 | | -3,200 | 3,400 | 4,669 | | | |
| | 15 | -5,556 | -0,556 | 5,583 | 0,027 | 0,054 | |
| | 24 | 2,356 | 3,956 | 4,604 | 0,024 | 0,049 | |
| 24 | | -8,700 | -1,700 | 8,865 | | | |
| | 22 | -5,475 | 1,703 | 5,734 | 0,033 | 0,052 | |
| | 23 | -2,331 | -3,906 | 4,549 | 0,024 | 0,049 | |
| | 25 | -0,893 | 0,503 | 1,025 | 0,002 | 0,003 | |
| 25 | | 0,000 | 0,000 | 0,000 | | | |
| | 24 | 0,895 | -0,500 | 1,025 | 0,002 | 0,003 | |
| | 26 | 3,541 | 2,361 | 4,256 | 0,041 | 0,061 | |
| | 27 | -4,436 | -1,861 | 4,810 | 0,022 | 0,043 | |
| 26 | | -3,500 | -2,300 | 4,188 | | | |
| | 25 | -3,500 | -2,300 | 4,188 | 0,041 | 0,061 | |
| 27 | | 0,000 | 0,000 | 0,000 | | | |
| | 25 | 4,458 | 1,903 | 4,848 | 0,022 | 0,043 | |
| | 28 | -17,623 | -0,192 | 17,624 | 0,000 | 1,072 | |
| | 29 | 5,871 | -2,774 | 6,493 | 0,081 | 0,153 | |
| | 30 | 7,294 | 1,063 | 7,371 | 0,057 | 0,285 | |
| 28 | | 0,000 | 0,000 | 0,000 | | | |
| | 27 | 17,623 | 1,265 | 17,668 | 0,000 | 1,072 | 0,968 |
| | 4 | -2,460 | -1,335 | 2,799 | 0,004 | -4,609 | |
| | 13 | -15,163 | 0,070 | 15,163 | 0,044 | -13,867 | |
| 29 | | -2,400 | 4,100 | 4,751 | | | |
| | 27 | -5,790 | 2,927 | 6,488 | 0,081 | 0,153 | |
| | 30 | 3,390 | 1,173 | 3,587 | 0,027 | 0,051 | |
| 30 | | -10,600 | -1,900 | 10,769 | | | |
| | 27 | -7,237 | -0,778 | 7,278 | 0,057 | 0,285 | |
| | 29 | -3,363 | -1,122 | 3,546 | 0,027 | 0,051 | |
| **Total lossess** | | | | **9,506** | | | |

Elapsed time is 0,298 seconds.

# VALIDASI METODE ABC DENGAN VARIABEL KUADRATIK DAN INTEGRAL

## Persamaan Kuadrat: $\mathbf{f(x) = x^2 + 2.x - 5}$

Elapsed time is 0,278 seconds.
Number of evaluations: 100
Minimum Function of ABC with f(x)=x^2+2*x-*5*, for x=0: fmin=-5

Elapsed time is 0,480 seconds.
Number of evaluations: 100
Minimum Function of ABC with f(x)=x^2+2*x-*5*, for x=1: fmin=-2

Elapsed Elapsed time is 0,357 seconds.
Number of evaluations: 100
Minimum Function of ABC with f(x)=x^2+2*x-*5*, for x=2: fmin=3

Elapsed time is 0,558 seconds.
Number of evaluations: 100
Minimum Function of ABC with f(x)=x^2+2*x-*5*, for x=3: fmin=10

Elapsed time is 0,347 seconds.
Number of evaluations: 100
Minimum Function of ABC with f(x)=x^2+2*x-*5*, for x=4: fmin=19

Elapsed time is 0,329 seconds.
Number of evaluations: 100
Minimum Function of ABC with f(x)=x^2+2*x-*5*, for x=5: fmin=30

## VALIDASI METODE ABC DENGAN VARIABEL KUADRATIK DAN INTEGRAL

**Persamaan Integral:** $\int_a^b (x^2 + 2.x - 5)dx$

Elapsed time is 144,566 seconds.
Number of evaluations: 100
Integral Function of ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=1 to x=3: fmin=6,6667

Elapsed time is 176,603 seconds.
Number of evaluations: 100
Integral Function of ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=0 to x=5: fmin=41,6667

Elapsed time is 130,254 seconds.
Number of evaluations: 100
Integral Function of ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=2 to x=7: fmin=131,6667

Elapsed time is 138,297 seconds.
Number of evaluations: 100
Integral Function of ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=3 to x=9: fmin=276

## VALIDASI METODE FOA DENGAN VARIABEL KUADRATIK DAN INTEGRAL

**Persamaan Kuadrat: $\mathbf{f(x) = x^2 + 2.x - 5}$**

Elapsed time is 0,019 seconds.
Number of evaluations: 100
Minimum Function of FOA with f(x)=x^2+2*x-*5*, for x=0: fmin=-5
ans =
-5

Elapsed time is 0,016 seconds.
Number of evaluations: 100
Minimum Function of FOA with f(x)=x^2+2*x-*5*, for x=1: fmin=-2
ans =
-2

Elapsed time is 0,022 seconds.
Number of evaluations: 100
Minimum Function of FOA with f(x)=x^2+2*x-*5*, for x=2: fmin=3
ans =
3

Elapsed time is 0,019 seconds.
Number of evaluations: 100
Minimum Function of FOA with f(x)=x^2+2*x-*5*, for x=3: fmin=10
ans =
10

Elapsed time is 0,017 seconds.
Number of evaluations: 100
Minimum Function of FOA with f(x)=x^2+2*x-*5*, for x=4: fmin=19
ans =
19

Elapsed time is 0,029 seconds.
Number of evaluations: 100
Minimum Function of FOA with f(x)=x^2+2*x-*5*, for x=5: fmin=30
ans =
30

# VALIDASI METODE FOA DENGAN VARIABEL KUADRATIK DAN INTEGRAL

**Persamaan Integral:** $\int_a^b (x^2 + 2.x - 5)dx$

Elapsed time is 83,518 seconds.
Number of evaluations: 100
Integral Function of FOA with integral f(x) dx for f(x)=x^2+2*x-5, from x=1 to x=3: fmin=6,6667

ans =
6,6667

Elapsed time is 85,794 seconds.
Number of evaluations: 100
Integral Function of FOA with integral f(x) dx for f(x)=x^2+2*x-5, from x=0 to x=5: fmin=41,6667

ans =
41,6667

Elapsed time is 80,903 seconds.
Number of evaluations: 100
Integral Function of FOA with integral f(x) dx for f(x)=x^2+2*x-5, from x=2 to x=7: fmin=131,6667

ans =
131,6667

Elapsed time is 98,963 seconds.
Number of evaluations: 100
Integral Function of FOA with integral f(x) dx for f(x)=x^2+2*x-5, from x=3 to x=9: fmin=276

ans =
276

# VALIDASI METODE HYBRID FOA-ABC DENGAN VARIABEL KUADRATIK DAN INTEGRAL

## Persamaan Kuadrat: $\mathbf{f(x) = x^2 + 2.x - 5}$

Elapsed time is 0,130 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* FOA-*ABC* with f(x)=x^2+2*x-*5*, for x=0: fmin=-5
ans =
-5

Elapsed time is 0,149 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* FOA-*ABC* with f(x)=x^2+2*x-*5*, for x=1: fmin=-2
ans =
-2

Elapsed time is 0,298 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* FOA-*ABC* with f(x)=x^2+2*x-*5*, for x=2: fmin=3
ans =
3

Elapsed time is 0,229 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* FOA-*ABC* with f(x)=x^2+2*x-*5*, for x=3: fmin=10
ans =
10

Elapsed time is 0,219 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* FOA-*ABC* with f(x)=x^2+2*x-*5*, for x=4: fmin=19
ans =
19

Elapsed time is 0,214 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* FOA-*ABC* with f(x)=x^2+2*x-*5*, for x=5: fmin=30
ans =
30

## VALIDASI METODE HYBRID FOA-ABC DENGAN VARIABEL KUADRATIK DAN INTEGRAL

**Persamaan Integral:** $\int_a^b (x^2 + 2.x - 5)dx$

Elapsed time is 274,119 seconds.
Number of evaluations: 100
Integral Function of Hybrid FOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=1 to x=3: fmin=6,6667

ans =
6,6667

Elapsed time is 260,097 seconds.
Number of evaluations: 100
Integral Function of Hybrid FOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=0 to x=5: fmin=41,6667

ans =
41,6667

Elapsed time is 270,584 seconds.
Number of evaluations: 100
Integral Function of Hybrid FOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=2 to x=7: fmin=131,6667

ans =
131,6667

Elapsed time is 303,233 seconds.
Number of evaluations: 100
Integral Function of Hybrid FOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=3 to x=9: fmin=276

ans =
276

## VALIDASI METODE HYBRID MFOA-ABC DENGAN VARIABEL KUADRATIK DAN INTEGRAL

### Persamaan Kuadrat: $\mathbf{f(x) = x^2 + 2.x - 5}$

Elapsed time is 0,197 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* MFOA-*ABC* with f(x)=-5+x^2+2*x, for x=0: fmin=-5
ans =
-5

Elapsed time is 0,133 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* MFOA-*ABC* with f(x)=-5+x^2+2*x, for x=1: fmin=-2
ans =
-2

Elapsed time is 0,313 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* MFOA-*ABC* with f(x)=-5+x^2+2*x, for x=2: fmin=3
ans =
3

Elapsed time is 0,270 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* MFOA-*ABC* with f(x)=-5+x^2+2*x, for x=3: fmin=10
ans =
10

Elapsed time is 0,230 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* MFOA-*ABC* with f(x)=-5+x^2+2*x, for x=4: fmin=19
ans =
19

Elapsed time is 0,305 seconds.
Number of evaluations: 100
Minimum Function of *Hybrid* MFOA-*ABC* with f(x)=-5+x^2+2*x, for x=5: fmin=30
ans =
30

## VALIDASI METODE HYBRID MFOA-ABC DENGAN VARIABEL KUADRATIK DAN INTEGRAL

**Persamaan Integral:** $\int_a^b (x^2 + 2.x - 5)dx$

Elapsed time is 285,220 seconds.
Number of evaluations: 100
Integral Function of Hybrid MFOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=1 to x=3: fmin=6,6667

ans =
6,6667

Elapsed time is 307,786 seconds.
Number of evaluations: 100
Integral Function of Hybrid MFOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=0 to x=5: fmin=41,6667

ans =
41,6667

Elapsed time is 284,562 seconds.
Number of evaluations: 100
Integral Function of Hybrid *M*FOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=7 to x=7: fmin=131,6667

ans =
131,6667

Elapsed time is 261,027 seconds.
Number of evaluations: 100
Integral Function of Hybrid MFOA-ABC with integral f(x) dx for f(x)=x^2+2*x-5, from x=3 to x=9: fmin=276

ans =
276

## HASIL SIMULASI IEEE 14 BUS

### 1. Hasil simulasi IEEE 14 bus menggunakan metode FOA

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 7,10964e-06
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,060 | 0,000 | 0,000 | 0,000 | 156,645 | 10,661 | 0,000 |
| 2 | 1,045 | -2,369 | 21,700 | 12,700 | 64,920 | 15,144 | 0,000 |
| 3 | 1,030 | -6,507 | 94,200 | 19,100 | 43,757 | 28,075 | 0,000 |
| 4 | 1,019 | -6,093 | 47,80 | -3,900 | 0,000 | 0,000 | 0,000 |
| 5 | 1,020 | -5,190 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 6 | 1,049 | -9,529 | 11,200 | 7,500 | 0,000 | 0,000 | 0,000 |
| 7 | 1,038 | -8,611 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,038 | -8,611 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,036 | -9,942 | 29,500 | 16,600 | 0,000 | 0,000 | 19,000 |
| 10 | 1,033 | -10,104 | 9,000 | 5,800 | 0,000 | 0,000 | 0,000 |
| 11 | 1,038 | -9,923 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 12 | 1,037 | -10,228 | 6,100 | 1,600 | 0,000 | 0,000 | 0,000 |
| 13 | 1,033 | -10,285 | 13,800 | 5,800 | 0,000 | 0,000 | 0,000 |
| 14 | 1,020 | -10,913 | 14,900 | 5,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 259,300 | 73,600 | 265,321 | 53,880 | 19,000 |
| Total losses | | | 6,022 | -0,718 | | | |

B =

| | | |
|---|---|---|
| 0,0165 | 0,0076 | -0,0020 |
| 0,0076 | 0,0104 | -0,0015 |
| -0,0020 | -0,0015 | 0,0154 |

B0 =

1,0e-03 *

| | | |
|---|---|---|
| 0,3365 | 0,8452 | -0,8420 |

B00 =

9,5539e-04

Incremental cost of delivered power (system lambda) = 4,276577 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0335 pu
Daya Pembangkitan = 160,000 MW
Daya Pembangkitan = 70,512 MW
Daya Pembangkitan = 35,304 MW

## HASIL SIMULASI IEEE 14 BUS

Total Daya Pembangkitan = 265,816 MW

Biaya Pembangkitan = 625,000 $/hour
Biaya Pembangkitan = 316,458 $/hour
Biaya Pembangkitan = 184,162 $/hour

Total Biaya Pembangkitan = 1125,620 $/hour
Elapsed time is 40,941 seconds.

**2. <u>Hasil simulasi IEEE 14 bus menggunakan metode ABC</u>**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 1,7907e-05
No. of Iterations = 5

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,060 | 0,000 | 0,000 | 0,000 | 165,494 | -18,910 | 0,000 |
| 2 | 1,055 | -3,080 | 21,700 | 12,700 | 69,396 | 42,814 | 0,000 |
| 3 | 1,040 | -8,440 | 94,200 | 19,100 | 32,17 | 36,609 | 0,000 |
| 4 | 1,023 | -7,412 | 47,800 | -3,900 | 0,000 | 0,000 | 0,000 |
| 5 | 1,023 | -6,298 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 6 | 1,048 | -11,245 | 11,200 | 7,500 | 0,000 | 0,000 | 0,000 |
| 7 | 1,039 | -10,275 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,039 | -10,275 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,037 | -11,794 | 29,500 | 16,600 | 0,000 | 0,000 | 19,000 |
| 10 | 1,032 | -11,967 | 9,000 | 5,800 | 0,000 | 0,000 | 0,000 |
| 11 | 1,037 | -11,730 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 12 | 1,035 | -12,049 | 6,100 | 1,600 | 0,000 | 0,000 | 0,000 |
| 13 | 1,030 | -12,123 | 13,800 | 5,800 | 0,000 | 0,000 | 0,000 |
| 14 | 1,017 | -12,880 | 14,900 | 5,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 259,300 | 73,600 | 267,062 | 60,513 | 19,000 |
| Total loss | | | 7,765 | 5,917 | | | |

B =

| | | |
|---|---|---|
| 0,0190 | 0,0076 | -0,0009 |
| 0,0076 | 0,0152 | -0,0025 |
| -0,0009 | -0,0025 | 0,0281 |

B0 =

| | | |
|---|---|---|
| -0,0003 | 0,0021 | -0,0014 |

B00 =

9,0099e-04

## HASIL SIMULASI IEEE 14 BUS

Incremental cost of delivered power (system lambda) = 4,314748 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0549 pu
Daya Pembangkitan = 160,000 MW
Daya Pembangkitan = 71,024 MW
Daya Pembangkitan = 35,903 MW

Total Daya Pembangkitan = 266,927 MW

Biaya Pembangkitan = 625,000 $/hour
Biaya Pembangkitan = 318,615 $/hour
Biaya Pembangkitan = 186,708 $/hour

Total Biaya Pembangkitan = 1130,323 $/hour
Elapsed time is 51,273771 seconds.

**3. <u>Hasil simulasi IEEE 14 bus menggunakan metode Hybrid FOA-ABC</u>**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 2,15623e-06
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | Load MW | Load Mvar | Generation MW | Generation Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,060 | 0,000 | 0,000 | 0,000 | 158,589 | -7,713 | 0,000 |
| 2 | 1,055 | -1,251 | 21,700 | 12,700 | 70,806 | 13,878 | 0,000 |
| 3 | 1,050 | -3,570 | 94,200 | 19,100 | 33,174 | 34,094 | 0,000 |
| 4 | 1,044 | -3,167 | 47,800 | -3,900 | 0,000 | 0,000 | 0,000 |
| 5 | 1,043 | -2,690 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 6 | 1,090 | -4,845 | 11,200 | 7,500 | 0,000 | 0,000 | 0,000 |
| 7 | 1,072 | -4,321 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,072 | -4,321 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,074 | -4,924 | 29,500 | 16,600 | 0,000 | 0,000 | 19,000 |
| 10 | 1,074 | -5,015 | 9,000 | 5,800 | 0,000 | 0,000 | 0,000 |
| 11 | 1,081 | -4,975 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 12 | 1,084 | -5,169 | 6,100 | 1,600 | 0,000 | 0,000 | 0,000 |
| 13 | 1,081 | -5,178 | 13,800 | 5,800 | 0,000 | 0,000 | 0,000 |
| 14 | 1,070 | -5,415 | 14,900 | 5,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 259,300 | 73,600 | 262,569 | 40,260 | 19,000 |
| Total loss | | | 3,269 | -14,340 | | | |

## HASIL SIMULASI IEEE 14 BUS

```
B =
   0,0084    0,0037   -0,0008
   0,0037    0,0051   -0,0007
  -0,0008   -0,0007    0,0108

B0 =
  1,0e-03 *
   0,0085    0,3803   -0,4431

B00 =
   0,0015
```

Incremental cost of delivered power (system lambda) = 4,240162 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0141 pu
Daya Pembangkitan = 160,0000 MW
Daya Pembangkitan = 70,0466 MW
Daya Pembangkitan = 32,6415 MW

Total Daya Pembangkitan = 262,6880 MW

Biaya Pembangkitan = 625,0000 $/hour
Biaya Pembangkitan = 314,4960 $/hour
Biaya Pembangkitan = 172,9027 $/hour

Total Biaya Pembangkitan = 1112,3987 $/hour
Total Rugi Daya Aktif = 3,26892 MW
Total Rugi Daya Reaktif = -14,33958 Mvar
Elapsed time is 210,44 seconds.

**4. <u>Hasil simulasi IEEE 14 bus menggunakan metode Hybrid MFOA-ABC</u>**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 0,000712962
No. of Iterations = 9

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,060 | 0,000 | 0,000 | 0,000 | 152,533 | -132,342 | 0,000 |
| 2 | 1,065 | -0,406 | 21,700 | 12,700 | 64,450 | 169,194 | 0,000 |
| 3 | 1,060 | -0,845 | 94,200 | 19,100 | 43,729 | -4,922 | 0,000 |
| 4 | 1,061 | -0,828 | 47,800 | -3,900 | 0,000 | 0,000 | 0,000 |
| 5 | 1,059 | -0,702 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 6 | 1,117 | -1,334 | 11,200 | 7,500 | 0,000 | 0,000 | 0,000 |
| 7 | 1,094 | -1,048 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI IEEE 14 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 8 | 1,094 | -1,048 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,099 | -1,162 | 29,500 | 16,600 | 0,000 | 0,000 | 19,000 |
| 10 | 1,101 | -1,211 | 9,000 | 5,800 | 0,000 | 0,000 | 0,000 |
| 11 | 1,109 | -1,275 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 12 | 1,115 | -1,406 | 6,100 | 1,600 | 0,000 | 0,000 | 0,000 |
| 13 | 1,113 | -1,381 | 13,800 | 5,800 | 0,000 | 0,000 | 0,000 |
| 14 | 1,103 | -1,346 | 14,900 | 5,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 259,300 | 73,600 | 260,712 | 31,931 | 19,000 |

Total loss 1,496 -22,626

B =

| | | |
|---|---|---|
| 0,0037 | -0,0012 | -0,0003 |
| -0,0012 | 0,0095 | -0,0004 |
| -0,0003 | -0,0004 | 0,0013 |

B0 =

1,0e-03 *

| | | |
|---|---|---|
| -0,1800 | 0,8727 | 0,0376 |

B00 =

0,0056

Incremental cost of delivered power (system lambda) = 4,233858 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0747 pu
Daya Pembangkitan = 160,0000 MW
Daya Pembangkitan = 66,7524 MW
Daya Pembangkitan = 34,2104 MW

Total Daya Pembangkitan = 260,9629 MW

Biaya Pembangkitan = 625,0000 $/hour
Biaya Pembangkitan = 300,6804 $/hour
Biaya Pembangkitan = 179,5304 $/hour

Total Biaya Pembangkitan = 1105,2108 $/hour
Elapsed time is 260,66 seconds.

# LAMPIRAN H

## HASIL SIMULASI IEEE 26 BUS

### 1. Hasil simulasi IEEE 26 Bus tanpa integrasi pembangkit listrik tenaga angin menggunakan metode hybrid FOA-ABC

Number of evaluations: 200
Rugi Daya = 5,3915 MW

Daya Pembangkitan Thermal= 448,0574 MW
Daya Pembangkitan Thermal= 172,0851 MW
Daya Pembangkitan Thermal= 264,3444 MW
Daya Pembangkitan Thermal= 126,0654 MW
Daya Pembangkitan Thermal= 172,7174 MW
Daya Pembangkitan Thermal= 85,1218 MW
Total Daya Pembangkitan Thermal= 1268,3915 MW

Biaya Pembangkitan Thermal= 4521,2889 $/hour
Biaya Pembangkitan Thermal= 2082,2510 $/hour
Biaya Pembangkitan Thermal= 2927,2361 $/hour
Biaya Pembangkitan Thermal= 1635,5531 $/hour
Biaya Pembangkitan Thermal= 2148,4450 $/hour
Biaya Pembangkitan Thermal= 1196,8714 $/hour

Total Biaya Pembangkitan Thermal= 14511,6454 $/hour
Elapsed time is 185,09 seconds.

### 2. Hasil simulasi IEEE 26 Bus terintegrasi dengan pembangkit listrik tenaga angin menggunakan metode hybrid FOA-ABC

Number of evaluations: 200

Daya Pembangkitan Thermal= 428,7157 MW
Daya Pembangkitan Thermal= 157,8367 MW
Daya Pembangkitan Thermal= 249,3172 MW
Daya Pembangkitan Thermal= 111,0211 MW
Daya Pembangkitan Thermal= 155,8246 MW
Daya Pembangkitan Thermal= 67,0959 MW
Daya Pembangkitan Wind = 98,5700 MW

Total Daya Pembangkitan Thermal= 1169,8111 MW
Total Daya Pembangkitan (Thermal+wind)= 1268,3811 MW

Biaya Pembangkitan Thermal= 4281,0272 $/hour
Biaya Pembangkitan Thermal= 1905,3000 $/hour
Biaya Pembangkitan Thermal= 2740,7741 $/hour
Biaya Pembangkitan Thermal= 1448,7247 $/hour
Biaya Pembangkitan Thermal= 1938,7475 $/hour
Biaya Pembangkitan Thermal= 972,8816 $/hour
Biaya Pembangkitan Langsung (Cw) = 689,9900 $/hour
Biaya Pembangkitan Penalti (Cp) = 164,3255 $/hour

## HASIL SIMULASI IEEE 26 BUS

Biaya Pembangkitan Cadangan (Cr) = 215,0226 $/hour

Total Biaya Pembangkitan Thermal= 13287,4551 $/hour
Total Biaya Pembangkitan Wind= 1069,3382 $/hour
Total Biaya Pembangkitan (Thermal+Wind)= 14356,7932 $/hour
Rugi Daya = 5,3811 MW
Elapsed time is 2355,97 seconds.

### 3. Hasil simulasi IEEE 26 Bus tanpa integrasi pembangkit listrik tenaga angin menggunakan metode hybrid MFOA-ABC

Number of evaluations: 200
Rugi Daya = 4,8632 MW

Daya Pembangkitan Thermal= 447,9555 MW
Daya Pembangkitan Thermal= 172,0085 MW
Daya Pembangkitan Thermal= 264,2656 MW
Daya Pembangkitan Thermal= 125,9734 MW
Daya Pembangkitan Thermal= 172,6361 MW
Daya Pembangkitan Thermal= 85,0242 MW
Total Daya Pembangkitan Thermal= 1267,8632 MW

Biaya Pembangkitan Thermal= 4079,0451 $/hour
Biaya Pembangkitan Thermal= 1878,2424 $/hour
Biaya Pembangkitan Thermal= 2640,7683 $/hour
Biaya Pembangkitan Thermal= 1474,9500 $/hour
Biaya Pembangkitan Thermal= 1937,9264 $/hour
Biaya Pembangkitan Thermal= 1079,0006 $/hour

Total Biaya Pembangkitan Thermal= 13089,9328 $/hour
Elapsed time is 95,94 seconds.

### 4. Hasil simulasi IEEE 26 Bus terintegrasi dengan pembangkit listrik tenaga angin menggunakan metode hybrid MFOA-ABC

Number of evaluations: 200

Daya Pembangkitan Thermal= 428,6150 MW
Daya Pembangkitan Thermal= 157,7609 MW
Daya Pembangkitan Thermal= 249,2393 MW
Daya Pembangkitan Thermal= 110,9308 MW
Daya Pembangkitan Thermal= 155,7423 MW
Daya Pembangkitan Thermal= 66,9963 MW
Daya Pembangkitan Wind= 98,5700 MW

Total Daya Pembangkitan Thermal= 1169,2845 MW

# LAMPIRAN H

## HASIL SIMULASI IEEE 26 BUS

Total Daya Pembangkitan (Thermal+wind)= 1267,8545 MW

Biaya Pembangkitan Thermal= 3862,2594 $/hour
Biaya Pembangkitan Thermal= 1718,5821 $/hour
Biaya Pembangkitan Thermal= 2472,5256 $/hour
Biaya Pembangkitan Thermal= 1306,3877 $/hour
Biaya Pembangkitan Thermal= 1748,6941 $/hour
Biaya Pembangkitan Thermal= 876,8636 $/hour
Biaya Pembangkitan Langsung (Cw) = 689,9900 $/hour
Biaya Pembangkitan Penalti (Cp) = 164,3255 $/hour
Biaya Pembangkitan Cadangan (Cr) = 215,0226 $/hour

Total Biaya Pembangkitan Thermal= 11985,3124 $/hour
Total Biaya Pembangkitan Wind= 1069,3382 $/hour
Total Biaya Pembangkitan (Thermal+Wind)= 13054,6506 $/hour
Rugi Daya = 4,8545 MW
Elapsed time is 2734,54 seconds.

## HASIL SIMULASI IEEE 30 BUS

**1. Hasil simulasi IEEE 30 Bus dengan dua variabel objektif menggunakan metode FOA**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 6,62926e-07

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 174,108 | -10,578 | 0,000 |
| 2 | 1,038 | -2,848 | 21,700 | 12,700 | 48,840 | 22,944 | 0,000 |
| 3 | 1,011 | -8,111 | 94,200 | 19,000 | 21,510 | 20,523 | 0,000 |
| 4 | 1,019 | -6,407 | 30,000 | 30,000 | 22,150 | 21,378 | 0,000 |
| 5 | 1,091 | -6,778 | 0,000 | 0,000 | 12,140 | 16,319 | 0,000 |
| 6 | 1,091 | -7,996 | 0,000 | 0,000 | 12,000 | 5,624 | 0,000 |
| 7 | 1,011 | -7,427 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,023 | -5,362 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,067 | -7,763 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,066 | -9,084 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,029 | -4,470 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,086 | -8,640 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,022 | -6,244 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,076 | -9,363 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,074 | -9,530 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,073 | -9,056 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,066 | -9,276 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,065 | -9,956 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,062 | -10,066 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,064 | -9,911 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,060 | -9,504 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,060 | -9,498 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,068 | -9,937 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,057 | -9,962 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,053 | -9,754 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,039 | -10,063 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,057 | -9,434 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,021 | -6,648 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,053 | -10,659 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,040 | -11,160 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 290,748 | 76,210 | 45,000 |

Total loss 7,348

## HASIL SIMULASI IEEE 30 BUS

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0176 | 0,0081 | 0,0003 | -0,0009 | 0,0001 | 0,0024 |
| 0,0081 | 0,0132 | -0,0000 | -0,0015 | 0,0001 | 0,0021 |
| 0,0003 | -0,0000 | 0,0248 | -0,0119 | -0,0122 | -0,0064 |
| -0,0009 | -0,0015 | -0,0119 | 0,0219 | 0,0091 | 0,0036 |
| 0,0001 | 0,0001 | -0,0122 | 0,0091 | 0,0223 | -0,0000 |
| 0,0024 | 0,0021 | -0,0064 | 0,0036 | -0,0000 | 0,0222 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0003 | 0,0014 | -0,0020 | 0,0018 | -0,0010 | 0,0045 |

B00 =

0,0011

Daya Pembangkitan = 174,10818 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 290,74818 MW
Total Emission = 0,05959 ton/hour
Total ActivePowerLosses = 7,34828 MW
Elapsed time is 120,85 seconds.

**2. Hasil simulasi IEEE 30 Bus dengan dua variabel objektif menggunakan metode ABC**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 1,42109e-14
No. of Iterations = 1

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 176,515 | -43,501 | 0,000 |
| 2 | 1,048 | -3,839 | 21,700 | 12,700 | 48,840 | 15,384 | 0,000 |
| 3 | 1,051 | -10,775 | 94,200 | 19,000 | 21,510 | 51,424 | 0,000 |
| 4 | 1,049 | -8,575 | 30,000 | 30,000 | 22,150 | 47,301 | 0,000 |
| 5 | 1,091 | -8,839 | 0,000 | 0,000 | 12,140 | 6,452 | 0,000 |
| 6 | 1,111 | -10,303 | 0,000 | 0,000 | 12,000 | 6,543 | 0,000 |
| 7 | 1,039 | -9,769 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,039 | -7,068 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,079 | -10,068 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,080 | -11,681 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |

## HASIL SIMULASI IEEE 30 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 11 | 1,042 | -5,885 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,103 | -11,088 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,043 | -8,236 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,092 | -11,978 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,090 | -12,195 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,088 | -11,619 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,080 | -11,909 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,078 | -12,730 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,074 | -12,874 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,077 | -12,687 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,073 | -12,198 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,073 | -12,191 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,083 | -12,714 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,070 | -12,771 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,069 | -12,565 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,052 | -12,944 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,076 | -12,199 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,043 | -8,754 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,072 | -13,693 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,055 | -14,306 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 293,155 | 83,603 | 45,000 |

Total loss 9,755

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0235 | 0,0094 | 0,0043 | -0,0025 | 0,0004 | 0,0021 |
| 0,0094 | 0,0147 | 0,0024 | -0,0035 | 0,0003 | 0,0022 |
| 0,0043 | 0,0024 | 0,1032 | -0,0433 | -0,0091 | -0,0097 |
| -0,0025 | -0,0035 | -0,0433 | 0,0748 | 0,0096 | 0,0058 |
| 0,0004 | 0,0003 | -0,0091 | 0,0096 | 0,0128 | 0,0000 |
| 0,0021 | 0,0022 | -0,0097 | 0,0058 | 0,0000 | 0,0286 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0012 | 0,0013 | -0,0037 | 0,0037 | -0,0000 | 0,0055 |

B00 =

0,0010

Daya Pembangkitan = 176,51497 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW

## HASIL SIMULASI IEEE 30 BUS

Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 293,15497 MW
Total Emisi = 0,06372 ton/hour
Total Rugi Daya Aktif = 9,75497 MW
Elapsed time is 156,39 seconds.

**3. Hasil simulasi IEEE 30 Bus dengan dua variabel objektif menggunakan metode Hybrid FOA-ABC**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 0,000889086
No. of Iterations = 2

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 173,480 | -43,864 | 0,000 |
| 2 | 1,048 | -2,718 | 21,700 | 12,700 | 48,840 | 8,559 | 0,000 |
| 3 | 1,051 | -7,701 | 94,200 | 19,000 | 21,510 | 50,593 | 0,000 |
| 4 | 1,049 | -6,108 | 30,000 | 30,000 | 22,150 | 43,849 | 0,000 |
| 5 | 1,091 | -6,287 | 0,000 | 0,000 | 12,140 | 6,679 | 0,000 |
| 6 | 1,111 | -7,395 | 0,000 | 0,000 | 12,000 | 6,286 | 0,000 |
| 7 | 1,043 | -6,978 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,042 | -5,042 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,082 | -7,171 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,084 | -8,316 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,045 | -4,201 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,106 | -7,960 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,046 | -5,878 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,097 | -8,595 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,095 | -8,735 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,093 | -8,309 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,085 | -8,489 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,085 | -9,098 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,082 | -9,189 | 9,500 | 3,400 | 0,000 | 0,00 | 0,000 |
| 20 | 1,084 | -9,050 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,079 | -8,687 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,080 | -8,683 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,089 | -9,090 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,078 | -9,110 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,076 | -8,954 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,064 | -9,223 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,081 | -8,688 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,046 | -6,247 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

# LAMPIRAN I

## HASIL SIMULASI IEEE 30 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 29 | 1,078 | -9,754 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,066 | -10,188 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 290,120 | 72,102 | 45,000 |
| Total loss | | | 6,943 | -8,648 | | | |

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0170 | 0,0072 | 0,0029 | -0,0016 | 0,0004 | 0,0017 |
| 0,0072 | 0,0099 | 0,0019 | -0,0023 | 0,0001 | 0,0015 |
| 0,0029 | 0,0019 | 0,0721 | -0,0288 | -0,0069 | -0,0068 |
| -0,0016 | -0,0023 | -0,0288 | 0,0478 | 0,0068 | 0,0040 |
| 0,0004 | 0,0001 | -0,0069 | 0,0068 | 0,0094 | -0,0000 |
| 0,0017 | 0,0015 | -0,0068 | 0,0040 | -0,0000 | 0,0202 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0009 | 0,0005 | -0,0028 | 0,0027 | -0,0004 | 0,0046 |

B00 =

0,0011

Daya Pembangkitan = 173,47984 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 290,11984 MW
Total Emission = 0,05852 ton/hour
Total Rugi Daya Aktif = 6,94306 MW
Elapsed time is 272,06 seconds.

## HASIL SIMULASI IEEE 30 BUS

**4. Hasil simulasi IEEE 30 Bus dengan dua variabel objektif menggunakan metode Hybrid MFOA-ABC**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 0,000407725

No. of Iterations = 9

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 168,802 | -31,284 | 0,000 |
| 2 | 1,048 | -0,677 | 21,700 | 12,700 | 48,840 | -22,917 | 0,000 |
| 3 | 1,051 | -2,014 | 94,200 | 19,000 | 21,510 | 56,181 | 0,000 |
| 4 | 1,049 | -1,567 | 30,000 | 30,000 | 22,150 | 28,048 | 0,000 |
| 5 | 1,091 | -1,582 | 0,000 | 0,000 | 12,140 | 13,344 | 0,000 |
| 6 | 1,111 | -2,033 | 0,000 | 0,000 | 12,000 | 10,438 | 0,000 |
| 7 | 1,049 | -1,817 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,047 | -1,299 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,086 | -1,816 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,091 | -2,091 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,048 | -1,085 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,109 | -2,183 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,049 | -1,523 | 0,000 | 0,000 | 0,000 | 0.000 | 0,000 |
| 14 | 1,105 | -2,341 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,103 | -2,335 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,100 | -2,189 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,093 | -2,164 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,097 | -2,381 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,094 | -2,376 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,094 | -2,324 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,090 | -2,195 | 17,500 | 1,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,090 | -2,196 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,098 | -2,389 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,091 | -2,344 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,088 | -2,280 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,085 | -2,349 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,088 | -2,200 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,050 | -1,616 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,087 | -2,478 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,084 | -2,589 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 285,442 | 53,810 | 45,000 |
| Total loss | | | 2,090 | -27,364 | | | |

## HASIL SIMULASI IEEE 30 BUS

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0044 | 0,0022 | 0,0007 | -0,0003 | 0,0001 | 0,0005 |
| 0,0022 | 0,0031 | 0,0009 | -0,0004 | -0,0002 | 0,0001 |
| 0,0007 | 0,0009 | 0,0227 | -0,0053 | -0,0039 | -0,0030 |
| -0,0003 | -0,0004 | -0,0053 | 0,0067 | 0,0022 | 0,0012 |
| 0,0001 | -0,0002 | -0,0039 | 0,0022 | 0,0042 | -0,0000 |
| 0,0005 | 0,0001 | -0,0030 | 0,0012 | -0,0000 | 0,0074 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0002 | -0,0003 | -0,0008 | 0,0007 | -0,0019 | 0,0051 |

B00 =

0,0031

Daya Pembangkitan = 168,80196 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 285,44196 MW
Total Emisi = 0,05074 ton/hour
Total Rugi Daya Aktif = 2,09045 MW
Elapsed time is 419,54 seconds.

**5. Hasil simulasi IEEE 30 Bus dengan tiga *variabel* objektif menggunakan metode FOA**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 0,000422346
No. of Iterations = 2

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 175,073 | -14,513 | 0,000 |
| 2 | 1,038 | -3,291 | 21,700 | 12,700 | 48,840 | 23,975 | 0,000 |
| 3 | 1,011 | -9,354 | 94,200 | 19,000 | 21,510 | 24,459 | 0,000 |
| 4 | 1,019 | -7,394 | 30,000 | 30,000 | 22,150 | 25,471 | 0,000 |
| 5 | 1,091 | -7,804 | 0,000 | 0,000 | 12,140 | 15,038 | 0,000 |
| 6 | 1,091 | -9,163 | 0,000 | 0,000 | 12,000 | 5,770 | 0,000 |
| 7 | 1,010 | -8,550 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,022 | -6,170 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,066 | -8,927 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI IEEE 30 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load-------- MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 10 | 1,064 | -10,438 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,028 | -5,139 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,085 | -9,896 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,021 | -7,188 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,074 | -10,724 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,072 | -10,923 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,071 | -10,387 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,064 | -10,651 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,062 | -11,418 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,059 | -11,550 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,062 | -11,375 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,057 | -10,917 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,058 | -10,910 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,066 | -11,396 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,053 | -11,437 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,050 | -11,210 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,034 | -11,564 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,055 | -10,849 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,020 | -7,652 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,051 | -12,251 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,035 | -12,825 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 291,713 | 80,200 | 45,000 |
| Total loss | | | 8,423 | -0,775 | | | |

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0201 | 0,0090 | 0,0008 | -0,0013 | 0,0001 | 0,0026 |
| 0,0090 | 0,0153 | 0,0002 | -0,0019 | 0,0001 | 0,0025 |
| 0,0008 | 0,0002 | 0,0339 | -0,0162 | -0,0140 | -0,0075 |
| -0,0013 | -0,0019 | -0,0162 | 0,0300 | 0,0108 | 0,0043 |
| 0,0001 | 0,0001 | -0,0140 | 0,0108 | 0,0230 | -0,0000 |
| 0,0026 | 0,0025 | -0,0075 | 0,0043 | -0,0000 | 0,0255 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0004 | 0,0017 | -0,0024 | 0,0023 | -0,0006 | 0,0049 |

B00 =

0,0010

## HASIL SIMULASI IEEE 30 BUS

Daya Pembangkitan = 175,07258 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 291,71258 MW
Total Emisi = 0,06123 ton/hour
Total Rugi Daya Aktif = 8,42322 ton/hour
Total Rugi Daya Reaktif = -0,77531 ton/hour
Elapsed time is 142,20 seconds.

**6. Hasil simulasi IEEE 30 Bus dengan tiga variabel objektif menggunakan metode ABC**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 9,04824e-07
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 174,279 | -68,944 | 0,000 |
| 2 | 1,058 | -3,073 | 21,700 | 12,700 | 48,840 | 52,512 | 0,000 |
| 3 | 1,051 | -8,202 | 94,200 | 19,000 | 21,510 | 42,331 | 0,000 |
| 4 | 1,049 | -6,500 | 30,000 | 30,000 | 22,150 | 37,392 | 0,000 |
| 5 | 1,091. | -6,723 | 0,000 | 0,000 | 12,140 | 5,872 | 0,000 |
| 6 | 1,111 | -7,896 | 0,000 | 0,000 | 12,000 | 5,201 | 0,000 |
| 7 | 1,043 | -7,446 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,045 | -5,405 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,083 | -7,667 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,085 | -8,893 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,046 | -4,503 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,106 | -8,500 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,047 | -6,282 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,097 | -9.177 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,095 | -9,330 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,093 | -8,879 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,086 | -9,076 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,085 | -9,722 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,082 | -9,821 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,084 | -9,674 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,079 | -9,289 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,080 | -9,284 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,089 | -9,712 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |

# LAMPIRAN I

## HASIL SIMULASI IEEE 30 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 24 | 1,078 | -9,737 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,077 | -9,570 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,064 | -9,857 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,082 | -9,286 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,047 | -6,670 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,078 | -10,423 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,066 | -10,887 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
| Total | | | 283,400 | 126,200 | 290,919 | 74,363 | 45,000 |
| Total loss | | | 7,519 | -6,837 | | | |

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0198 | 0,0041 | 0,0031 | -0,0016 | 0,0003 | 0,0016 |
| 0,0041 | 0,0218 | -0,0001 | -0,0024 | 0,0009 | 0,0027 |
| 0,0031 | -0,0001 | 0,0575 | -0,0235 | -0,0064 | -0,0060 |
| -0,0016 | -0,0024 | -0,0235 | 0,0399 | 0,0063 | 0,0036 |
| 0,0003 | 0,0009 | -0,0064 | 0,0063 | 0,0095 | -0,0000 |
| 0,0016 | 0,0027 | -0,0060 | 0,0036 | -0,0000 | 0,0202 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0015 | 0,0031 | -0,0026 | 0,0025 | -0,0002 | 0,0041 |

B00 =

0,0011

Daya Pembangkitan = 174,27921 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 290,91921 MW
Total Emisi = 0,05988 ton/hour
Total Rugi Daya Aktif = 7,51936 MW
Total Rugi Daya Reaktif = -6,83691 Mvar
Elapsed time is 196,35 seconds.

## HASIL SIMULASI IEEE 30 BUS

### 7. Hasil simulasi IEEE 30 Bus dengan tiga variabel objektif menggunakan metode Hybrid FOA-ABC

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 2,28793e-06
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 173,670 | -43,861 | 0,000 |
| 2 | 1,048 | -2,705 | 21,700 | 12,700 | 48,840 | 8,589 | 0,000 |
| 3 | 1,051 | -7,664 | 94,200 | 19,000 | 21,510 | 50,639 | 0,000 |
| 4 | 1,049 | -6,079 | 30,000 | 30,000 | 22,150 | 43,980 | 0,000 |
| 5 | 1,091 | -6,256 | 0,000 | 0,000 | 12,140 | 6,725 | 0,000 |
| 6 | 1,111 | -7,360 | 0,000 | 0,000 | 12,000 | 6,349 | 0,000 |
| 7 | 1,043 | -6,944 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,042 | -5,018 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,082 | -7,136 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,084 | -8,275 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,045 | -4,181 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,106 | -7,923 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,046 | -5,849 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,097 | -8,554 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,095 | -8,693 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,093 | -8,270 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,085 | -8,448 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,085 | -9,054 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,082 | -9,145 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,084 | -9,006 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,079 | -8,645 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,080 | -8,641 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,089 | -9,046 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,078 | -9,066 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,076 | -8,911 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,065 | -9,178 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,081 | -8,646 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,046 | -6,217 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,078 | -9,707 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,066 | -10,138 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 290,310 | 72,421 | 45,000 |
| Total loss | | | 6,910 | -8,778 | | | |

## HASIL SIMULASI IEEE 30 BUS

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0169 | 0,0071 | 0,0029 | -0,0016 | 0,0003 | 0,0017 |
| 0,0071 | 0,0099 | 0,0019 | -0,0023 | 0,0001 | 0,0015 |
| 0,0029 | 0,0019 | 0,0719 | -0,0288 | -0,0069 | -0,0068 |
| -0,0016 | -0,0023 | -0,0288 | 0,0478 | 0,0068 | 0,0040 |
| 0,0003 | 0,0001 | -0,0069 | 0,0068 | 0,0094 | -0,0000 |
| 0,0017 | 0,0015 | -0,0068 | 0,0040 | -0,0000 | 0,0202 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0009 | 0,0005 | -0,0027 | 0,0027 | -0,0004 | 0,0046 |

B00 =

0,0011

Daya Pembangkitan = 173,66955 MW
Daya Pembangkitan = 48,84000 MW
Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 290,30955 MW
Total Emission = 0,05884 ton/hour
Total Rugi Daya Aktif = 6,90990 MW
Total Rugi Daya Reaktif = -8,77822 Mvar
Elapsed time is 369,55 seconds.

**8. Hasil simulasi IEEE 30 Bus dengan tiga variabel objektif menggunakan metode Hybrid MFOA-ABC**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 0,000668421
No. of Iterations = 8

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 168,290 | -17,055 | 0,000 |
| 2 | 1,048 | -0,390 | 21,700 | 12,700 | 48,840 | -45,778 | 0,000 |
| 3 | 1,051 | -1,206 | 94,200 | 19,000 | 21,510 | 63,552 | 0,000 |
| 4 | 1,049 | -0,924 | 30,000 | 30,000 | 22,150 | 16,288 | 0,000 |
| 5 | 1,091 | -0,915 | 0,000 | 0,000 | 12,140 | 20,088 | 0,000 |
| 6 | 1,111 | -1,272 | 0,000 | 0,000 | 12,000 | 15,215 | 0,000 |
| 7 | 1,050 | -1,083 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,047 | -0,767 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |

# LAMPIRAN I

## HASIL SIMULASI IEEE 30 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 9 | 1,087 | -1,054 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,092 | -1,206 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,048 | -0,641 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,109 | -1,361 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,050 | -0,905 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,106 | -1,451 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,104 | -1,425 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,101 | -1,318 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,094 | -1,264 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,099 | -1,426 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,096 | -1,406 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,095 | -1,367 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,091 | -1,271 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,091 | -1,273 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,099 | -1,436 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,093 | -1,382 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,089 | -1,331 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,088 | -1,372 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,088 | -1,277 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,050 | -0,958 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,088 | -1,443 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,086 | -1,510 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 284,930 | 52,310 | 45,000 |
| Total loss | | | 1,609 | -28,847 | | | |

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0026 | 0,0013 | 0,0004 | -0,0001 | 0,0000 | 0,0003 |
| 0,0013 | 0,0029 | 0,0008 | -0,0002 | -0,0002 | -0,0002 |
| 0,0004 | 0,0008 | 0,0169 | -0,0020 | -0,0038 | -0,0028 |
| -0,0001 | -0,0002 | -0,0020 | 0,0024 | 0,0012 | 0,0007 |
| 0,0000 | -0,0002 | -0,0038 | 0,0012 | 0,0043 | -0,0000 |
| 0,0003 | -0,0002 | -0,0028 | 0,0007 | -0,0000 | 0,0066 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0001 | -0,0003 | -0,0004 | 0,0003 | -0,0031 | 0,0071 |

B00 =

0,0051

Daya Pembangkitan = 168,28971 MW
Daya Pembangkitan = 48,84000 MW

## HASIL SIMULASI IEEE 30 BUS

Daya Pembangkitan = 21,51000 MW
Daya Pembangkitan = 22,15000 MW
Daya Pembangkitan = 12,14000 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 284,92971 MW
Total Emission = 0,04990 ton/hour
Total Rugi Daya Aktif = 1,60887 MW
Total Rugi Daya Reaktif = -28,84748 Mvar
Elapsed time is 392,19 seconds.

**9. Hasil simulasi IEEE 30 Bus dengan lima *variabel* objektif menggunakan metode FOA**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 6,62984e-07
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 174,342 | -10,659 | 0,000 |
| 2 | 1,038 | -2,855 | 21,700 | 12,700 | 48,636 | 23,029 | 0,000 |
| 3 | 1,011 | -8,141 | 94,200 | 19,000 | 20,917 | 20,727 | 0,000 |
| 4 | 1,019 | -6,400 | 30,000 | 30,000 | 22,339 | 21,236 | 0,000 |
| 5 | 1,091 | -6,723 | 0,000 | 0,000 | 12,532 | 16,311 | 0,000 |
| 6 | 1,091 | -7,987 | 0,000 | 0,000 | 12,000 | 5,621 | 0,000 |
| 7 | 1,011 | -7,438 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,023 | -5,361 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,067 | -7,740 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,066 | -9,067 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,029 | -4,468 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,086 | -8,631 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,022 | -6,241 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,076 | -9,353 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,074 | -9,520 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,073 | -9,044 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,066 | -9,261 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,065 | -9,943 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,062 | -10,052 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,064 | -9,897 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,060 | -9,488 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,060 | -9,482 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,068 | -9,926 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,057 | -9,949 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,053 | -9,745 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI IEEE 30 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 26 | 1,039 | -10,054 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,057 | -9,426 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,021 | -6,644 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,053 | -10,652 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,040 | -11,153 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 290,766 | 76,266 | 45,000 |
| Total loss | | | 7,366 | -4,934 | | | |

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0176 | 0,0081 | 0,0003 | -0,0009 | 0,0001 | 0,0024 |
| 0,0081 | 0,0132 | -0,0000 | -0,0014 | 0,0001 | 0,0022 |
| 0,0003 | -0,0000 | 0,0257 | -0,0119 | -0,0121 | -0,0064 |
| -0,0009 | -0,0014 | -0,0119 | 0,0216 | 0,0089 | 0,0036 |
| 0,0001 | 0,0001 | -0,0121 | 0,0089 | 0,0214 | -0,0000 |
| 0,0024 | 0,0022 | -0,0064 | 0,0036 | -0,0000 | 0,0222 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0003 | 0,0014 | -0,0020 | 0,0018 | -0,0009 | 0,0045 |

B00 =

0,0011

Incremental cost of delivered power (system lambda) = 3,592247 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0426 pu
Daya Pembangkitan = 178,60486 MW
Daya Pembangkitan = 48,27247 MW
Daya Pembangkitan = 20,67506 MW
Daya Pembangkitan = 19,90309 MW
Daya Pembangkitan = 11,62614 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 291,08162 MW

Biaya Pembangkitan = 476,83357 $/hour
Biaya Pembangkitan = 125,25585 $/hour
Biaya Pembangkitan = 47,39118 $/hour
Biaya Pembangkitan = 67,98879 $/hour
Biaya Pembangkitan = 38,25761 $/hour
Biaya Pembangkitan = 39,60000 $/hour

Total Biaya Pembangkitan = 795,32702 $/hour

## HASIL SIMULASI IEEE 30 BUS

Total Emission = 0,06835 ton/hour
Total F = 0,21125
Elapsed time is 368,57 seconds.

**10. Hasil simulasi IEEE 30 Bus dengan lima variabel objektif menggunakan metode ABC**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 1,07611e-06

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 173,791 | -43,837 | 0,000 |
| 2 | 1,048 | -2,881 | 21,700 | 12,700 | 49,484 | 9,632 | 0,000 |
| 3 | 1,051 | -8,213 | 94,200 | 19,000 | 20,104 | 51,213 | 0,000 |
| 4 | 1,049 | -6,454 | 30,000 | 30,000 | 22,629 | 44,291 | 0,000 |
| 5 | 1,091 | -6,574 | 0,000 | 0,000 | 12,776 | 6,628 | 0,000 |
| 6 | 1,111 | -7,807 | 0,000 | 0,000 | 12,000 | 6,347 | 0,000 |
| 7 | 1,042 | -7,409 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,042 | -5,333 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,082 | -7,559 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,084 | -8,784 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,044 | -4,443 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,105 | -8,405 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,046 | -6,216 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,096 | -9,077 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,094 | -9,227 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,092 | -8,777 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,085 | -8,968 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,084 | -9,613 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,081 | -9,710 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,083 | -9,562 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,078 | -9,179 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,079 | -9,174 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,088 | -9,605 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,077 | -9,629 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,075 | -9,469 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,063 | -9,755 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,081 | -9,192 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,046 | -6,606 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,077 | -10,321 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,064 | -10,782 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI IEEE 30 BUS

| | | | | | |
|---|---|---|---|---|---|
| Total | 283,400 | 126,200 | 290,783 | 74,273 | 45,000 |
| Total loss | 7,383 | -6,927 | | | |

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0180 | 0,0075 | 0,0035 | -0,0017 | 0,0004 | 0,0017 |
| 0,0075 | 0,0106 | 0,0021 | -0,0024 | 0,0002 | 0,0016 |
| 0,0035 | 0,0021 | 0,0875 | -0,0318 | -0,0070 | -0,0074 |
| -0,0017 | -0,0024 | -0,0318 | 0,0496 | 0,0069 | 0,0042 |
| 0,0004 | 0,0002 | -0,0070 | 0,0069 | 0,0097 | 0,0000 |
| 0,0017 | 0,0016 | -0,0074 | 0,0042 | 0,0000 | 0,0215 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0009 | 0,0006 | -0,0031 | 0,0028 | -0,0003 | 0,0047 |

B00 =

0,0011

Incremental cost of delivered power (system lambda) = 3,597275 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0491 pu
Daya Pembangkitan = 178,69941 MW
Daya Pembangkitan = 48,89622 MW
Daya Pembangkitan = 19,86502 MW
Daya Pembangkitan = 20,12247 MW
Daya Pembangkitan = 11,69186 MW
Daya Pembangkitan = 12,00000 MW

Total Daya Pembangkitan = 291,27497 MW

Biaya Pembangkitan = 477,14937 $/hour
Biaya Pembangkitan = 127,40807 $/hour
Biaya Pembangkitan = 44,52871 $/hour
Biaya Pembangkitan = 68,77499 $/hour
Biaya Pembangkitan = 38,49306 $/hour
Biaya Pembangkitan = 39,60000 $/hour

Total Biaya Pembangkitan = 795,95420 $/hour

Total Emission = 0,06867 ton/hour
Total Rugi Daya Aktif = 7,38326 MW
Total Rugi Daya Reaktif = -6,92693 Mvar
Total F = 0,21125
Elapsed time is 254,38 seconds.

## HASIL SIMULASI IEEE 30 BUS

**11. Hasil simulasi IEEE 30 Bus dengan lima variabel objektif menggunakan metode hybrid FOA-ABC dengan batas-batas daya generator sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 2,41871e-06

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 173,218 | -40,191 | 0,000 |
| 2 | 1,048 | -2,694 | 21,700 | 12,700 | 49,188 | 26,479 | 0,000 |
| 3 | 1,041 | -7,576 | 94,200 | 19,000 | 20,299 | 41,776 | 0,000 |
| 4 | 1,039 | -5,898 | 30,000 | 30,000 | 22,822 | 33,592 | 0,000 |
| 5 | 1,081 | -6,074 | 0,000 | 0,000 | 12,612 | 5,734 | 0,000 |
| 6 | 1,101 | -7,253 | 0,000 | 0,000 | 12,000 | 4,764 | 0,000 |
| 7 | 1,034 | -6,835 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,037 | -4,910 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,073 | -7,000 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,076 | -8,163 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,040 | -4,092 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,097 | -7,823 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,038 | -5,716 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,088 | -8,460 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,086 | -8,599 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,084 | -8,167 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,077 | -8,340 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,077 | -8,960 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,073 | -9,049 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,075 | -8,907 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,071 | -8,537 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,071 | -8,533 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,081 | -8,952 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,070 | -8,967 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,068 | -8,808 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,056 | -9,078 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,073 | -8,539 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,038 | -6,078 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,070 | -9,612 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,058 | -10,049 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 290,138 | 72,153 | 45,000 |
| Total loss | | | 6,739 | -9,046 | | | |

# LAMPIRAN I

## HASIL SIMULASI IEEE 30 BUS

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0167 | 0,0064 | 0,0024 | -0,0013 | 0,0005 | 0,0019 |
| 0,0064 | 0,0123 | 0,0009 | -0,0019 | 0,0005 | 0,0019 |
| 0,0024 | 0,0009 | 0,0583 | -0,0201 | -0,0057 | -0,0053 |
| -0,0013 | -0,0019 | -0,0201 | 0,0311 | 0,0055 | 0,0031 |
| 0,0005 | 0,0005 | -0,0057 | 0,0055 | 0,0088 | -0,0000 |
| 0,0019 | 0,0019 | -0,0053 | 0,0031 | -0,0000 | 0,0186 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0008 | 0,0014 | -0,0025 | 0,0021 | -0,0003 | 0,0037 |

B00 =

0,0011

Incremental cost of delivered power (system lambda) = 3,579589 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0597 pu
Daya Pembangkitan = 179,1844 MW
Daya Pembangkitan = 48,5765 MW
Daya Pembangkitan = 20,0321 MW
Daya Pembangkitan = 19,5279 MW
Daya Pembangkitan = 11,3307 MW
Daya Pembangkitan = 12,0000 MW

Total Daya Pembangkitan = 290,6517 MW

Biaya Pembangkitan = 478,7703 $/hour
Biaya Pembangkitan = 126,3031 $/hour
Biaya Pembangkitan = 45,1126 $/hour
Biaya Pembangkitan = 66,6460 $/hour
Biaya Pembangkitan = 37,2019 $/hour
Biaya Pembangkitan = 39,6000 $/hour

Total Biaya Pembangkitan = 793,6340 $/hour
Total Rugi Daya Aktif = 6,739 MW
Total Rugi Daya Reaktif = -9,046 Mvar
Total Emission = 0,06977 ton/hour
Total F = 0,21125
Elapsed time is 389,22 seconds.

## HASIL SIMULASI IEEE 30 BUS

**12. Hasil simulasi IEEE 30 Bus dengan lima variabel objektif menggunakan metode hybrid FOA-ABC dengan batas-batas daya generator dan generator ramp rate sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 2,77924e-06

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0 ,000 | 170,805 | -72,959 | 0,000 |
| 2 | 1,058 | -2,752 | 21,700 | 12,700 | 49,313 | 39,757 | 0,000 |
| 3 | 1,061 | -7,554 | 94,200 | 19,000 | 19,183 | 53,277 | 0,000 |
| 4 | 1,059 | -5,880 | 30,000 | 30,000 | 24,000 | 53,654 | 0,000 |
| 5 | 1,081 | -5,897 | 0,000 | 0,000 | 13,000 | -0,340 | 0,000 |
| 6 | 1,101 | -6,851 | 0,000 | 0,000 | 14,000 | -1,832 | 0,000 |
| 7 | 1,052 | -6,765 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,049 | -4,830 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,082 | -6,823 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,085 | -7,929 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,050 | -4,024 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,103 | -7,498 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,054 | -5,648 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,095 | -8,123 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,093 | -8,275 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,092 | -7,874 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,085 | -8,082 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,085 | -8,648 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,082 | -8,749 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,084 | -8,621 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,080 | -8,287 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,081 | -8,283 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,089 | -8,645 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,079 | -8,697 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,080 | -8,594 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,069 | -8,852 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,087 | -8,364 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,054 | -6,001 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,084 | -9,386 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,072 | -9,802 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 290,301 | 71,557 | 45,000 |
| Total loss | | | | 6,902 - 9,642 | | | |

# LAMPIRAN I

## HASIL SIMULASI IEEE 30 BUS

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0183 | 0,0045 | 0,0042 | -0,0018 | 0,0007 | 0,0024 |
| 0,0045 | 0,0151 | 0,0009 | -0,0027 | 0,0007 | 0,0018 |
| 0,0042 | 0,0009 | 0,0918 | -0,0347 | 0,0008 | 0,0016 |
| -0,0018 | -0,0027 | -0,0347 | 0,0553 | 0,0026 | 0,0006 |
| 0,0007 | 0,0007 | 0,0008 | 0,0026 | 0,0071 | -0,0000 |
| 0,0024 | 0,0018 | 0,0016 | 0,0006 | -0,0000 | 0,0159 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0014 | 0,0021 | -0,0029 | 0,0028 | 0,0002 | 0,0001 |

B00 =

0,0011

Incremental cost of delivered power (system lambda) = 3,530687 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,0214 pu
Daya Pembangkitan = 172,9497 MW
Daya Pembangkitan = 47,6590 MW
Daya Pembangkitan = 19,0000 MW
Daya Pembangkitan = 24,0000 MW
Daya Pembangkitan = 13,0000 MW
Daya Pembangkitan = 14,0000 MW

Total Daya Pembangkitan = 290,6087 MW

Biaya Pembangkitan = 458,0678 $/hour
Biaya Pembangkitan = 123,1526 $/hour
Biaya Pembangkitan = 41,5625 $/hour
Biaya Pembangkitan = 82,8038 $/hour
Biaya Pembangkitan = 43,2250 $/hour
Biaya Pembangkitan = 46,9000 $/hour

Total Biaya Pembangkitan = 795,3117 $/hour

Total Rugi Daya Aktif = 6,90177 MW
Total Rugi Daya Reaktif = -9,64174 Mvar
Total Emission = 0,05696 ton/hour
Total F = 0,21125
Elapsed time is 442,16 seconds.

## HASIL SIMULASI IEEE 30 BUS

**13. Hasil simulasi IEEE 30 Bus dengan lima variabel objektif menggunakan metode hybrid MFOA-ABC**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 0,000705997

No. of Iterations = 5

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 167,437 | -27,107 | 0,000 |
| 2 | 1,048 | -0,653 | 21,700 | 12,700 | 49,588 | -16,911 | 0,000 |
| 3 | 1,051 | -1,970 | 94,200 | 19,000 | 19,727 | 59,849 | 0,000 |
| 4 | 1,049 | -1,504 | 30,000 | 30,000 | 23,840 | 42,759 | 0,000 |
| 5 | 1,081 | -1,490 | 0,000 | 0,000 | 12,693 | -0,018 | 0,000 |
| 6 | 1,101 | -1,930 | 0,000 | 0,000 | 12,000 | -5,055 | 0,000 |
| 7 | 1,048 | -1,753 | 22,800 | 10,900 | 0,000 | 0,000 | 0,000 |
| 8 | 1,046 | -1,229 | 7,600 | 1,600 | 0,000 | 0,000 | 0,000 |
| 9 | 1,081 | -1,730 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 10 | 1,086 | -2,002 | 5,800 | 2,000 | 0,000 | 0,000 | 5,000 |
| 11 | 1,047 | -1,027 | 2,400 | 1,200 | 0,000 | 0,000 | 0,000 |
| 12 | 1,102 | -2,078 | 11,200 | 7,500 | 0,000 | 0,000 | 5,000 |
| 13 | 1,048 | -1,452 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,099 | -2,233 | 6,200 | 1,600 | 0,000 | 0,000 | 0,000 |
| 15 | 1,097 | -2,232 | 8,200 | 2,500 | 0,000 | 0,000 | 5,000 |
| 16 | 1,095 | -2,090 | 3,500 | 1,800 | 0,000 | 0,000 | 0,000 |
| 17 | 1,088 | -2,071 | 9,000 | 5,800 | 0,000 | 0,000 | 5,000 |
| 18 | 1,092 | -2,281 | 3,200 | 0,900 | 0,000 | 0,000 | 0,000 |
| 19 | 1,089 | -2,277 | 9,500 | 3,400 | 0,000 | 0,000 | 0,000 |
| 20 | 1,089 | -2,227 | 2,200 | 0,700 | 0,000 | 0,000 | 5,000 |
| 21 | 1,085 | -2,104 | 17,500 | 11,200 | 0,000 | 0,000 | 5,000 |
| 22 | 1,085 | -2,105 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,093 | -2,291 | 3,200 | 1,600 | 0,000 | 0,000 | 5,000 |
| 24 | 1,087 | -2,253 | 8,700 | 6,700 | 0,000 | 0,000 | 5,000 |
| 25 | 1,085 | -2,205 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 26 | 1,082 | -2,272 | 3,500 | 2,300 | 0,000 | 0,000 | 0,000 |
| 27 | 1,085 | -2,134 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,049 | -1,544 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,085 | -2,405 | 2,400 | 0,900 | 0,000 | 0,000 | 5,000 |
| 30 | 1,081 | -2,514 | 10,600 | 1,900 | 0,000 | 0,000 | 0,000 |
| Total | | | 283,400 | 126,200 | 285,286 | 53,517 | 45,000 |
| Total loss | | | 1,995 | -27,594 | | | |

# LAMPIRAN I

## HASIL SIMULASI IEEE 30 BUS

B =

| | | | | | |
|---|---|---|---|---|---|
| 0,0042 | 0,0021 | 0,0008 | -0,0004 | 0,0002 | 0,0007 |
| 0,0021 | 0,0028 | 0,0010 | -0,0005 | 0,0000 | 0,0005 |
| 0,0008 | 0,0010 | 0,0288 | -0,0081 | 0,0002 | 0,0016 |
| -0,0004 | -0,0005 | -0,0081 | 0,0105 | 0,0008 | -0,0001 |
| 0,0002 | 0,0000 | 0,0002 | 0,0008 | 0,0019 | -0,0000 |
| 0,0007 | 0,0005 | 0,0016 | -0,0001 | -0,0000 | 0,0049 |

B0 =

| | | | | | |
|---|---|---|---|---|---|
| -0,0001 | -0,0002 | -0,0008 | 0,0009 | 0,0000 | -0,0022 |

B00 =

0,0032

Incremental cost of delivered power (system lambda) = 3,447621 $/MWh
Absolute value of the slack bus real power mismatch, dpslack = 0,1743 pu
Daya Pembangkitan = 184,8716 MW
Daya Pembangkitan = 47,4842 MW
Daya Pembangkitan = 19,2406 MW
Daya Pembangkitan = 12,1349 MW
Daya Pembangkitan = 10,0000 MW
Daya Pembangkitan = 12,0000 MW

Total Daya Pembangkitan = 285,7313 MW

Biaya Pembangkitan = 497,9089 $/hour
Biaya Pembangkitan = 122,5553 $/hour
Biaya Pembangkitan = 42,3782 $/hour
Biaya Pembangkitan = 40,6665 $/hour
Biaya Pembangkitan = 32,5000 $/hour
Biaya Pembangkitan = 39,6000 $/hour

Total Biaya Pembangkitan = 775,6090 $/hour
Total Emission = 0,08275 ton/hour
Total F = 0,21125
Elapsed time is 712,83 seconds.

## HASIL SIMULASI INDIAN UTILITY 62 BUS

**1. Hasil simulasi IEEE 62 Bus Indian Utility menggunakan metode FOA**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 0,000741069

No. of Iterations = 2

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 253,693 | -23,332 | 0,000 |
| 2 | 1,060 | 0,442 | 0,000 | 0,000 | 190,581 | 24,890 | 0,000 |
| 3 | 1,061 | -0,404 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 4 | 1,065 | -1,146 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 5 | 1,070 | 0,765 | 0,000 | 0,000 | 255,687 | 92,424 | 0,000 |
| 6 | 1,060 | 0,402 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 7 | 1,060 | 0,379 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,059 | 0,357 | 109,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,050 | 0,073 | 66,000 | 23,000 | 78,202 | 19,433 | 0,000 |
| 10 | 1,012 | -5,063 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 11 | 1,001 | -6,621 | 161,000 | 93,000 | 0,000 | 0,000 | 0,000 |
| 12 | 1,016 | -7,892 | 155,000 | 79,000 | 0,000 | 0,000 | 0,000 |
| 13 | 1,044 | -5,995 | 132,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,050 | -2,356 | 0,000 | 0,000 | 171,083 | 104,083 | 0,000 |
| 15 | 1,071 | -2,488 | 155,000 | 63,000 | 0,000 | 0,000 | 0,000 |
| 16 | 1,040 | -3,267 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 17 | 1,050 | -3,239 | 0,000 | 0,000 | 190,612 | 19,732 | 0,000 |
| 18 | 1,033 | -2,752 | 121,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 19 | 1,060 | -4,360 | 130,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 20 | 0,999 | -12,191 | 80,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 21 | 1,049 | -8,424 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 22 | 1,042 | -12,159 | 64,000 | 50,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,050 | -12,657 | 0,000 | 0,000 | 151,842 | 142,903 | 0,000 |
| 24 | 1,036 | -13,923 | 58,000 | 34,000 | 0,000 | 0,000 | 0,000 |
| 25 | 1,050 | -12,708 | 0,000 | 0,000 | 250,249 | 89,626 | 0,000 |
| 26 | 1,017 | -15,337 | 116,000 | 52,000 | 0,000 | 0,000 | 0,000 |
| 27 | 1,023 | -16,041 | 85,000 | 35,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,042 | -14,436 | 63,000 | 8,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,022 | -16,457 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 30 | 1,008 | -17,947 | 77,000 | 41,000 | 0,000 | 0,000 | 0,000 |
| 31 | 1,016 | -17,806 | 51,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 32 | 1,050 | -15,276 | 0,000 | 0,000 | 106,624 | 131,459 | 0,000 |
| 33 | 1,050 | -14,899 | 46,000 | 25,000 | 62,380 | 16,365 | 0,000 |
| 34 | 1,040 | -15,152 | 100,000 | 70,000 | 134,508 | 18,444 | 0,000 |
| 35 | 1,049 | -15,358 | 107,000 | 33,000 | 0,000 | 0,000 | 0,000 |
| 36 | 1,049 | -15,214 | 20,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 37 | 1,040 | -14,319 | 0,000 | 0,000 | 78,533 | -7,674 | 0,000 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 38 | 1,028 | -17,000 | 166,000 | 22,000 | 0,000 | 0,000 | 0,000 |
| 39 | 1,033 | -14,849 | 30,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 40 | 1,010 | -17,146 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 41 | 1,014 | -16,047 | 92,000 | 91,000 | 0,000 | 0,000 | 0,000 |
| 42 | 1,016 | -15,930 | 30,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 43 | 1,013 | -16,549 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 44 | 1,028 | -14,012 | 109,000 | 17,000 | 0,000 | 0,000 | 0,000 |
| 45 | 1,019 | -15,729 | 20,000 | 4,000 | 0,000 | 0,000 | 0,000 |
| 46 | 1,039 | -13,841 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 47 | 1,022 | -8,744 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 48 | 1,044 | -0,197 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 49 | 1,060 | 1,228 | 0,000 | 0,000 | 213,957 | -62,352 | 0,000 |
| 50 | 1,080 | 0,070 | 0,000 | 0,000 | 92,784 | -42,568 | 0,000 |
| 51 | 1,050 | -4,067 | 0,000 | 0,000 | 82,957 | 53,055 | 0,000 |
| 52 | 1,040 | -7,828 | 0,000 | 0,000 | 24,608 | 19,364 | 0,000 |
| 53 | 1,010 | -9,604 | 248,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 54 | 1,050 | -2,556 | 0,000 | 0,000 | 72,633 | -8,764 | 0,000 |
| 55 | 1,049 | -5,499 | 94,000 | 29,000 | 0,000 | 0,000 | 0,000 |
| 56 | 1,060 | -4,193 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 57 | 1,060 | -3,926 | 0,000 | 0,000 | 219,441 | -44,484 | 0,000 |
| 58 | 1,060 | -4,643 | 0,000 | 0,000 | 339,708 | 135,195 | 0,000 |
| 59 | 1,039 | -10,395 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 60 | 1,052 | -6,112 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 61 | 1,052 | -6,665 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 62 | 1,040 | -11,492 | 93,000 | 23,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 2908,000 | 1270,000 | 2970,082 | 677,797 | 0,000 |
| Total loss | | | 62,288 | -593,689 | | | |

B =

Columns 1 through 12

0,0109 0,0104 0,0099 0,0106 0,0082 0,0061 -0,0027 -0,0031 -0,0047 -0,0066 -0,0067 -0,0061

0,0104 0,0117 0,0112 0,0108 0,0094 0,0063 -0,0034 -0,0034 -0,0067 -0,0072 -0,0072 -0,0061

0,0099 0,0112 0,0142 0,0111 0,0108 0,0066 -0,0041 -0,0037 -0,0088 -0,0079 -0,0076 -0,0062

0,0106 0,0108 0,0111 0,0136 0,0101 0,0065 -0,0038 -0,0035 -0,0080 -0,0076 -0,0075 -0,0062

0,0082 0,0094 0,0108 0,0101 0,0128 0,0070 -0,0046 -0,0037 -0,0111 -0,0083 -0,0078 -0,0058

# HASIL SIMULASI INDIAN UTILITY 62 BUS

B =

Columns 1 through 12

0,0061 0,0063 0,0066 0,0065 0,0070 0,0087 -0,0021 -0,0020 -0,0055 -0,0057 -0,0056 -0,0045

-0,0027 -0,0034 -0,0041 -0,0038 -0,0046 -0,0021 0,0091 0,0060 0,0013 0,0007 0,0007 0,0011

-0,0031 -0,0034 -0,0037 -0,0035 -0,0037 -0,0020 0,0060 0,0058 0,0008 0,0005 0,0005 0,0011

-0,0047 -0,0067 -0,0088 -0,0080 -0,0111 -0,0055 0,0013 0,0008 0,0290 0,0152 0,0136 0,0057

-0,0066 -0,0072 -0,0079 -0,0076 -0,0083 -0,0057 0,0007 0,0005 0,0152 0,0208 0,0131 0,0065

-0,0067 -0,0072 -0,0076 -0,0075 -0,0078 -0,0056 0,0007 0,0005 0,0136 0,0131 0,0141 0,0066

-0,0061 -0,0061 -0,0062 -0,0062 -0,0058 -0,0045 0,0011 0,0011 0,0057 0,0065 0,0066 0,0085

-0,0051 -0,0046 -0,0041 -0,0044 -0,0031 -0,0033 0,0000 0,0002 0,0002 0,0024 0,0027 0,0045

-0,0051 -0,0044 -0,0038 -0,0041 -0,0026 -0,0031 -0,0001 0,0002 -0,0007 0,0021 0,0025 0,0043

-0,0036 -0,0041 -0,0046 -0,0044 -0,0048 -0,0030 -0,0003 -0,0001 0,0011 0,0010 0,0010 0,0021

-0,0027 -0,0032 -0,0037 -0,0035 -0,0040 -0,0022 -0,0003 0,0000 -0,0008 -0,0004 -0,0003 0,0009

-0,0041 -0,0039 -0,0037 -0,0038 -0,0031 -0,0028 -0,0003 -0,0001 0,0002 0,0010 0,0011 0,0024

-0,0017 -0,0016 -0,0014 -0,0015 -0,0010 -0,0008 -0,0003 -0,0001 -0,0010 -0,0011 -0,0010 -0,0000

-0,0018 -0,0019 -0,0020 -0,0019 -0,0018 -0,0010 -0,0001 0,0001 -0,0014 -0,0010 -0,0009 0,0002

Columns 13 through 19

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0051 | -0,0051 | -0,0036 | -0,0027 | -0,0041 | -0,0017 | -0,0018 |
| -0,0046 | -0,0044 | -0,0041 | -0,0032 | -0,0039 | -0,0016 | -0,0019 |
| -0,0041 | -0,0038 | -0,0046 | -0,0037 | -0,0037 | -0,0014 | -0,0020 |
| -0,0044 | -0,0041 | -0,0044 | -0,0035 | -0,0038 | -0,0015 | -0,0019 |
| -0,0031 | -0,0026 | -0,0048 | -0,0040 | -0,0031 | -0,0010 | -0,0018 |
| -0,0033 | -0,0031 | -0,0030 | -0,0022 | -0,0028 | -0,0008 | -0,0010 |
| 0,0000 | -0,0001 | -0,0003 | -0,0003 | -0,0003 | -0,0003 | -0,0001 |
| 0,0002 | 0,0002 | -0,0001 | 0,0000 | -0,0001 | -0,0001 | 0,0001 |
| 0,0002 | -0,0007 | 0,0011 | -0,0008 | 0,0002 | -0,0010 | -0,0014 |
| 0,0024 | 0,0021 | 0,0010 | -0,0004 | 0,0010 | -0,0011 | -0,0010 |
| 0,0027 | 0,0025 | 0,0010 | -0,0003 | 0,0011 | -0,0010 | -0,0009 |
| 0,0045 | 0,0043 | 0,0021 | 0,0009 | 0,0024 | -0,0000 | 0,0002 |
| 0,0193 | 0,0180 | 0,0057 | 0,0024 | 0,0098 | 0,0021 | 0,0018 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

Columns 13 through 19

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0180 | 0,0195 | 0,0049 | 0,0019 | 0,0100 | 0,0022 | 0,0017 |
| 0,0057 | 0,0049 | 0,0157 | 0,0082 | 0,0093 | 0,0028 | 0,0040 |
| 0,0024 | 0,0019 | 0,0082 | 0,0180 | 0,0042 | 0,0028 | 0,0047 |
| 0,0098 | 0,0100 | 0,0093 | 0,0042 | 0,0130 | 0,0030 | 0,0028 |
| 0,0021 | 0,0022 | 0,0028 | 0,0028 | 0,0030 | 0,0064 | 0,0046 |
| 0,0018 | 0,0017 | 0,0040 | 0,0047 | 0,0028 | 0,0046 | 0,0059 |

B0 =

Columns 1 through 12

-0,0076 -0,0126 -0,0174 -0,0158 -0,0231 -0,0089 0,0110 0,0068 0,0407 0,0193 0,0160 0,0082

Columns 13 through 19

-0,0077 -0,0117 0,0092 0,0060 -0,0020 -0,0027 0,0023

B00 =

0,0626

Daya Pembangkitan = 253,693 MW
Daya Pembangkitan = 190,581 MW
Daya Pembangkitan = 255,687 MW
Daya Pembangkitan = 78,202 MW
Daya Pembangkitan = 171,083 MW
Daya Pembangkitan = 190,612 MW
Daya Pembangkitan = 151,842 MW
Daya Pembangkitan = 250,249 MW
Daya Pembangkitan = 106,624 MW
Daya Pembangkitan = 62,380 MW
Daya Pembangkitan = 134,508 MW
Daya Pembangkitan = 78,533 MW
Daya Pembangkitan = 213,957 MW
Daya Pembangkitan = 92,784 MW
Daya Pembangkitan = 82,957 MW
Daya Pembangkitan = 24,608 MW
Daya Pembangkitan = 72,633 MW
Daya Pembangkitan = 219,441 MW
Daya Pembangkitan = 339,708 MW

Total Daya Pembangkitan = 2970,082 MW

Biaya Pembangkitan = 2270,637 $/hour
Biaya Pembangkitan = 992,090 $/hour
Biaya Pembangkitan = 1427,315 $/hour
Biaya Pembangkitan = 91,761 $/hour
Biaya Pembangkitan = 982,598 $/hour

## HASIL SIMULASI INDIAN UTILITY 62 BUS

Biaya Pembangkitan = 1052,279 $/hour
Biaya Pembangkitan = 905,521 $/hour
Biaya Pembangkitan = 1766,929 $/hour
Biaya Pembangkitan = 791,378 $/hour
Biaya Pembangkitan = 96,973 $/hour
Biaya Pembangkitan = 361,629 $/hour
Biaya Pembangkitan = 160,172 $/hour
Biaya Pembangkitan = 689,011 $/hour
Biaya Pembangkitan = 272,194 $/hour
Biaya Pembangkitan = 514,630 $/hour
Biaya Pembangkitan = 127,176 $/hour
Biaya Pembangkitan = 84,927 $/hour
Biaya Pembangkitan = 592,800 $/hour
Biaya Pembangkitan = 2881,606 $/hour

Total Biaya Pembangkitan = 16061,626 $/hour
Elapsed time is 946,24 seconds.

**2. Hasil simulasi IEEE 62 Bus Indian Utility menggunakan metode ABC**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 1,43164e-05
No. of Iterations = 10

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 255,146 | -438,287 | 0,000 |
| 2 | 1,070 | 0,165 | 0,000 | 0,000 | 190,581 | 253,269 | 0,000 |
| 3 | 1,072 | -0,376 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 4 | 1,077 | -0,850 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 5 | 1,070 | 0,467 | 0,000 | 0,000 | 255,687 | 10,614 | 0,000 |
| 6 | 1,065 | 0,192 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 7 | 1,065 | 0,179 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,064 | 0,168 | 109,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,050 | 0,048 | 66,000 | 23,000 | 78,202 | 19,430 | 0,000 |
| 10 | 1,064 | -3,605 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 11 | 1,073 | -4,701 | 161,000 | 93,000 | 0,000 | 0,000 | 0,000 |
| 12 | 1,181 | -6,391 | 155,000 | 79,000 | 0,000 | 0,000 | 0,000 |
| 13 | 1,111 | -4,375 | 132,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,070 | -1,691 | 0,000 | 0,000 | 171,083 | 203,504 | 0,000 |
| 15 | 1,091 | -1,736 | 155,000 | 63,000 | 0,000 | 0,000 | 0,000 |
| 16 | 1,056 | -2,220 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 17 | 1,050 | -2,045 | 0,000 | 0,000 | 190,612 | -411,973 | 0,000 |
| 18 | 1,054 | -1,940 | 121,000 | 46,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 19 | 1,092 | -2,942 | 130,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 20 | 1,194 | -8,541 | 80,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 21 | 1,148 | -6,006 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 22 | 1,216 | -8,461 | 64,000 | 50,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,240 | -8,837 | 0,000 | 0,000 | 151,842 | -63,142 | 0,000 |
| 24 | 1,242 | -9,479 | 58,000 | 34,000 | 0,000 | 0,000 | 0,000 |
| 25 | 1,250 | -8,943 | 0,000 | 0,000 | 250,249 | 308,441 | 0,000 |
| 26 | 1,233 | -10,142 | 116,000 | 52,000 | 0,000 | 0,000 | 0,000 |
| 27 | 1,245 | -10,501 | 85,000 | 35,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,246 | -9,745 | 63,000 | 8,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,248 | -10,703 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 30 | 1,251 | -11,387 | 77,000 | 41,000 | 0,000 | 0,000 | 0,000 |
| 31 | 1,259 | -11,342 | 51,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 32 | 1,280 | -10,241 | 0,000 | 0,000 | 106,624 | -15,512 | 0,000 |
| 33 | 1,280 | -10,074 | 46,000 | 25,000 | 62,380 | -4,718 | 0,000 |
| 34 | 1,280 | -10,231 | 100,000 | 70,000 | 134,508 | 89,812 | 0,000 |
| 35 | 1,280 | -10,280 | 107,000 | 33,000 | 0,000 | 0,000 | 0,000 |
| 36 | 1,281 | -10,225 | 20,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 37 | 1,280 | -9,871 | 0,000 | 0,000 | 78,533 | -34,659 | 0,000 |
| 38 | 1,275 | -11,030 | 166,000 | 22,000 | 0,000 | 0,000 | 0,000 |
| 39 | 1,273 | -10,086 | 30,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 40 | 1,251 | -11,033 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 41 | 1,251 | -10,546 | 92,000 | 91,000 | 0,000 | 0,000 | 0,000 |
| 42 | 1,254 | -10,505 | 30,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 43 | 1,253 | -10,775 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 44 | 1,268 | -9,703 | 109,000 | 17,000 | 0,000 | 0,000 | 0,000 |
| 45 | 1,250 | -10,384 | 20,000 | 4,000 | 0,000 | 0,000 | 0,000 |
| 46 | 1,281 | -9,675 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 47 | 1,289 | -7,645 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 48 | 1,350 | -4,388 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 49 | 1,370 | -3,809 | 0,000 | 0,000 | 213,957 | -131,568 | 0,000 |
| 50 | 1,400 | -4,302 | 0,000 | 0,000 | 92,784 | 134,010 | 0,000 |
| 51 | 1,320 | -5,694 | 0,000 | 0,000 | 82,957 | 77,861 | 0,000 |
| 52 | 1,280 | -6,992 | 0,000 | 0,000 | 24,608 | -7,718 | 0,000 |
| 53 | 1,283 | -7,857 | 248,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 54 | 1,330 | -5,150 | 0,000 | 0,000 | 72,633 | 7,467 | 0,000 |
| 55 | 1,289 | -6,045 | 94,000 | 29,000 | 0,000 | 0,000 | 0,000 |
| 56 | 1,280 | -5,333 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 57 | 1,280 | -5,212 | 0,000 | 0,000 | 219,441 | -46,718 | 0,000 |
| 58 | 1,280 | -5,535 | 0,000 | 0,000 | 39,708 | 393,258 | 0,000 |
| 59 | 1,271 | -8,102 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 60 | 1,267 | -6,119 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 61 | 1,273 | -6,411 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 62 | 1,257 | -8,489 | 93,000 | 23,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 2908,000 | 1270,000 | 2971,535 | 343,371 | 0,000 |
| Total loss | | | 63,537 | -929,379 | | | |

B =

Columns 1 through 12

0,0234 -0,0071 0,0052 0,0034 -0,0053 0,0150 -0,0029 0,0022 -0,0035 -0,0033 0,0014 -0,0047

-0,0071 0,0172 0,0060 0,0074 0,0119 -0,0052 -0,0009 -0,0047 -0,0032 -0,0036 -0,0066 -0,0017

0,0052 0,0060 0,0070 0,0055 0,0046 0,0033 -0,0017 -0,0017 -0,0033 -0,0034 -0,0032 -0,0030

0,0034 0,0074 0,0055 0,0076 0,0058 0,0019 -0,0016 -0,0023 -0,0033 -0,0035 -0,0038 -0,0028

-0,0053 0,0119 0,0046 0,0058 0,0117 -0,0049 -0,0008 -0,0040 -0,0029 -0,0033 -0,0059 -0,0016

0,0150 -0,0052 0,0033 0,0019 -0,0049 0,0278 -0,0019 0,0016 -0,0029 -0,0027 0,0017 -0,0039

-0,0029 -0,0009 -0,0017 -0,0016 -0,0008 -0,0019 0,0027 0,0011 0,0004 0,0003 0,0002 0,0008

0,0022 -0,0047 -0,0017 -0,0023 -0,0040 0,0016 0,0011 0,0062 0,0004 0,0004 0,0007 0,0003

-0,0035 -0,0032 -0,0033 -0,0033 -0,0029 -0,0029 0,0004 0,0004 0,0051 0,0050 0,0045 0,0031

-0,0033 -0,0036 -0,0034 -0,0035 -0,0033 -0,0027 0,0003 0,0004 0,0050 0,0085 0,0052 0,0030

0,0014 -0,0066 -0,0032 -0,0038 -0,0059 0,0017 0,0002 0,0007 0,0045 0,0052 0,0086 0,0020

-0,0047 -0,0017 -0,0030 -0,0028 -0,0016 -0,0039 0,0008 0,0003 0,0031 0,0030 0,0020 0,0043

-0,0049 -0,0004 -0,0023 -0,0020 -0,0004 -0,0040 0,0004 -0,0001 0,0016 0,0015 0,0006 0,0025

0,0035 -0,0068 -0,0025 -0,0032 -0,0060 0,0033 0,0003 0,0009 0,0016 0,0017 0,0032 0,0012

0,0013 -0,0042 -0,0019 -0,0023 -0,0036 0,0013 0,0002 0,0001 0,0006 0,0005 0,0008 0,0007

-0,0023 -0,0010 -0,0016 -0,0015 -0,0009 -0,0017 0,0001 -0,0001 0,0000 -0,0001 -0,0001 0,0005

-0,0016 -0,0023 -0,0020 -0,0021 -0,0020 -0,0011 0,0002 0,0001 0,0008 0,0007 0,0007 0,0012

-0,0015 -0,0007 -0,0010 -0,0010 -0,0006 -0,0009 0,0002 -0,0000 -0,0002 -0,0002 -0,0003 0,0002

# HASIL SIMULASI INDIAN UTILITY 62 BUS

B =

Columns 1 through 12

0,0009 -0,0026 -0,0011 -0,0014 -0,0022 0,0007 0,0002 0,0004 -0,0000 -0,0001 -0,0003 0,0002

Columns 13 through 19

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0049 | 0,0035 | 0,0013 | -0,0023 | -0,0016 | -0,0015 | 0,0009 |
| -0,0004 | -0,0068 | -0,0042 | -0,0010 | -0,0023 | -0,0007 | -0,0026 |
| -0,0023 | -0,0025 | -0,0019 | -0,0016 | -0,0020 | -0,0010 | -0,0011 |
| -0,0020 | -0,0032 | -0,0023 | -0,0015 | -0,0021 | -0,0010 | -0,0014 |
| -0,0004 | -0,0060 | -0,0036 | -0,0009 | -0,0020 | -0,0006 | -0,0022 |
| -0,0040 | 0,0033 | 0,0013 | -0,0017 | -0,0011 | -0,0009 | 0,0007 |
| 0,0004 | 0,0003 | 0,0002 | 0,0001 | 0,0002 | 0,0002 | 0,0002 |
| -0,0001 | 0,0009 | 0,0001 | -0,0001 | 0,0001 | -0,0000 | 0,0004 |
| 0,0016 | 0,0016 | 0,0006 | 0,0000 | 0,0008 | -0,0002 | -0,0000 |
| 0,0015 | 0,0017 | 0,0005 | -0,0001 | 0,0007 | -0,0002 | -0,0001 |
| 0,0006 | 0,0032 | 0,0008 | -0,0001 | 0,0007 | -0,0003 | -0,0003 |
| 0,0025 | 0,0012 | 0,0007 | 0,0005 | 0,0012 | 0,0002 | 0,0002 |
| 0,0095 | 0,0006 | 0,0012 | 0,0019 | 0,0035 | 0,0011 | 0,0003 |
| 0,0006 | 0,0191 | 0,0073 | 0,0009 | 0,0044 | 0,0006 | 0,0025 |
| 0,0012 | 0,0073 | 0,0088 | 0,0018 | 0,0046 | 0,0011 | 0,0030 |
| 0,0019 | 0,0009 | 0,0018 | 0,0053 | 0,0021 | 0,0018 | 0,0011 |
| 0,0035 | 0,0044 | 0,0046 | 0,0021 | 0,0053 | 0,0013 | 0,0015 |
| 0,0011 | 0,0006 | 0,0011 | 0,0018 | 0,0013 | 0,0029 | 0,0017 |
| 0,0003 | 0,0025 | 0,0030 | 0,0011 | 0,0015 | 0,0017 | 0,0054 |

B0 =

Columns 1 through 12

0,0282 -0,0283 -0,0043 -0,0087 -0,0242 0,0197 -0,0003 0,0092 0,0023 0,0037 0,0155 -0,0028

Columns 13 through 19

-0,0089 0,0253 0,0097 -0,0018 0,0020 -0,0011 0,0068

B00 =

0,0753

Daya Pembangkitan = 255,146 MW
Daya Pembangkitan = 190,581 MW
Daya Pembangkitan = 255,687 MW
Daya Pembangkitan = 78,202 MW
Daya Pembangkitan = 171,083 MW
Daya Pembangkitan = 190,612 MW
Daya Pembangkitan = 151,842 MW
Daya Pembangkitan = 250,249 MW

## HASIL SIMULASI INDIAN UTILITY 62 BUS

Daya Pembangkitan = 106,624 MW
Daya Pembangkitan = 62,380 MW
Daya Pembangkitan = 134,508 MW
Daya Pembangkitan = 78,533 MW
Daya Pembangkitan = 213,957 MW
Daya Pembangkitan = 92,784 MW
Daya Pembangkitan = 82,957 MW
Daya Pembangkitan = 24,608 MW
Daya Pembangkitan = 72,633 MW
Daya Pembangkitan = 219,441 MW
Daya Pembangkitan = 339,708 MW

Total Daya Pembangkitan = 2971,535 MW

Biaya Pembangkitan = 2285,689 $/hour
Biaya Pembangkitan = 992,090 $/hour
Biaya Pembangkitan = 1427,315 $/hour
Biaya Pembangkitan = 91,761 $/hour
Biaya Pembangkitan = 982,598 $/hour
Biaya Pembangkitan = 1052,279 $/hour
Biaya Pembangkitan = 905,521 $/hour
Biaya Pembangkitan = 1766,929 $/hour
Biaya Pembangkitan = 791,378 $/hour
Biaya Pembangkitan = 96,973 $/hour
Biaya Pembangkitan = 361,629 $/hour
Biaya Pembangkitan = 160,172 $/hour
Biaya Pembangkitan = 689,011 $/hour
Biaya Pembangkitan = 272,194 $/hour
Biaya Pembangkitan = 514,630 $/hour
Biaya Pembangkitan = 127,176 $/hour
Biaya Pembangkitan = 84,927 $/hour
Biaya Pembangkitan = 592,800 $/hour
Biaya Pembangkitan = 2881,606 $/hour

Total Biaya Pembangkitan = 16076,678 $/hour
Elapsed time is 1242,58 seconds.

## HASIL SIMULASI INDIAN UTILITY 62 BUS

**3. Hasil simulasi IEEE 62 Bus Indian Utility menggunakan metode hybrid FOA-ABC**

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 2,62235e-13

No. of Iterations = 1

| Bus | Voltage | Angle | ------Load------ | | ---Generation--- | | Injected |
|---|---|---|---|---|---|---|---|
| No. | Mag. | Degree | MW | Mvar | MW | Mvar | Mvar |
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 252,837 | -102,436 | 0,000 |
| 2 | 1,060 | 0,469 | 0,000 | 0,000 | 190,581 | 10,475 | 0,000 |
| 3 | 1,063 | -0,440 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 4 | 1,069 | -1,242 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 5 | 1,070 | 0,815 | 0,000 | 0,000 | 255,687 | 74,131 | 0,000 |
| 6 | 1,060 | 0,427 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 7 | 1,060 | 0,403 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,059 | 0,380 | 109,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,050 | 0,077 | 66,000 | 23,000 | 78,202 | 19,433 | 0,000 |
| 10 | 1,034 | -5,456 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 11 | 1,031 | -7,117 | 161,000 | 93,000 | 0,000 | 0,000 | 0,000 |
| 12 | 1,107 | -8,909 | 155,000 | 79,000 | 0,000 | 0,000 | 0,000 |
| 13 | 1,078 | -6,508 | 132,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,060 | -2,556 | 0,000 | 0,000 | 171,083 | 162,087 | 0,000 |
| 15 | 1,078 | -2,664 | 155,000 | 63,000 | 0,000 | 0,000 | 0,000 |
| 16 | 1,047 | -3,452 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 17 | 1,050 | -3,318 | 0,000 | 0,000 | 190,612 | -140,640 | 0,000 |
| 18 | 1,043 | -2,966 | 121,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 19 | 1,069 | -4.628 | 130,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 20 | 1,108 | -12,716 | 80,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 21 | 1,111 | -8,953 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 22 | 1,150 | -12,631 | 64,000 | 50,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,170 | -13,138 | 0,000 | 0,000 | 151,842 | 190,321 | 0,000 |
| 24 | 1,162 | -14,218 | 58,000 | 34,000 | 0,000 | 0,000 | 0,000 |
| 25 | 1,170 | -13,175 | 0,000 | 0,000 | 250,249 | 55,215 | 0,000 |
| 26 | 1,140 | -15,394 | 116,000 | 52,000 | 0,000 | 0,000 | 0,000 |
| 27 | 1,151 | -15,993 | 85,000 | 35,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,163 | -14,642 | 63,000 | 8,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,153 | -16,343 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 30 | 1,145 | -17,556 | 77,000 | 41,000 | 0,000 | 0,000 | 0,000 |
| 31 | 1,152 | -17,419 | 51,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 32 | 1,180 | -15,261 | 0,000 | 0,000 | 106,624 | -21,615 | 0,000 |
| 33 | 1,190 | -15,043 | 46,000 | 25,000 | 62,380 | 26,042 | 0,000 |
| 34 | 1,180 | -15,244 | 100,000 | 70,000 | 134,508 | 87,666 | 0,000 |
| 35 | 1,179 | -15,333 | 107,000 | 33,000 | 0,000 | 0,000 | 0,000 |
| 36 | 1,181 | -15,226 | 20,000 | 5,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 37 | 1,180 | -14,561 | 0,000 | 0,000 | 78,533 | -29,944 | 0,000 |
| 38 | 1,170 | -16,754 | 166,000 | 22,000 | 0,000 | 0,000 | 0,000 |
| 39 | 1,173 | -15,001 | 30,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 40 | 1,148 | -16,900 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 41 | 1,151 | -15,997 | 92,000 | 91,000 | 0,000 | 0,000 | 0,000 |
| 42 | 1,153 | -15,901 | 30,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 43 | 1,151 | -16,410 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 44 | 1,167 | -14,323 | 109,000 | 17,000 | 0,000 | 0,000 | 0.000 |
| 45 | 1,153 | -15,734 | 20,000 | 4,000 | 0,000 | 0,000 | 0.000 |
| 46 | 1,181 | -14,176 | 0,000 | 0,000 | 0,000 | 0,000 | 0.000 |
| 47 | 1,180 | -10,172 | 0,000 | 0,000 | 0,000 | 0,000 | 0.000 |
| 48 | 1,228 | -3,675 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 49 | 1,260 | -2,712 | 0,000 | 0,000 | 213,957 | 62,068 | 0,000 |
| 50 | 1,270 | -3,464 | 0,000 | 0,000 | 92,784 | -128,466 | 0,000 |
| 51 | 1,210 | -6,421 | 0,000 | 0,000 | 82,957 | 37,343 | 0,000 |
| 52 | 1,180 | -9,222 | 0,000 | 0,000 | 24,608 | 9,501 | 0,000 |
| 53 | 1,164 | -10,734 | 248,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 54 | 1,220 | -5,334 | 0,000 | 0,000 | 72,633 | 19,302 | 0,000 |
| 55 | 1,190 | -7,353 | 94,000 | 29,000 | 0,000 | 0,000 | 0,000 |
| 56 | 1,190 | -6,157 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 57 | 1,190 | -5,934 | 0,000 | 0,000 | 219,441 | -45,543 | 0,000 |
| 58 | 1,190 | -6,532 | 0,000 | 0,000 | 339,708 | 196,769 | 0,000 |
| 59 | 1,175 | -11,334 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 60 | 1,178 | -7,720 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 61 | 1,182 | -8,211 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 62 | 1,167 | -12,203 | 93,000 | 23,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 2908,000 | 1270,000 | 2969,226 | 481,711 | 0,000 |
| Total loss | | | 61,226 | -790,806 | | | |

B =

Columns 1 through 12

0,0131 0,0107 0,0094 0,0101 0,0050 0,0084 -0,0014 -0,0030 -0,0072 -0,0050 -0,0040 -0,0069

0,0107 0,0120 0,0112 0,0110 0,0092 0,0065 -0,0033 -0,0034 -0,0070 -0,0068 -0,0066 -0,0063

0,0094 0,0112 0,0142 0,0113 0,0112 0,0056 -0,0043 -0,0036 -0,0069 -0,0077 -0,0078 -0,0059

0,0101 0,0110 0,0113 0,0141 0,0110 0,0057 -0,0042 -0,0036 -0,0070 -0,0077 -0,0077 -0,0060

0,0050 0,0092 0,0112 0,0110 0,0179 0,0024 -0,0066 -0,0038 -0,0060 -0,0097 -0,0110 -0,0043

## HASIL SIMULASI INDIAN UTILITY 62 BUS

0,0084 0,0065 0,0056 0,0057 0,0024 0,0136 -0,0005 -0,0018 -0,0057 -0,0033 -0,0022 -0,0056
-0,0014 -0,0033 -0,0043 -0,0042 -0,0066 -0,0005 0,0111 0,0051 0,0009 0,0013 0,0016 0,0008
-0,0030 -0,0034 -0,0036 -0,0036 -0,0038 -0,0018 0,0051 0,0049 0,0010 0,0008 0,0009 0,0012

B =

Columns 1 through 12

-0,0072 -0,0070 -0,0069 -0,0070 -0,0060 -0,0057 0,0009 0,0010 0,0107 0,0094 0,0089 0,0068
-0,0050 -0,0068 -0,0077 -0,0077 -0,0097 -0,0033 0,0013 0,0008 0,0094 0,0196 0,0141 00051
-0,0040 -0,0066 -0,0078 -0,0077 -0,0110 -0,0022 0,0016 0,0009 0,0089 0,0141 0,0172 0,0044
-0,0069 -0.0063 -0,0059 -0,0060 -0,0043 -0,0056 0,0008 0,0012 0,0068 0,0051 0,0044 0,0086
-0,0047 -0,0052 -0,0054 -0,0054 -0,0055 -0,0033 0,0007 0,0007 0,0038 0,0036 0,0036 0,0044
-0,0074 -0,0042 -0,0025 -0,0027 0,0028 -0,0068 -0,0011 0,0001 0,0033 -0,0003 -0,0017 0.,055
-0,0032 -0,0039 -0,0042 -0,0042 -0,0048 -0,0020 0,0000 0,0002 0,0014 0,0012 0,0012 0,0019
-0,0025 -0,0031 -0,0034 -0,0033 -0,0037 -0,0016 -0,0001 0,0002 0,0004 -0,0000 -0,0001 0,0010
-0,0037 -0,0042 -0,0044 -0,0044 -0,0045 -0,0026 0,0001 0,0003 0,0019 0,0017 0,0016 0,0026
-0,0021 -0,0019 -0,0017 -0,0017 -0,0010 -0,0014 -0,0002 0,0001 -0,0003 -0,0006 -0,0007 0,0004
-0,0017 -0,0021 -0,0023 -0,0023 -0,0026 -0,0010 0,0002 0,0004 -0,0000 -0,0005 -0,0006 0,0006

Columns 13 through 19

-0,0047 -0,0074 -0,0032 -0,0025 -0,0037 -0,0021 -0,0017
-0,0052 -0,0042 -0,0039 -0,0031 -0,0042 -0,0019 -0,0021
-0,0054 -0,0025 -0,0042 -0,0034 -0,0044 -0,0017 -0,0023
-0,0054 -0,0027 -0,0042 -0,0033 -0,0044 -0,0017 -0,0023
-0,0055 0,0028 -0,0048 -0,0037 -0,0045 -0,0010 -0,0026
-0,0033 -0,0068 -0,0020 -0,0016 -0,0026 -0,0014 -0,0010
0,0007 -0,0011 0,0000 -0,0001 0,0001 -0,0002 0,0002
0,0007 0,0001 0,0002 0,0002 0,0003 0,0001 0,0004
0,0038 0,0033 0,0014 0,0004 0,0019 -0,0003 -0,0000
0,0036 -0,0003 0,0012 -0,0000 0,0017 -0,0006 -0,0005
0,0036 -0,0017 0,0012 -0,0001 0,0016 -0,0007 -0,0006
0,0044 0,0055 0,0019 0,0010 0,0026 0,0004 0,0006
0,0149 0,0077 0,0070 0,0035 0,0083 0,0017 0,0022

## HASIL SIMULASI INDIAN UTILITY 62 BUS

Columns 13 through 19

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0077 | 0,0371 | 0,0020 | 0,0012 | 0,0046 | 0,0025 | 0,0004 |
| 0,0070 | 0,0020 | 0,0110 | 0,0055 | 0,0094 | 0,0025 | 0,0035 |
| 0,0035 | 0,0012 | 0,0055 | 0,0107 | 0,0047 | 0,0028 | 0,0039 |
| 0,0083 | 0,0046 | 0,0094 | 0,0047 | 0,0111 | 0,0024 | 0,0030 |
| 0,0017 | 0,0025 | 0,0025 | 0,0028 | 0,0024 | 0,0055 | 0,0038 |
| 0,0022 | 0,0004 | 0,0035 | 0,0039 | 0,0030 | 0,0038 | 0,0058 |

B0 =

Columns 1 through 12

0,0014 -0,0124 -0,0191 -0,0190 -0,0381 0,0040 0,0169 0,0072 0,0080 0,0257 0,0313 0,0013

Columns 13 through 19

0,0118 -0,0382 0,0090 0,0047 0,0074 -0,0022 0,0056

B00 =

0,0727

Daya Pembangkitan = 252,8367 MW
Daya Pembangkitan = 190,5810 MW
Daya Pembangkitan = 255,6870 MW
Daya Pembangkitan = 78,020 MW
Daya Pembangkitan = 171,0830 MW
Daya Pembangkitan = 190,6120 MW
Daya Pembangkitan = 151,8420 MW
Daya Pembangkitan = 250,2490 MW
Daya Pembangkitan = 106,6240 MW
Daya Pembangkitan = 62,3800 MW
Daya Pembangkitan = 134,5080 MW
Daya Pembangkitan = 78,5330 MW
Daya Pembangkitan = 213,9570 MW
Daya Pembangkitan = 92,7840 MW
Daya Pembangkitan = 82,9570 MW
Daya Pembangkitan = 24,6080 MW
Daya Pembangkitan = 72,6330 MW
Daya Pembangkitan = 219,4410 MW
Daya Pembangkitan = 339,7080 MW

Total Daya Pembangkitan = 2969,2257 MW

Biaya Pembangkitan = 2261,7743 $/hour
Biaya Pembangkitan = 992,0901 $/hour
Biaya Pembangkitan = 1427,3151 $/hour
Biaya Pembangkitan = 91,7606 $/hour
Biaya Pembangkitan = 982,5982 $/hour

## HASIL SIMULASI INDIAN UTILITY 62 BUS

Biaya Pembangkitan = 1052,2791 $/hour
Biaya Pembangkitan = 905,5214 $/hour
Biaya Pembangkitan = 1766,9292 $/hour
Biaya Pembangkitan = 791,3778 $/hour
Biaya Pembangkitan = 96,9725 $/hour
Biaya Pembangkitan = 361,6286 $/hour
Biaya Pembangkitan = 160,1716 $/hour
Biaya Pembangkitan = 689,0106 $/hour
Biaya Pembangkitan = 272,1943 $/hour
Biaya Pembangkitan = 514,6300 $/hour
Biaya Pembangkitan = 127,1762 $/hour
Biaya Pembangkitan = 84,9269 $/hour
Biaya Pembangkitan = 592,8002 $/hour
Biaya Pembangkitan = 2881,6062 $/hour

Total Biaya Pembangkitan = 16052,3630 $/hour
Total Rugi Daya Aktif = 61,2257 MW
Total Rugi Daya Reaktif = -790,8061 Mvar
Elapsed time is 1525,79 seconds.

**4. Hasil simulasi IEEE 62 Bus Indian Utility menggunakan metode hybrid MFOA-ABC**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 2,27374e-13
No. of Iterations = 1

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 1,050 | 0,000 | 0,000 | 0,000 | 251,236 | -91,524 | 0,000 |
| 2 | 1,060 | 0,470 | 0,000 | 0,000 | 190,581 | 10,476 | 0,000 |
| 3 | 1,063 | -0,437 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 4 | 1,069 | -1,238 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 5 | 1,070 | 0,817 | 0,000 | 0,000 | 255,687 | 74,110 | 0,000 |
| 6 | 1,060 | 0,428 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 7 | 1,060 | 0,404 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 8 | 1,059 | 0,382 | 109,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 9 | 1,050 | 0,077 | 66,000 | 23,000 | 78,202 | 19,433 | 0,000 |
| 10 | 1,026 | -5,388 | 40,000 | 10,000 | 0,000 | 0,000 | 0,000 |
| 11 | 1,020 | -7,033 | 161,000 | 93,000 | 0,000 | 0,000 | 0,000 |
| 12 | 1,072 | -8,640 | 155,000 | 79,000 | 0,000 | 0,000 | 0,000 |
| 13 | 1,066 | -6,401 | 132,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 14 | 1,060 | -2,548 | 0,000 | 0,000 | 171,083 | 187,003 | 0,000 |
| 15 | 1,078 | -2,658 | 155,000 | 63,000 | 0,000 | 0,000 | 0,000 |
| 16 | 1,046 | -3,425 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 17 | 1,050 | -3,299 | 0,000 | 0,000 | 190,612 | -89,211 | 0,000 |
| 18 | 1,043 | -2,957 | 121,000 | 46,000 | 0,000 | 0,000 | 0,000 |
| 19 | 1,069 | -4,619 | 130,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 20 | 1,063 | -12,622 | 80,000 | 70,000 | 0,000 | 0,000 | 0,000 |
| 21 | 1,085 | -8,773 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 22 | 1,105 | -12,490 | 64,000 | 50,000 | 0,000 | 0,000 | 0,000 |
| 23 | 1,120 | -12,987 | 0,000 | 0,000 | 151,842 | 134,716 | 0,000 |
| 24 | 1,114 | -14,185 | 58,000 | 34,000 | 0,000 | 0,000 | 0,000 |
| 25 | 1,120 | -13,029 | 0,000 | 0,000 | 250,249 | 55,410 | 0,000 |
| 26 | 1,088 | -15,456 | 116,000 | 52,000 | 0,000 | 0,000 | 0,000 |
| 27 | 1,102 | -16,092 | 85,000 | 35,000 | 0,000 | 0,000 | 0,000 |
| 28 | 1,113 | -14,630 | 63,000 | 8,000 | 0,000 | 0,000 | 0,000 |
| 29 | 1,105 | -16,471 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 30 | 1,103 | -17,785 | 77,000 | 41,000 | 0,000 | 0,000 | 0,000 |
| 31 | 1,114 | -17,598 | 51,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 32 | 1,150 | -15,249 | 0,000 | 0,000 | 106,624 | 91,565 | 0,000 |
| 33 | 1,150 | -14,869 | 46,000 | 25,000 | 62,380 | 13,307 | 0,000 |
| 34 | 1,140 | -15,036 | 100,000 | 70,000 | 134,508 | -74,210 | 0,000 |
| 35 | 1,149 | -15,316 | 107,000 | 33,000 | 0,000 | 0,000 | 0,000 |
| 36 | 1,151 | -15,244 | 20,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 37 | 1,150 | -14,766 | 0,000 | 0,000 | 78,533 | 65,653 | 0,000 |
| 38 | 1,134 | -16,870 | 166,000 | 22,000 | 0,000 | 0,000 | 0,000 |
| 39 | 1,140 | -15,202 | 30,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 40 | 1,106 | -17,112 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 41 | 1,109 | -16,170 | 92,000 | 91,000 | 0,000 | 0,000 | 0,000 |
| 42 | 1,112 | -16,077 | 30,000 | 25,000 | 0,000 | 0,000 | 0,000 |
| 43 | 1,110 | -16,623 | 25,000 | 5,000 | 0,000 | 0,000 | 0,000 |
| 44 | 1,127 | -14.406 | 109,000 | 17,000 | 0,000 | 0,000 | 0,000 |
| 45 | 1,110 | -15,873 | 20,000 | 4,000 | 0,000 | 0,000 | 0,000 |
| 46 | 1,151 | -14,338 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 47 | 1,160 | -10,208 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 48 | 1,225 | -3,660 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 49 | 1,250 | -2,624 | 0,000 | 0,000 | 213,957 | -21,644 | 0,000 |
| 50 | 1,270 | -3,474 | 0,000 | 0,000 | 92,784 | 17,459 | 0,000 |
| 51 | 1,180 | -6,130 | 0,000 | 0,000 | 82,957 | 15,334 | 0,000 |
| 52 | 1,140 | -8,948 | 0,000 | 0,000 | 24,608 | 17,065 | 0,000 |
| 53 | 1,128 | -10,627 | 248,000 | 78,000 | 0,000 | 0,000 | 0,000 |
| 54 | 1,200 | -5,116 | 0,000 | 0,000 | 72,633 | 43,899 | 0,000 |
| 55 | 1,146 | -6,908 | 94,000 | 29,000 | 0,000 | 0,000 | 0,000 |
| 56 | 1,140 | -5,506 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 57 | 1,140 | -5,264 | 0,000 | 0,000 | 219,441 | -45,108 | 0,000 |
| 58 | 1,140 | -5,916 | 0,000 | 0,000 | 339,708 | 106,823 | 0,000 |
| 59 | 1,131 | -11,165 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

## HASIL SIMULASI INDIAN UTILITY 62 BUS

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 60 | 1,131 | -7,233 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 61 | 1,135 | -7,762 | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |
| 62 | 1,118 | -12,030 | 93,000 | 23,000 | 0,000 | 0,000 | 0,000 |
| Total | | | 2908,000 | 1270,000 | 2967,625 | 530,556 | 0,000 |
| Total loss | | | 59,625 | -741,899 | | | |

B =

Columns 1 through 14

0,0129 0,0108 0,0096 0,0103 0,0049 0,0076 -0,0021 -0,0031 -0,0035 -0,0060 -0,0088 -0,0033 -0,0052 -0,0048

0,0108 0,0121 0,0114 0,0111 0,0093 0,0066 -0,0034 -0,0035 -0,0064 -0,0071 -0,0076 -0,0057 -0,0049 -0,0050

0,0096 0,0114 0,0143 0,0114 0,0117 0,0060 -0,0041 -0,0037 -0,0079 -0,0077 -0,0069 -0,0070 -0,0046 -0,0052

0,0103 0,0111 0,0114 0,0142 0,0114 0,0061 -0,0040 -0,0037 -0,0078 -0,0077 -0,0071 -0,0069 -0,0047 -0,0052

0,0049 0,0093 0,0117 0,0114 0,0210 0,0036 -0,0061 -0,0040 -0,0130 -0,0091 -0,0039 -0,0112 -0,0033 -0,0050

0,0076 0,0066 0,0060 0,0061 0,0036 0,0109 -0,0014 -0,0019 -0,0026 -0,0047 -0,0070 -0,0024 -0,0039 -0,0035

-0,0021 -0,0034 -0,0041 -0,0040 -0,0061 -0,0014 0,0083 0,0052 0,0016 0,0010 0,0006 0,0023 0,0003 0,0006

-0,0031 -0,0035 -0,0037 -0,0037 -0,0040 -0,0019 0,0052 0,0052 0,0010 0,0008 0,0008 0,0015 0,0005 0,0006

-0,0035 -0,0064 -0,0079 -0,0078 -0,0130 -0,0026 0,0016 0,0010 0,0185 0,0126 0,0056 0,0112 0,0022 0,0034

-0,0060 -0,0071 -0,0077 -0,0077 -0,0091 -0,0047 0,0010 0,0008 0,0126 0,0185 0,0103 0,0076 0,0030 0,0035

-0,0088 -0,0076 -0,0069 -0,0071 -0,0039 -0,0070 0,0006 0,0008 0,0056 0,0103 0,0166 0,0037 0,0040 0,0037

-0,0033 -0,0057 -0,0070 -0,0069 -0,0112 -0,0024 0,0023 0,0015 0,0112 0,0076 0,0037 0,0132 0,0028 0,0042

-0,0052 -0,0049 -0,0046 -0,0047 -0,0033 -0,0039 0,0003 0,0005 0,0022 0,0030 0,0040 0,0028 0,0140 0,0121

-0,0048 -0,0050 -0,0052 -0,0052 -0,0050 -0,0035 0,0006 0,0006 0,0034 0,0035 0,0037 0,0042 0,0121 0,0131

-0,0036 -0,0038 -0,0039 -0,0039 -0,0039 -0,0026 -0,0001 0,0001 0,0009 0,0010 0,0012 0,0017 0,0062 0,0066

-0,0023 -0,0032 -0,0036 -0,0036 -0,0049 -0,0015 0,0000 0,0002 0,0000 0,0001 0,0004 0,0011 0,0028 0,0036

## HASIL SIMULASI INDIAN UTILITY 62 BUS

B =

Columns 1 through 14

-0,0033 -0,0043 -0,0048 -0,0048 -0,0060 -0,0024 0,0002 0,0003 0,0024 0,0020 0,0018 0,0035 0,0072 0,0087

-0,0021 -0,0018 -0,0017 -0,0017 -0,0008 -0,0012 -0,0001 0,0001 -0,0007 -0,0007 -0,0005 -0,0002 0,0019 0,0018

-0,0019 -0,0020 -0,0021 -0,0021 -0,0020 -0,0011 0,0001 0,0003 -0,0007 -0,0006 -0,0002 0,0001 0,0018 0,0020

Columns 15 through 19

| | | | | |
|---|---|---|---|---|
| -0,0036 | -0,0023 | -0,0033 | -0,0021 | -0,0019 |
| -0,0038 | -0,0032 | -0,0043 | -0,0018 | -0,0020 |
| -0,0039 | -0,0036 | -0,0048 | -0,0017 | -0,0021 |
| -0,0039 | -0,0036 | -0,0048 | -0,0017 | -0,0021 |

Columns 15 through 19

| | | | | |
|---|---|---|---|---|
| -0,0039 | -0,0049 | -0,0060 | -0,0008 | -0,0020 |
| -0,0026 | -0,0015 | -0,0024 | -0,0012 | -0,0011 |
| -0,0001 | 0,0000 | 0,0002 | -0,0001 | 0,0001 |
| 0,0001 | 0,0002 | 0,0003 | 0,0001 | 0,0003 |
| 0,0009 | 0,0000 | 0,0024 | -0,0007 | -0,0007 |
| 0,0010 | 0,0001 | 0,0020 | -0,0007 | -0,0006 |
| 0,0012 | 0,0004 | 0,0018 | -0,0005 | -0,0002 |
| 0,0017 | 0,0011 | 0,0035 | -0,0002 | 0,0001 |
| 0,0062 | 0,0028 | 0,0072 | 0,0019 | 0,0018 |
| 0,0066 | 0,0036 | 0,0087 | 0,0018 | 0,0020 |
| 0,0099 | 0,0055 | 0,0098 | 0,0028 | 0,0031 |
| 0,0055 | 0,0147 | 0,0063 | 0,0027 | 0,0040 |
| 0,0098 | 0,0063 | 0,0145 | 0,0023 | 0,0032 |
| 0,0028 | 0,0027 | 0,0023 | 0,0059 | 0,0044 |
| 0,0031 | 0,0040 | 0,0032 | 0,0044 | 0,0052 |

B0 =

Columns 1 through 14

-0,0004 -0,0122 -0,0185 -0,0184 -0,0403 -0,0010 0,0129 0,0069 0,0362 0,0198 -0,0008 0,0324 -0,0001 0,0087

Columns 15 through 19

0,0041 0,0075 0,0137 -0,0024 0,0026

B00 =

0,0697

Daya Pembangkitan = 251,2358 MW
Daya Pembangkitan = 190,5810 MW
Daya Pembangkitan = 255,6870 MW
Daya Pembangkitan = 78,2020 MW
Daya Pembangkitan = 171,0830 MW

## HASIL SIMULASI INDIAN UTILITY 62 BUS

Daya Pembangkitan = 190,6120 MW
Daya Pembangkitan = 151,8420 MW
Daya Pembangkitan = 250,2490 MW
Daya Pembangkitan = 106,6240 MW
Daya Pembangkitan = 62,3800 MW
Daya Pembangkitan = 134,5080 MW
Daya Pembangkitan = 78,5330 MW
Daya Pembangkitan = 213,9570 MW
Daya Pembangkitan = 92,7840 MW
Daya Pembangkitan = 82,9570 MW
Daya Pembangkitan = 24,6080 MW
Daya Pembangkitan = 72,6330 MW
Daya Pembangkitan = 219,4410 MW
Daya Pembangkitan = 339,7080 MW

Total Daya Pembangkitan = 2967,6248 MW

Biaya Pembangkitan = 2245,2399 $/hour
Biaya Pembangkitan = 992,0901 $/hour
Biaya Pembangkitan = 1427,3151 $/hour
Biaya Pembangkitan = 91,7606 $/hour
Biaya Pembangkitan = 982,5982 $/hour
Biaya Pembangkitan = 1052,2791 $/hour
Biaya Pembangkitan = 905,5214 $/hour
Biaya Pembangkitan = 1766,9292 $/hour
Biaya Pembangkitan = 791,3778 $/hour
Biaya Pembangkitan = 96,9725 $/hour
Biaya Pembangkitan = 361,6286 $/hour
Biaya Pembangkitan = 160,1716 $/hour
Biaya Pembangkitan = 689,0106 $/hour
Biaya Pembangkitan = 272,1943 $/hour
Biaya Pembangkitan = 514,6300 $/hour
Biaya Pembangkitan = 127,1762 $/hour
Biaya Pembangkitan 84,9269 $/hour
Biaya Pembangkitan = 592,8002 $/hour
Biaya Pembangkitan = 2881,6062 $/hour

Total Biaya Pembangkitan = 16035,3630 $/hour
Elapsed time is 1530,89 seconds.

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

**1. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode FOA dengan batas-batas daya generator sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 4,40322e-07

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ----Generation---- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -12,9251 | 34,8000 | 4,9000 | 8,0000 | 85,8798 | 0,0000 |
| 2 | 0,9434 | -13,3991 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9069 | -15,7206 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9431 | -12,8479 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9364 | -13,0682 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9410 | -12,4783 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9544 | -9,3004 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -7,6996 | 2,4000 | 0,5700 | 22,9300 | -12,7741 | 0,0000 |
| 9 | 0,9460 | -10,8471 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9365 | -11,9999 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9687 | -5,0484 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -3,9824 | 16,0000 | 6,3000 | 8,0000 | -12,6712 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 248,1988 | 56,9570 | 0,0000 |
| 14 | 0,9794 | -2,3789 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9711 | -3,1901 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9647 | -3,7291 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9617 | -4,1085 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9639 | -3,6421 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -5,5088 | 18,7000 | 5,7300 | 51,1000 | 45,6699 | 0,0000 |
| 20 | 0,9727 | -6,2087 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9717 | -6,7222 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9726 | -6,5510 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9843 | -2,7965 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9913 | -1,0268 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 2,7687 | 23,0000 | 8,5500 | 242,6700 | 66,4059 | 0,0000 |
| 26 | 0,9404 | -6,7747 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -7,7636 | 19,4300 | 6,1200 | 5,0000 | -2,8547 | 0,0000 |
| 28 | 0,9564 | -8,6122 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9515 | -9,2362 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 585,8988 | 226,6126 | 0,0000 |
| Total loss | | | 20,749 | 56,873 | | | |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,7980 | 0,0156 | -0,0572 | 0,0003 | -0,0388 | -0,0077 | 0,0539 |
| 0,0156 | 0,0242 | -0,0065 | -0,0036 | 0,0072 | 0,0038 | 0,0017 |
| -0,0572 | -0,0065 | 0,0425 | 0,0073 | 0,0023 | -0,0028 | -0,0158 |
| 0,0003 | -0,0036 | 0,0073 | 0,0191 | -0,0051 | -0,0032 | -0,0078 |
| -0,0388 | 0,0072 | 0,0023 | -0,0051 | 0,0294 | 0,0062 | 0,0016 |
| -0,0077 | 0,0038 | -0,0028 | -0,0032 | 0,0062 | 0,0188 | 0,0083 |
| 0,0539 | 0,0017 | -0,0158 | -0,0078 | 0,0016 | 0,0083 | 0,1513 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0176 | -0,0011 | 0,0005 | 0,0001 | 0,0032 | 0,0004 | -0,0009 |

B00 =

4,1365e-04

Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 22,9300 MW
Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 248,1988 MW
Daya Pembangkitan = 51,1000 MW
Daya Pembangkitan = 242,6700 MW
Daya Pembangkitan = 5,0000 MW

Total Daya Pembangkitan = 585,8988 MW

Biaya Pembangkitan = 17927200,0000 $/hour
Biaya Pembangkitan = 9800282,0000 $/hour
Biaya Pembangkitan = 15342400,0000 $/hour
Biaya Pembangkitan = 107408041,2579 $/hour
Biaya Pembangkitan = 97521284,0000 $/hour
Biaya Pembangkitan = 103809372,5938 $/hour
Biaya Pembangkitan = 13171500,0000 $/hour

Total Biaya Pembangkitan = 364980079,8517 $/hour
Total Rugi Daya Aktif = 20,7489 MW
Elapsed time is 370,47 seconds.

**2. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode ABC dengan batas-batas daya generator sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 0,000247754

No. of Iterations = 3

| Bus | Voltage | Angle | ------Load------ | | ---Generation--- | | Injected |
|---|---|---|---|---|---|---|---|
| No. | Mag. | Degree | MW | Mvar | MW | Mvar | Mvar |
| 1 | 0,9480 | -12,9925 | 34,8000 | 4,9000 | 8,0000 | 86,1131 | 0,0000 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 2 | 0,9434 | -13,4687 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9067 | -15,8015 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9430 | -12,9149 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9363 | -13,1362 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9409 | -12,5435 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9544 | -9,3506 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -7,7423 | 2,4000 | 0,5700 | 22,9300 | -12,6879 | 0,0000 |
| 9 | 0,9460 | -10,9042 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9364 | -12,0624 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9685 | -5,0773 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -4,0058 | 16,0000 | 6,3000 | 8,0000 | -12,1045 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 248,2684 | 56,4909 | 0,0000 |
| 14 | 0,9794 | -2,3917 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9710 | -3,2070 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9646 | -3,7489 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9615 | -4,1304 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9637 | -3,6620 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -5,5410 | 18,7000 | 5,7300 | 51,1000 | 45,7057 | 0,0000 |
| 20 | 0,9727 | -6,2441 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9717 | -6,7600 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9726 | -6,5880 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9842 | -2,8146 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9912 | -1,0352 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 2,7776 | 23,0000 | 8,5500 | 242,6700 | 66,2424 | 0,0000 |
| 26 | 0,9404 | -6,8139 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -7,8091 | 19,4300 | 6,1200 | 5,0000 | -2,7832 | 0,0000 |
| 28 | 0,9562 | -8,6589 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9513 | -9,2860 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 585,9684 | 226,9766 | 0,0000 |
| Total loss | | | 20,844 | 57,315 | | | |

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,8061 | 0,0156 | -0,0552 | 0,0002 | -0,0391 | -0,0077 | 0,0528 |
| 0,0156 | 0,0242 | -0,0063 | -0,0036 | 0,0073 | 0,0038 | 0,0017 |
| -0,0552 | -0,0063 | 0,0400 | 0,0074 | 0,0020 | -0,0029 | -0,0153 |
| 0,0002 | -0,0036 | 0,0074 | 0,0192 | -0,0051 | -0,0032 | -0,0079 |
| -0,0391 | 0,0073 | 0,0020 | -0,0051 | 0,0296 | 0,0063 | 0,0016 |
| -0,0077 | 0,0038 | -0,0029 | -0,0032 | 0,0063 | 0,0189 | 0,0083 |
| 0,0528 | 0,0017 | -0,0153 | -0,0079 | 0,0016 | 0,0083 | 0,1501 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B0 =
-0,0177 -0,0011 0,0005 0,0001 0,0032 0,0004 -0,0009

B00 =
4,1572e-04

Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 22,930 MW
Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 248,268 MW
Daya Pembangkitan = 51,100 MW
Daya Pembangkitan = 242,670 MW
Daya Pembangkitan = 5,000 MW

Total Daya Pembangkitan = 585,968 MW

Biaya Pembangkitan = 17927200,000 IDR/hour
Biaya Pembangkitan = 9800282,000 IDR/hour
Biaya Pembangkitan = 15342400,000 IDR/hour
Biaya Pembangkitan = 107438150,093 IDR/hour
Biaya Pembangkitan = 97521284,000 IDR/hour
Biaya Pembangkitan = 103809372,594 IDR/hour
Biaya Pembangkitan = 13171500,000 IDR/hour

Total Biaya Pembangkitan = 365010188,687 IDR/hour
Elapsed time is 1201,32 seconds,

**3. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid FOA-ABC dengan batas-batas daya generator sebagai *constraint* untuk beban 339,74 MW**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 9,92563e-06
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | -------Load------- MW | Mvar | -----Generation----- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -0,9609 | 34,8000 | 4,9000 | 8,0000 | 49,8961 | 0,0000 |
| 2 | 0,9453 | -1,1329 | 17,3000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9280 | -1,8936 | 33,7000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9457 | -0,4144 | 9,1000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9420 | -0,1615 | 15,3000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9451 | 0,2391 | 9,2500 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9562 | 3,2764 | 4,1000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

| Bus No. | Voltage Mag. | Angle Degree | -------Load------- MW | Mvar | -----Generation----- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 8 | 0,9630 | 4,7123 | 2,4000 | 0,5700 | 22,9300 | -20,3729 | 0,0000 |
| 9 | 0,9502 | -0,5584 | 12,7500 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9442 | -0,9841 | 24,8500 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9747 | 6,4383 | 11,5000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | 0,2226 | 16,0000 | 6,3000 | 8,0000 | -94,8910 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 13,5536 | 149,5591 | 0,0000 |
| 14 | 0,9809 | 0,5941 | 6,1500 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9758 | 1,2053 | 4,1000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9735 | 2,0644 | 11,2500 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9733 | 2,7084 | 6,2000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9734 | 3,8746 | 12,7500 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | 6,7348 | 18,7000 | 5,7300 | 51,1000 | 35,3863 | 0,0000 |
| 20 | 0,9759 | 6,4811 | 11,6000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9764 | 6,2667 | 0,9000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9766 | 6,3354 | 1,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9881 | 8,3299 | 15,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9961 | 8,4430 | 6,0500 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 12,2191 | 23,0000 | 8,5500 | 242,6700 | 72,6163 | 0,0000 |
| 26 | 0,9419 | 5,8284 | 3,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | 5,1378 | 19,4300 | 6,1200 | 5,0000 | -7,7702 | 0,0000 |
| 28 | 0,9687 | 5,5660 | 4,2500 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9661 | 5,3375 | 5,3100 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 339,7400 | 169,7400 | 351,2536 | 184,4237 | 0,0000 |
| Total loss | | | | 11,515 | 14,688 | | |

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,2321 | 0,0107 | -0,2044 | 0,1073 | -0,0162 | -0,0076 | 0,0783 |
| 0,0107 | 0,0251 | -0,0339 | 0,0265 | 0,0043 | 0,0020 | -0,0036 |
| -0,2044 | -0,0339 | 1,3826 | -0,9999 | 0,0254 | 0,0037 | -0,1633 |
| 0,1073 | 0,0265 | -0,9999 | 1,7911 | -0,0305 | -0,0093 | 0,1200 |
| -0,0162 | 0,0043 | 0,0254 | -0,0305 | 0,0180 | 0,0041 | -0,0024 |
| -0,0076 | 0,0020 | 0,0037 | -0,0093 | 0,0041 | 0,0140 | 0,0016 |
| 0,0783 | -0,0036 | -0,1633 | 0,1200 | -0,0024 | 0,0016 | 0,2932 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0075 | -0,0018 | 0,0027 | 0,0043 | 0,0011 | -0,0001 | -0,0001 |

B00 =

2,8389e-04

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 22,930 MW
Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 13,554 MW
Daya Pembangkitan = 51,100 MW
Daya Pembangkitan = 242,670 MW
Daya Pembangkitan = 5,000 MW

Total Daya Pembangkitan = 351,254 MW

Biaya Pembangkitan = 17927200,000 IDR/hour
Biaya Pembangkitan = 9800282,000 IDR/hour
Biaya Pembangkitan = 15342400,000 IDR/hour
Biaya Pembangkitan = 5865335,127 IDR/hour
Biaya Pembangkitan = 97521284,000 IDR/hour
Biaya Pembangkitan = 103809372,594 IDR/hour
Biaya Pembangkitan = 13171500,000 IDR/hour

Total Biaya Pembangkitan = 263437373,721 IDR/hour

Total Rugi Daya aktif = 11,515 MW
Elapsed time is 460,67 seconds.

4. **Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid FOA-ABC dengan batas-batas daya generator sebagai *constraint* untuk beban puncak 452.445 MW**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 1,65451e-06
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | -------Load------- MW | Mvar | -----Generation----- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -6,3495 | 34,8000 | 4,9000 | 8,0000 | 65,8957 | 0,0000 |
| 2 | 0,9444 | -6,6629 | 25,9500 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9181 | -8,1417 | 50,5500 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9444 | -5,9997 | 13,6500 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9392 | -5,9530 | 22,9500 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9430 | -5,4557 | 13,8750 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9553 | -2,2686 | 6,1500 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -0,7176 | 2,4000 | 0,5700 | 22,9300 | -16,0399 | 0,0000 |
| 9 | 0,9487 | -5,1856 | 19,1250 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9409 | -5,9496 | 37,2750 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9717 | 1,4772 | 17,2500 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -1,6586 | 16,0000 | 6,3000 | 8,0000 | -56,5952 | 0,0000 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

| Bus No. | Voltage Mag. | Angle Degree | -------Load------- MW | Mvar | -----Generation----- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 128,0098 | 97,4623 | 0,0000 |
| 14 | 0,9805 | -0,7237 | 9,2250 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9741 | -0,7337 | 6,1500 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9699 | -0,4754 | 16,8750 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9683 | -0,2687 | 9,3000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9692 | 0,6188 | 19,1250 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | 1,4398 | 18,7000 | 5,7300 | 51,1000 | 40,1480 | 0,0000 |
| 20 | 0,9743 | 0,9773 | 17,4000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9743 | 0,6221 | 1,3500 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9748 | 0,7389 | 1,5000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9863 | 3,5868 | 22,5000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9940 | 4,4500 | 9,0750 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 8,3452 | 23,0000 | 8,5500 | 242,6700 | 67,5179 | 0,0000 |
| 26 | 0,9413 | 0,3377 | 4,5000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -0,5151 | 19,4300 | 6,1200 | 5,0000 | -4,9088 | 0,0000 |
| 28 | 0,9629 | -0,6317 | 6,3750 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9593 | -1,0432 | 7,9650 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 452,4450 | 169,7400 | 465,7098 | 193,4799 | 0,0000 |
| Total loss | | | 3,265 | 23,741 | | | |

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,4387 | 0,0134 | -0,1741 | 0,0102 | -0,0253 | -0,0074 | 0,0694 |
| 0,0134 | 0,0245 | -0,0193 | -0,0019 | 0,0058 | 0,0030 | 0,0000 |
| -0,1741 | -0,0193 | 0,5634 | -0,0361 | 0,0189 | 0,0004 | -0,0666 |
| 0,0102 | -0,0019 | -0,0361 | 0,0262 | -0,0066 | -0,0034 | -0,0034 |
| -0,0253 | 0,0058 | 0,0189 | -0,0066 | 0,0234 | 0,0052 | -0,0004 |
| -0,0074 | 0,0030 | 0,0004 | -0,0034 | 0,0052 | 0,0166 | 0,0055 |
| 0,0694 | 0,0000 | -0,0666 | -0,0034 | -0,0004 | 0,0055 | 0,1990 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0121 | -0,0016 | 0,0021 | 0,0004 | 0,0020 | 0,0001 | -0,0011 |

B00 =

3,5060e-04

Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 22,930 MW
Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 128,010 MW
Daya Pembangkitan = 51,100 MW
Daya Pembangkitan = 242,670 MW

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

Daya Pembangkitan = 5,000 MW
Total Daya Pembangkitan = 465,710 MW

Biaya Pembangkitan = 17927200,000 IDR/hour
Biaya Pembangkitan = 9800282,000 IDR/hour
Biaya Pembangkitan = 15342400,000 IDR/hour
Biaya Pembangkitan = 55396220,178 IDR/hour
Biaya Pembangkitan = 97521284,000 IDR/hour
Biaya Pembangkitan = 103809372,594 IDR/hour
Biaya Pembangkitan = 13171500,000 IDR/hour

Total Biaya Pembangkitan = 312968258,772 IDR/hour
Total Rugi Daya aktif = 13,265 MW
Elapsed time is 699,07 seconds.

**5. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid FOA-ABC dengan batas-batas daya generator sebagai *constraint* untuk beban puncak 565,15 MW**

Number of evaluations: 200
Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 2,63696e-05
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | -----Generation----- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -9,8741 | 34,8000 | 4,9000 | 8,0000 | 72,2067 | 0,0000 |
| 2 | 0,9444 | -10,2480 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9160 | -12,0589 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9446 | -9,8169 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9397 | -9,9917 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9435 | -9,5300 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9557 | -7,0441 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -5,7881 | 2,4000 | 0,5700 | 22,9300 | -17,5824 | 0,0000 |
| 9 | 0,9482 | -8,2660 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9407 | -9,1699 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9734 | -3,7660 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -2,9271 | 16,0000 | 6,3000 | 8,0000 | -45,0101 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 244,0306 | 84,5797 | 0,0000 |
| 14 | 0,9819 | -1,8036 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9760 | -2,4294 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9716 | -2,8410 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9697 | -3,1302 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9719 | -2,7540 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -4,0820 | 18,7000 | 5,7300 | 51,1000 | 43,6960 | 0,0000 |
| 20 | 0,9743 | -4,6338 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | -----Generation----- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 21 | 0,9737 | -5,0383 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9743 | -4,9035 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9871 | -2,0112 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9951 | -0,6772 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 2,3183 | 23,0000 | 8,5500 | 242,6700 | 76,2975 | 0,0000 |
| 26 | 0,9412 | -5,0266 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -5,7311 | 19,4300 | 6,1200 | 5,0000 | -7,0372 | 0,0000 |
| 28 | 0,9618 | -6,5197 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9580 | -7,0066 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 581,7306 | 207,1501 | 0,0000 |
| Total loss | | | 16,583 | 37,417 | | | |

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,4456 | 0,0146 | -0,1278 | 0,0028 | -0,0249 | -0,0081 | 0,0918 |
| 0,0146 | 0,0231 | -0,0144 | -0,0024 | 0,0040 | 0,0027 | 0,0019 |
| -0,1278 | -0,0144 | 0,3114 | -0,0047 | 0,0139 | 0,0008 | -0,0596 |
| 0,0028 | -0,0024 | -0,0047 | 0,0161 | -0,0044 | -0,0026 | -0,0044 |
| -0,0249 | 0,0040 | 0,0139 | -0,0044 | 0,0222 | 0,0052 | -0,0007 |
| -0,0081 | 0,0027 | 0,0008 | -0,0026 | 0,0052 | 0,0151 | 0,0051 |
| 0,0918 | 0,0019 | -0,0596 | -0,0044 | -0,0007 | 0,0051 | 0,2677 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0116 | -0,0014 | 0,0012 | 0,0001 | 0,0023 | 0,0004 | -0,0016 |

B00 =

3,2037e-04

Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 22,9300 MW
Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 244,0306 MW
Daya Pembangkitan = 51,1000 MW
Daya Pembangkitan = 242,6700 MW
Daya Pembangkitan = 5,0000 MW
Total Daya Pembangkitan = 581,7306 MW

Biaya Pembangkitan = 17927200,0000 IDR/hour
Biaya Pembangkitan = 9800282,0000 IDR/hour
Biaya Pembangkitan = 15342400,0000 IDR/hour
Biaya Pembangkitan = 105604256,0778 IDR/hour
Biaya Pembangkitan = 97521284,0000 IDR/hour

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

Biaya Pembangkitan = 103809372,5938 IDR/hour
Biaya Pembangkitan = 13171500,0000 IDR/hour

Total Biaya Pembangkitan = 363176294,6716 IDR/hour
Total Rugi Daya Aktif = 16,5831 MW
Elapsed time is 1816,88 seconds,

**6. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid FOA-ABC dengan batas-batas daya generator sebagai *constraint* terintegrasi dengan PLTB Tolo**

Number of evaluations: 200
Daya Pembangkitan Thermal= 2,0000 MW
Daya Pembangkitan Thermal= 38,7300 MW
Daya Pembangkitan Thermal= 5,0000 MW
Daya Pembangkitan Thermal= 222,3500 MW
Daya Pembangkitan Thermal= 15,0000 MW
Daya Pembangkitan Thermal= 245,0000 MW
Daya Pembangkitan Thermal= 1,2500 MW
Daya Pembangkitan Wind= 50,3300 MW

Total Daya Pembangkitan Thermal= 529,3300 MW

Total Daya Pembangkitan (Thermal+wind)= 579,6600 MW

Biaya Pembangkitan Thermal= 4466282,6690 IDR/hour
Biaya Pembangkitan Thermal= 16495889,8676 IDR/hour
Biaya Pembangkitan Thermal= 9555800,0163 IDR/hour
Biaya Pembangkitan Thermal= 95888813,3186 IDR/hour
Biaya Pembangkitan Thermal= 28527486,1555 IDR/hour
Biaya Pembangkitan Thermal= 104443229,9534 IDR/hour
Biaya Pembangkitan Thermal= 3281474,0826 IDR/hour
Biaya Pembangkitan Langsung (Cw) = 5070797,8300 IDR/hour
Biaya Pembangkitan Penalti (Cp) = 71,8821 IDR/hour
Biaya Pembangkitan Cadangan (Cr) = 590826,8015 IDR/hour

Total Biaya Pembangkitan Thermal= 262658976,0630 IDR/hour
Total Biaya Pembangkitan Wind= 5661696,5136 IDR/hour
Total Biaya Pembangkitan (Thermal+Wind)= 268320672,5766 IDR/hour

Rugi Daya = 14,7969 MW
Elapsed time is 2902,94 seconds.

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

**7. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid MFOA-ABC dengan batas-batas daya generator sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 3,58271e-08

No, of Iterations = 4

| Bus No, | Voltage Mag, | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -3,8108 | 34,8000 | 4,9000 | 8,0000 | 11,4623 | 0,0000 |
| 2 | 0,9464 | -3,9769 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9342 | -4,7642 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9477 | -3,8019 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9463 | -3,8888 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9484 | -3,6917 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9580 | -2,6532 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -2,1241 | 2,4000 | 0,5700 | 22,9300 | -41,7676 | 0,0000 |
| 9 | 0,9517 | -3,1405 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9484 | -3,5381 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9816 | -1,3800 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -0,8425 | 16,0000 | 6,3000 | 8,0000 | -210,3048 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 238,1638 | 254,0930 | 0,0000 |
| 14 | 0,9866 | -0,6720 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9852 | -0,9441 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9846 | -1,1265 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9848 | -1,2558 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9871 | -1,0842 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -1,4333 | 18,7000 | 5,7300 | 51,1000 | 42,0481 | 0,0000 |
| 20 | 0,9775 | -1,6782 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9774 | -1,8576 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9776 | -1,7978 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9916 | -0,6562 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 1,0019 | -0,1790 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 1,1257 | 23,0000 | 8,5500 | 242,6700 | 152,1412 | 0,0000 |
| 26 | 0,9421 | -1,7144 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -1,8407 | 19,4300 | 6,1200 | 5,0000 | -30,2795 | 0,0000 |
| 28 | 0,9723 | -2,5079 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9706 | -2,7196 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 575,8638 | 177,3927 | 0,0000 |
| Total loss | | | 10,714 | 7,653 | | | |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0073 | 0,0019 | -0,0410 | 0,0013 | -0,0030 | -0,0031 | 0,0269 |
| 0,0019 | 0,0277 | -0,0609 | 0,0012 | -0,0021 | -0,0001 | 0,0046 |
| -0,0410 | -0,0609 | 2,9241 | -0,0883 | 0,0308 | 0,0176 | -0,4900 |
| 0,0013 | 0,0012 | -0,0883 | 0,0136 | -0,0028 | -0,0017 | 0,0146 |
| -0,0030 | -0,0021 | 0,0308 | -0,0028 | 0,0095 | 0,0029 | -0,0048 |
| -0,0031 | -0,0001 | 0,0176 | -0,0017 | 0,0029 | 0,0085 | -0,0074 |
| 0,0269 | 0,0046 | -0,4900 | 0,0146 | -0,0048 | -0,0074 | 1,4972 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0009 | -0,0016 | 0,0023 | 0,0001 | 0,0009 | 0,0005 | -0,0029 |

B00 =

1,3766e-04

Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 22,930 MW
Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 238,164 MW
Daya Pembangkitan = 51,100 MW
Daya Pembangkitan = 242,670 MW
Daya Pembangkitan = 5,000 MW

Total Daya Pembangkitan = 575,864 MW

Biaya Pembangkitan = 17927200,000 IDR/hour
Biaya Pembangkitan = 9800282,000 IDR/hour
Biaya Pembangkitan = 15342400,000 IDR/hour
Biaya Pembangkitan = 103065402,587 IDR/hour
Biaya Pembangkitan = 97521284,000 IDR/hour
Biaya Pembangkitan = 103809372,594 IDR/hour
Biaya Pembangkitan = 13171500,000 IDR/hour

Total Biaya Pembangkitan = 360637441,180 IDR/hour
Elapsed time is 2687,74 seconds.

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

**8. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode FOA dengan batas-batas daya generator dan generator ramp rate sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 4,40322e-07
No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -12,9251 | 34,8000 | 4,9000 | 8,0000 | 85,8798 | 0,0000 |
| 2 | 0,9434 | -13,3991 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9069 | -15,7206 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9431 | -12,8479 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9364 | -13,0682 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9410 | -12,4783 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9544 | -9,3004 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -7,6996 | 2,4000 | 0,5700 | 22,9300 | -12,7741 | 0,0000 |
| 9 | 0,9460 | -10,8471 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9365 | -11,9999 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9687 | -5,0484 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -3,9824 | 16,0000 | 6,3000 | 8,0000 | -12,6712 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 248,1988 | 56,9570 | 0,0000 |
| 14 | 0,9794 | -2,3789 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9711 | -3,1901 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9647 | -3,7291 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9617 | -4,1085 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9639 | -3,6421 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -5,5088 | 18,7000 | 5,7300 | 51,1000 | 45,6699 | 0,0000 |
| 20 | 0,9727 | -6,2087 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9717 | -6,7222 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9726 | -6,5510 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9843 | -2,7965 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9913 | -1,0268 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 2,7687 | 23,0000 | 8,5500 | 242,6700 | 66,4059 | 0,0000 |
| 26 | 0,9404 | -6,7747 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -7,7636 | 19,4300 | 6,1200 | 5,0000 | -2,8547 | 0,0000 |
| 28 | 0,9564 | -8,6122 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9515 | -9,2362 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 585,8988 | 226,6126 | 0,0000 |
| Total loss | | | 20,749 | 56,873 | | | |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,7980 | 0,0156 | -0,0572 | 0,0003 | -0,0388 | -0,0077 | 0,0539 |
| 0,0156 | 0,0242 | -0,0065 | -0,0036 | 0,0072 | 0,0038 | 0,0017 |
| -0,0572 | -0,0065 | 0,0425 | 0,0073 | 0,0023 | -0,0028 | -0,0158 |
| 0,0003 | -0,0036 | 0,0073 | 0,0191 | -0,0051 | -0,0032 | -0,0078 |
| -0,0388 | 0,0072 | 0,0023 | -0,0051 | 0,0294 | 0,0062 | 0,0016 |
| -0,0077 | 0,0038 | -0,0028 | -0,0032 | 0,0062 | 0,0188 | 0,0083 |
| 0,0539 | 0,0017 | -0,0158 | -0,0078 | 0,0016 | 0,0083 | 0,1513 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0176 | -0,0011 | 0,0005 | 0,0001 | 0,0032 | 0,0004 | -0,0009 |

B00 =

4,1365e-04

Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 22,9300 MW
Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 248,1988 MW
Daya Pembangkitan = 51,1000 MW
Daya Pembangkitan = 242,6700 MW
Daya Pembangkitan = 5,0000 MW

Total Daya Pembangkitan = 585,8988 MW

Biaya Pembangkitan = 17927200,0000 $/hour
Biaya Pembangkitan = 9800282,0000 $/hour
Biaya Pembangkitan = 15342400,0000 $/hour
Biaya Pembangkitan = 107408041,2579 $/hour
Biaya Pembangkitan = 97521284,0000 $/hour
Biaya Pembangkitan = 103809372,5938 $/hour
Biaya Pembangkitan = 13171500,0000 $/hour

Total Biaya Pembangkitan = 364980079,8517 $/hour

Total Rugi Daya Aktif = 20,7489 MW
Elapsed time is 370,47 seconds.

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

**9. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode ABC dengan batas-batas daya generator dan generator ramp rate sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 0,000256303

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -13,1445 | 34,8000 | 4,9000 | 8,0000 | 86,6926 | 0,0000 |
| 2 | 0,9433 | -13,6256 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9062 | -15,9837 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9429 | -13,0660 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9361 | -13,2896 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9408 | -12,6906 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9543 | -9,4638 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -7,8387 | 2,4000 | 0,5700 | 22,9300 | -12,4935 | 0,0000 |
| 9 | 0,9459 | -11,0328 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9362 | -12,2033 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9683 | -5,1426 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -4,0585 | 16,0000 | 6,3000 | 8,0000 | -10,7971 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 248,4831 | 55,4629 | 0,0000 |
| 14 | 0,9792 | -2,4204 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9708 | -3,2451 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9642 | -3,7935 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9611 | -4,1798 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9633 | -3,7071 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -5,6138 | 18,7000 | 5,7300 | 51,1000 | 45,8100 | 0,0000 |
| 20 | 0,9726 | -6,3241 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9716 | -6,8453 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9725 | -6,6715 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9841 | -2,8555 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9910 | -1,0543 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 2,7974 | 23,0000 | 8,5500 | 242,6700 | 65,9172 | 0,0000 |
| 26 | 0,9403 | -6,9024 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -7,9116 | 19,4300 | 6,1200 | 5,0000 | -2,6201 | 0,0000 |
| 28 | 0,9560 | -8,7644 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9510 | -9,3983 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 586,1831 | 227,9720 | 0,0000 |
| Total losses | | | 21,060 | 58,313 | | | |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,8254 | 0,0156 | -0,0506 | 0,0001 | -0,0399 | -0,0076 | 0,0503 |
| 0,0156 | 0,0243 | -0,0061 | -0,0037 | 0,0074 | 0,0039 | 0,0017 |
| -0,0506 | -0,0061 | 0,0347 | 0,0078 | 0,0013 | -0,0030 | -0,0144 |
| 0,0001 | -0,0037 | 0,0078 | 0,0194 | -0,0051 | -0,0032 | -0,0080 |
| -0,0399 | 0,0074 | 0,0013 | -0,0051 | 0,0300 | 0,0063 | 0,0017 |
| -0,0076 | 0,0039 | -0,0030 | -0,0032 | 0,0063 | 0,0191 | 0,0085 |
| 0,0503 | 0,0017 | -0,0144 | -0,0080 | 0,0017 | 0,0085 | 0,1476 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0180 | -0,0011 | 0,0004 | 0,0001 | 0,0033 | 0,0004 | -0,0008 |

B00 =

4,2040e-04

Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 22,930 MW
Daya Pembangkitan = 8,000 MW
Daya Pembangkitan = 248,483 MW
Daya Pembangkitan = 51,100 MW
Daya Pembangkitan = 242,670 MW
Daya Pembangkitan = 5,000 MW

Total Daya Pembangkitan = 586,183 MW

Biaya Pembangkitan = 17927200,000 IDR/hour
Biaya Pembangkitan = 9800282,000 IDR/hour
Biaya Pembangkitan = 15342400,000 IDR/hour
Biaya Pembangkitan = 107531044,382 IDR/hour
Biaya Pembangkitan = 97521284,000 IDR/hour
Biaya Pembangkitan = 103809372,594 IDR/hour
Biaya Pembangkitan = 13171500,000 IDR/hour

Total Biaya Pembangkitan = 365103082,976 IDR/hour
Elapsed time is 352,67 seconds.

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

**10. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid FOA-ABC dengan batas-batas daya generator dan generator ramp rate sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 2,19267e-05

No. of Iterations = 3

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -10,0748 | 34,8000 | 4,9000 | 8,0000 | 73,2531 | 0,0000 |
| 2 | 0,9443 | -10,4554 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9154 | -12,2999 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9445 | -10,0162 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9395 | -10,1940 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9433 | -9,7237 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9556 | -7,1915 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -5,9125 | 2,4000 | 0,5700 | 22,9300 | -17,2010 | 0,0000 |
| 9 | 0,9481 | -8,4357 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9404 | -9,3562 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9731 | -3,8488 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -2,9964 | 16,0000 | 6,3000 | 8,0000 | -42,4415 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 244,2938 | 82,2577 | 0,0000 |
| 14 | 0,9818 | -1,8414 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9757 | -2,4791 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9711 | -2,8989 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9691 | -3,1938 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9713 | -2,8115 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -4,1740 | 18,7000 | 5,7300 | 51,1000 | 43,8164 | 0,0000 |
| 20 | 0,9742 | -4,7357 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9735 | -5,1474 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9742 | -5,0101 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9869 | -2,0608 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 0,9949 | -0,6983 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 2,3509 | 23,0000 | 8,5500 | 242,6700 | 75,4019 | 0,0000 |
| 26 | 0,9411 | -5,1400 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -5,8633 | 19,4300 | 6,1200 | 5,0000 | -6,6964 | 0,0000 |
| 28 | 0,9614 | -6,6559 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9575 | -7,1518 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 581,9938 | 208,3902 | 0,0000 |
| Total loss | | | 16,846 | 38,656 | | | |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,4667 | 0,0148 | -0,1246 | 0,0027 | -0,0258 | -0,0081 | 0,0901 |

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0148 | 0,0231 | -0,0137 | -0,0025 | 0,0042 | 0,0028 | 0,0019 |
| -0,1246 | -0,0137 | 0,2829 | -0,0037 | 0,0132 | 0,0006 | -0,0550 |
| 0,0027 | -0,0025 | -0,0037 | 0,0163 | -0,0044 | -0,0026 | -0,0047 |
| -0,0258 | 0,0042 | 0,0132 | -0,0044 | 0,0227 | 0,0052 | -0,0006 |
| -0,0081 | 0,0028 | 0,0006 | -0,0026 | 0,0052 | 0,0154 | 0,0053 |
| 0,0901 | 0,0019 | -0,0550 | -0,0047 | -0,0006 | 0,0053 | 0,2554 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0120 | -0,0013 | 0,0012 | 0,0001 | 0,0024 | 0,0004 | -0,0016 |

B00 =

3,2647e-04

Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 22,9300 MW
Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 244,2938 MW
Daya Pembangkitan = 51,1000 MW
Daya Pembangkitan = 242,6700 MW
Daya Pembangkitan = 5,0000 MW

Total Daya Pembangkitan = 581,9938 MW

Biaya Pembangkitan = 17927200,0000 $/hour
Biaya Pembangkitan = 9800282,0000 $/hour
Biaya Pembangkitan = 15342400,0000 $/hour
Biaya Pembangkitan = 105718137,7515 $/hour
Biaya Pembangkitan = 97521284,0000 $/hour
Biaya Pembangkitan = 103809372,5938 $/hour
Biaya Pembangkitan = 13171500,0000 $/hour

Total Biaya Pembangkitan = 363290176,3453 $/hour
Total Rugi Daya Aktif = 16,8458 MW
Elapsed time is 1377,86 seconds.

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

**11. Hasil simulasi sistem kelistrikan Sulselbar 150 kV menggunakan metode Hybrid MFOA-ABC dengan batas-batas daya generator dan generator ramp rate sebagai *constraint***

Number of evaluations: 200

Power Flow Solution by Newton-Raphson Method
Maximum Power Mismatch = 3,58208e-08
No. of Iterations = 4

| Bus No. | Voltage Mag. | Angle Degree | ------Load------ MW | Mvar | ---Generation--- MW | Mvar | Injected Mvar |
|---|---|---|---|---|---|---|---|
| 1 | 0,9480 | -3,8110 | 34,8000 | 4,9000 | 8,0000 | 11,4663 | 0,0000 |
| 2 | 0,9464 | -3,9771 | 34,6000 | 9,1000 | 0,0000 | 0,0000 | 0,0000 |
| 3 | 0,9342 | -4,7644 | 67,4000 | 14,7000 | 0,0000 | 0,0000 | 0,0000 |
| 4 | 0,9477 | -3,8021 | 18,2000 | 5,5000 | 0,0000 | 0,0000 | 0,0000 |
| 5 | 0,9463 | -3,8890 | 30,6000 | 11,8500 | 0,0000 | 0,0000 | 0,0000 |
| 6 | 0,9484 | -3,6919 | 18,5000 | 6,0000 | 0,0000 | 0,0000 | 0,0000 |
| 7 | 0,9580 | -2,6534 | 8,2000 | 1,5700 | 0,0000 | 0,0000 | 0,0000 |
| 8 | 0,9630 | -2,1242 | 2,4000 | 0,5700 | 22,9300 | -41,7659 | 0,0000 |
| 9 | 0,9517 | -3,1407 | 25,5000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 |
| 10 | 0,9484 | -3,5383 | 49,7000 | 15,1000 | 0,0000 | 0,0000 | 0,0000 |
| 11 | 0,9816 | -1,3800 | 23,0000 | 9,8000 | 0,0000 | 0,0000 | 0,0000 |
| 12 | 0,9620 | -0,8426 | 16,0000 | 6,3000 | 8,0000 | -210,2934 | 0,0000 |
| 13 | 1,0000 | 0,0000 | 0,0000 | 0,0000 | 238,1639 | 254,0806 | 0,0000 |
| 14 | 0,9866 | -0,6720 | 12,3000 | 4,6000 | 0,0000 | 0,0000 | 0,0000 |
| 15 | 0,9852 | -0,9441 | 8,2000 | 2,3000 | 0,0000 | 0,0000 | 0,0000 |
| 16 | 0,9846 | -1,1266 | 22,5000 | 7,9000 | 0,0000 | 0,0000 | 0,0000 |
| 17 | 0,9848 | -1,2559 | 12,4000 | 4,1000 | 0,0000 | 0,0000 | 0,0000 |
| 18 | 0,9871 | -1,0842 | 25,5000 | 10,7000 | 0,0000 | 0,0000 | 0,0000 |
| 19 | 0,9800 | -1,4333 | 18,7000 | 5,7300 | 51,1000 | 42,0480 | 0,0000 |
| 20 | 0,9775 | -1,6783 | 23,2000 | 10,3000 | 0,0000 | 0,0000 | 0,0000 |
| 21 | 0,9774 | -1,8577 | 1,8000 | 0,7300 | 0,0000 | 0,0000 | 0,0000 |
| 22 | 0,9776 | -1,7979 | 2,0000 | 0,2000 | 0,0000 | 0,0000 | 0,0000 |
| 23 | 0,9916 | -0,6562 | 30,0000 | 12,9000 | 0,0000 | 0,0000 | 0,0000 |
| 24 | 1,0019 | -0,1790 | 12,1000 | 4,6200 | 0,0000 | 0,0000 | 0,0000 |
| 25 | 1,0200 | 1,1257 | 23,0000 | 8,5500 | 242,6700 | 152,1353 | 0,0000 |
| 26 | 0,9421 | -1,7145 | 6,0000 | 0,4000 | 0,0000 | 0,0000 | 0,0000 |
| 27 | 0,9230 | -1,8408 | 19,4300 | 6,1200 | 5,0000 | -30,2779 | 0,0000 |
| 28 | 0,9723 | -2,5080 | 8,5000 | 2,5500 | 0,0000 | 0,0000 | 0,0000 |
| 29 | 0,9706 | -2,7197 | 10,6200 | 2,6500 | 0,0000 | 0,0000 | 0,0000 |
| Total | | | 565,1500 | 169,7400 | 575,8639 | 177,3931 | 0,0000 |
| Total loss | | | 10,714 | 7,653 | | | |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

B =

| | | | | | | |
|---|---|---|---|---|---|---|
| 0,0073 | 0,0019 | -0,0410 | 0,0013 | -0,0030 | -0,0031 | 0,0269 |
| 0,0019 | 0,0277 | -0,0609 | 0,0012 | -0,0021 | -0,0001 | 0,0046 |
| -0,0410 | -0,0609 | 2,9239 | -0,0883 | 0,0308 | 0,0176 | -0,4899 |
| 0,0013 | 0,0012 | -0,0883 | 0,0136 | -0,0028 | -0,0017 | 0,0146 |
| -0,0030 | -0,0021 | 0,0308 | -0,0028 | 0,0095 | 0,0029 | -0,0048 |
| -0,0031 | -0,0001 | 0,0176 | -0,0017 | 0,0029 | 0,0085 | -0,0074 |
| 0,0269 | 0,0046 | -0,4899 | 0,0146 | -0,0048 | -0,0074 | 1,4971 |

B0 =

| | | | | | | |
|---|---|---|---|---|---|---|
| -0,0009 | -0,0016 | 0,0023 | 0,0001 | 0,0009 | 0,0005 | -0,0029 |

B00 =

1,3766e-04

Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 22,9300 MW
Daya Pembangkitan = 8,0000 MW
Daya Pembangkitan = 238,1639 MW
Daya Pembangkitan = 51,1000 MW
Daya Pembangkitan = 242,6700 MW
Daya Pembangkitan = 5,0000 MW

Total Daya Pembangkitan = 575,8639 MW

Biaya Pembangkitan = 17927200,0000 $/hour
Biaya Pembangkitan = 9800282,0000 $/hour
Biaya Pembangkitan = 15342400,0000 $/hour
Biaya Pembangkitan = 103065419,3463 $/hour
Biaya Pembangkitan = 97521284,0000 $/hour
Biaya Pembangkitan = 103809372,5938 $/hour
Biaya Pembangkitan = 13171500,0000 $/hour

Total Biaya Pembangkitan = 360637457,9401 $/hour
Total Rugi Daya Aktif = 10,7139 MW
Elapsed time is 1514,01 seconds.

**12. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV dengan indeks L menggunakan metode FOA dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0049 | 0,9434 |
| 3 | 0,0454 | 0,9069 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 4 | 0,0081 | 0,9431 |
| 5 | 0,0172 | 0,9364 |
| 6 | 0,0129 | 0,9410 |
| 7 | 0,0061 | 0,9544 |
| 9 | 0,0086 | 0,9460 |
| 10 | 0,0189 | 0,9365 |
| 11 | 0,0213 | 0,9687 |
| 14 | 0,0136 | 0,9794 |
| 15 | 0,0259 | 0,9711 |
| 16 | 0,0369 | 0,9647 |
| 17 | 0,0435 | 0,9617 |
| 18 | 0,0425 | 0,9639 |
| 20 | 0,0092 | 0,9727 |
| 21 | 0,0138 | 0,9717 |
| 22 | 0,0120 | 0,9726 |
| 23 | 0,0116 | 0,9843 |
| 24 | 0,0185 | 0,9913 |
| 26 | 0,0048 | 0,9404 |
| 28 | 0,0342 | 0,9564 |
| 29 | 0,0406 | 0,9515 |

sigma L^2=0,0132
nilai L3(maks)=0,0454

**13. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV dengan indeks L menggunakan metode ABC dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0049 | 0,9434 |
| 3 | 0,0456 | 0,9067 |
| 4 | 0,0081 | 0,9430 |
| 5 | 0,0173 | 0,9363 |
| 6 | 0,0130 | 0,9409 |
| 7 | 0,0061 | 0,9544 |
| 9 | 0,0086 | 0,9460 |
| 10 | 0,0190 | 0,9364 |
| 11 | 0,0215 | 0,9685 |
| 14 | 0,0137 | 0,9794 |
| 15 | 0,0260 | 0,9710 |
| 16 | 0,0371 | 0,9646 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 17 | 0,0437 | 0,9615 |
| 18 | 0,0428 | 0,9637 |
| 20 | 0,0092 | 0,9727 |
| 21 | 0,0138 | 0,9717 |
| 22 | 0,0121 | 0,9726 |
| 23 | 0,0117 | 0,9842 |
| 24 | 0,0186 | 0,9912 |
| 26 | 0,0048 | 0,9404 |
| 28 | 0,0344 | 0,9562 |
| 29 | 0,0408 | 0,9513 |

sigma L^2=0,0133
nilai L3(maks)=0,0456

**14. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV dengan indeks L menggunakan metode hybrid FOA-ABC dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0039 | 0,9444 |
| 3 | 0,0349 | 0,9160 |
| 4 | 0,0062 | 0,9446 |
| 5 | 0,0133 | 0,9397 |
| 6 | 0,0100 | 0,9435 |
| 7 | 0,0046 | 0,9557 |
| 9 | 0,0062 | 0,9482 |
| 10 | 0,0142 | 0,9407 |
| 11 | 0,0157 | 0,9734 |
| 14 | 0,0105 | 0,9819 |
| 15 | 0,0199 | 0,9760 |
| 16 | 0,0283 | 0,9716 |
| 17 | 0,0333 | 0,9697 |
| 18 | 0,0325 | 0,9719 |
| 20 | 0,0072 | 0,9743 |
| 21 | 0,0106 | 0,9737 |
| 22 | 0,0094 | 0,9743 |
| 23 | 0,0085 | 0,9871 |
| 24 | 0,0139 | 0,9951 |
| 26 | 0,0037 | 0,9412 |
| 28 | 0,0264 | 0,9618 |
| 29 | 0,0313 | 0,9580 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

sigma L^2=0,0077
nilai L3(maks)=0,0349

**15. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV dengan indeks L menggunakan metode hybrid MFOA-ABC dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0017 | 0,9464 |
| 3 | 0,0148 | 0,9342 |
| 4 | 0,0027 | 0,9477 |
| 5 | 0,0057 | 0,9463 |
| 6 | 0,0042 | 0,9484 |
| 7 | 0,0019 | 0,9580 |
| 9 | 0,0022 | 0,9517 |
| 10 | 0,0057 | 0,9484 |
| 11 | 0,0061 | 0,9816 |
| 14 | 0,0045 | 0,9866 |
| 15 | 0,0085 | 0,9852 |
| 16 | 0,0120 | 0,9846 |
| 17 | 0,0141 | 0,9848 |
| 18 | 0,0137 | 0,9871 |
| 20 | 0,0031 | 0,9775 |
| 21 | 0,0045 | 0,9774 |
| 22 | 0,0040 | 0,9776 |
| 23 | 0,0033 | 0,9916 |
| 24 | 0,0057 | 1,0019 |
| 26 | 0,0023 | 0,9421 |
| 28 | 0,0112 | 0,9723 |
| 29 | 0,0133 | 0,9706 |

sigma L^2=0,0014
nilai L3(maks)=0,0148

**16. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV saat pembebanan pada bus 3 (bus Panakkukang) sebesar 289 MW dengan indeks L menggunakan metode FOA dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0048 | 0,9435 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 3 | 0,3709 | 0,6915 |
| 4 | 0,0087 | 0,9425 |
| 5 | 0,0180 | 0,9356 |
| 6 | 0,0141 | 0,9399 |
| 7 | 0,0074 | 0,9531 |
| 9 | 0,0214 | 0,9341 |
| 10 | 0,0319 | 0,9247 |
| 11 | 0,0261 | 0,9641 |
| 14 | 0,0148 | 0,9782 |
| 15 | 0,0277 | 0,9694 |
| 16 | 0,0402 | 0,9615 |
| 17 | 0,0480 | 0,9574 |
| 18 | 0,0445 | 0,9619 |
| 20 | 0,0090 | 0,9729 |
| 21 | 0,0134 | 0,9720 |
| 22 | 0,0117 | 0,9728 |
| 23 | 0,0137 | 0,9822 |
| 24 | 0,0205 | 0,9892 |
| 26 | 0,0053 | 0,9398 |
| 28 | 0,0334 | 0,9569 |
| 29 | 0,0396 | 0,9522 |

sigma L^2=0,1510
nilai L3(maks)=0,3709

**17. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV saat pembebanan pada bus 3 (bus Panakkukang) sebesar 289 MW dengan indeks L menggunakan metode ABC dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0049 | 0,9434 |
| 3 | 0,3999 | 0,6772 |
| 4 | 0,0090 | 0,9422 |
| 5 | 0,0186 | 0,9351 |
| 6 | 0,0146 | 0,9394 |
| 7 | 0,0078 | 0,9528 |
| 9 | 0,0230 | 0,9327 |
| 10 | 0,0338 | 0,9230 |
| 11 | 0,0274 | 0,9630 |
| 14 | 0,0156 | 0,9776 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 15 | 0,0289 | 0,9683 |
| 16 | 0,0420 | 0,9601 |
| 17 | 0,0500 | 0,9557 |
| 18 | 0,0464 | 0,9604 |
| 20 | 0,0092 | 0,9727 |
| 21 | 0,0138 | 0,9717 |
| 22 | 0,0121 | 0,9726 |
| 23 | 0,0144 | 0,9816 |
| 24 | 0,0215 | 0,9884 |
| 26 | 0,0055 | 0,9397 |
| 28 | 0,0344 | 0,9562 |
| 29 | 0,0408 | 0,9513 |

sigma L^2=0,1745

nilai L3(maks)=0,3999

**18. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV saat pembebanan pada bus 3 (bus Panakkukang) sebesar 289 MW dengan indeks L menggunakan metode hybrid FOA-ABC dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0039 | 0,9443 |
| 3 | 0,2388 | 0,7653 |
| 4 | 0,0068 | 0,9441 |
| 5 | 0,0142 | 0,9389 |
| 6 | 0,0109 | 0,9426 |
| 7 | 0,0056 | 0,9548 |
| 9 | 0,0136 | 0,9413 |
| 10 | 0,0219 | 0,9337 |
| 11 | 0,0189 | 0,9705 |
| 14 | 0,0107 | 0,9817 |
| 15 | 0,0207 | 0,9753 |
| 16 | 0,0303 | 0,9697 |
| 17 | 0,0364 | 0,9668 |
| 18 | 0,0339 | 0,9706 |
| 20 | 0,0072 | 0,9743 |
| 21 | 0,0107 | 0,9736 |
| 22 | 0,0094 | 0,9742 |
| 23 | 0,0099 | 0,9857 |

HASIL SIMULASI SISTEM KELISTRIKAN SULSELBAR 150 kV

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 24 | 0,0154 | 0,9937 |
| 26 | 0,0040 | 0,9408 |
| 28 | 0,0267 | 0,9616 |
| 29 | 0,0316 | 0,9577 |

sigma L^2=0,0647
nilai L3(maks)=0,2388

**19. Hasil simulasi stabilitas tegangan sistem kelistrikan Sulselbar 150 kV saat pembebanan pada bus 3 (bus Panakkukang) sebesar 289 MW dengan indeks L menggunakan metode hybrid MFOA-ABC dengan batas-batas daya generator dan keseimbangan daya sebagai *constraints***

======= Indeks L Stabilitas Tegangan =======

| no.bus beban | Lj | Tegangan |
|---|---|---|
| 2 | 0,0012 | 0,9469 |
| 3 | 0,0491 | 0,9037 |
| 4 | 0,0019 | 0,9484 |
| 5 | 0,0040 | 0,9478 |
| 6 | 0,0030 | 0,9495 |
| 7 | 0,0013 | 0,9584 |
| 9 | 0,0020 | 0,9519 |
| 10 | 0,0044 | 0,9496 |
| 11 | 0,0043 | 0,9831 |
| 14 | 0,0027 | 0,9880 |
| 15 | 0,0055 | 0,9877 |
| 16 | 0,0082 | 0,9878 |
| 17 | 0,0099 | 0,9882 |
| 18 | 0,0092 | 0,9907 |
| 20 | 0,0022 | 0,9783 |
| 21 | 0,0031 | 0,9782 |
| 22 | 0,0028 | 0,9783 |
| 23 | 0,0023 | 0,9924 |
| 24 | 0,0042 | 1,0032 |
| 26 | 0,0021 | 0,9422 |
| 28 | 0,0077 | 0,9747 |
| 29 | 0,0092 | 0,9735 |

sigma L^2=0,0030
nilai L3(maks)=0,0491