Application of Fuzzy-Flower Pollination Algorithm for Peak Load Forecasting on National Holiday

Andi Imran#1, I Made Yulistya Negara#2, Imam Robandi#3

#Department of Electrical Engineering, Sepuluh Nopember Institute of Technology, Sukolilo Campus, Surabaya, Indonesia
1andi.imran13@mhs.ee.its.ac.id
2yulistya@ee.its.ac.id
3robandi@ee.its.ac.id

Abstract—Application of Type-2 Fuzzy Logic System (T2FLS) has became attention for a short-term load forecasting problems solution. This paper presents application optimization membership function of antecedent (X,Y) and consequent (Z) interval type-2 Fuzzy Logic System using Flower Pollination Algorithm (FPA) for short-term load forecasting on national holiday. This method has been implemented on the historical peak load data during 14 national holidays case study in Jawa-Bali Indonesia electrical power system in 2011. Flower Pollination Algorithm (FPA) will be applied to optimize interval Footprint of Uncertainty (FOU) membership functions of interval type-2 fuzzy logic system. The test result showed Main Absolute Percentage Error (MAPE) is less than type-2 Fuzzy Logic System (FLS) and optimization type-2 FLS-Big Bang Big Crunch Algorithm. Finally, this paper defined Main Absolute Percentage Error (MAPE) 2.040612143% for type-2 FLS, 1.279257143% for optimization type-2 FLS-Big Bang Big Crunch Algorithm and 1.091543571% for optimization type2 FLS-Flower Pollination Algorithm.

Keywords: Type-2 Fuzzy Logic, Flower Pollination Algorithm, MAPE, Membership Function, National Holiday

I. INTRODUCTION

The most important thing in electric power transmission system is the precise calculation of power generation that meet a certain required load [1]. Required load at a certain time can be solved by load forecast technique. Load forecasting is classified into three categories that are short-term load forecasting, mid-term load forecasting and long-term load forecasting [2]. Research on load forecasting becomes very important in modern countries especially short-term load forecasting because the appearance of energy market which is very competitive [2]. Load forecasting on holiday becomes an interest because it differs from ordinary days [3]. Are normally implemented in load forecasting that is conventional method and intelligent method [4,5]. Conventional method is statistical method. A complex nonlinear system with series uncertainty factor is difficult to solve using conventional method. Sometimes it leads to high inaccurate of load forecasting [5]. Intelligent method has ability to give better performance in handling non-linear problem [5]. Intelligent method which is often used is load forecasting that is Artificial Neural Network (ANN) [6-9] and fuzzy logic [10-14]. The advantage of ANN is its ability to learn the historical load pattern. However, conventional ANN model sometimes has overfitting problems which result in improper forecasting results [15]. Moreover, it is often difficult to obtain the best ANN due to tiresome tuning and trial-and-error process [5].

On the other hand, Fuzzy Logic (FL) provides a simple way to solve some drawbacks which are feedback which is vague, ambiguous, inexact, noise, or missing information to get on exact conclusion. Linguistic variables are used to represent parameter of an FL system operation. FL uses "if X and Y then Z" as an approach in mathematical solving. It is very useful in controlling complex nonlinear system, which is unsolvable by mathematical model [16]. Fuzzy logic is found by Prof. Zadeh which has developed into fuzzy logic type 2 [17]. FLSs type-1 cannot directly handle the uncertainty of rule, because it uses certain type-1 fuzzy set (that is fully explained by single numerical value). On the other hand, type-2 FLSs use fuzzy difficulty situation to determine exact numeric membership function, and the uncertainty of measurement [18]. Type-2 FLSs can be used in uncertainty situations to determine the exact membership values such as in training where the data is influenced by noisy [18].

In this research, authors apply fuzzy logic type 2 method which is optimized by using flower pollination algorithm in order to forecast peak load on Indonesian national holiday. Flower pollination algorithm is optimization method which is inspired by flower pollination process [19]. This method is claimed to be more efficient than GA and PSO [19].

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II. INTERVAL TYPE-2 FUZZY LOGIC

Fuzzy logic system type 2 is the expansion of fuzzy logic system type 1 where membership function of fuzzy logic system type 2 has two membership degrees that are primary and secondary membership degrees. Fuzzy logic system type 2 consists of fuzzification, a set of rules (rules), fuzzy inference machine and output processor. Output processor in fuzzy logic system type 2 consists of type-reducer and defuzzification. Type-reducer changes fuzzy type-2 set into some fuzzy type-1 set; one of them uses Kernik Mendel Algorithm (KMA) and defuzzification which will result in output crisp (output crisp). Fuzzy logic system type 2 is also characterized by IF-THEN rule, but its antecedent and consequence membership sets is type-2. Generally, fuzzy logic system type 2 can be seen on figure 1.

Fig 1. Type-2 Fuzzy Logic System (T2FLS) Structure [17]

A. Interval Type-2 Fuzzy Set

Interval Type-2 Fuzzy Set (IT2FS) is denoted $\tilde{A}$, $\mu\tilde{A}$ is membership function with $x \in X$ and $u \in f(x) \subseteq [0,1]$. Characteristic of IT2FS can be recognized on the following equation:

$$\tilde{A} = \int_{x \in X} \int_{u \in [0,1]} \mu_{A}(x,u) | f(x) \subseteq [0,1]$$

(1)

Primary variable $x$ which has domain $X, u \in U$, secondary variable, have domain $f(x)$ for each $x \in X; Jx$ is expressed primary membership of $x, \tilde{A}$ is combination of all primary membership ($f(x)$) which is expressed the Footprint of Uncertainty (FOU) of $\tilde{A}$. The equation can be seen as follows:

$$FOU(\tilde{A}) = \cup_{x \in X} Jx = \{(x, u); u \in Jx \subseteq [0,1]\}$$

(2)

Jx is interval with the following equation:

$$Jx = \{(x, u); u \in [\mu_{A}(x), \bar{\mu}_{A}(x)]\}$$

(3)

From equation FOU ($\tilde{A}$) can be expressed by the equation:

$$FOU(\tilde{A}) = \cup_{x \in X} [\mu_{A}(x), \bar{\mu}_{A}(x)]$$

(4)

$Jx$ = Primary membership of $x$

$\mu\tilde{A}$ = Lower Membership Function (LMF) of $\tilde{A}$

$\bar{\mu}\tilde{A}$ = Upper Membership Function (UMF) of $\tilde{A}$

Fig 2. FOU (dark color), LMF (dotted line), UMF (solid line) and Embedded FS (wavy line) [17]
B. Interval Type-2 Fuzzy Membership Function Operations

Interval type-2 fuzzy set operation which is represented by FOU is done by using two intervals that is Upper Membership Function (UMF) and Lower Membership Function (LMF). Operation on membership function fuzzy interval type-2 can be seen on figure 3:

C. Kernik Mendel Algorithm

On interval type-2 fuzzy, process of searching the centroid can be done by using Kernik Mendel Method. This search method formulated as follows:

\[ Y_{cos}(x') = \bigcup_{y'_{n} \in Y} \frac{\sum_{n=1}^{N} f^{n+1}_{y'_{n}}}{\sum_{n=1}^{N} f^{n}_{y'_{n}}} = [y_{l}, y_{r}] \] (5)

\[ y_{l} = \min_{k \in [1, N-1]} \frac{\sum_{n=1}^{K} f^{n+1}_{y_{k}} + \sum_{n=K+1}^{N} f^{n+1}_{y_{k}}}{\sum_{n=1}^{K} f^{n}_{y_{k}} + \sum_{n=K+1}^{N} f^{n}_{y_{k}}} \]

\[ y_{r} = \max_{k \in [1, N-1]} \frac{\sum_{n=1}^{K} f^{n+1}_{y_{k}} + \sum_{n=K+1}^{N} f^{n+1}_{y_{k}}}{\sum_{n=1}^{K} f^{n}_{y_{k}} + \sum_{n=K+1}^{N} f^{n}_{y_{k}}} \] (6)

Switch point of L and R are as follows:

\[ y_{L} - 1 \leq y_{l} \leq y_{L} + 1 \]

\[ y_{R} - 1 \leq y_{r} \leq y_{R} + 1 \]

The searching of centroid value is done by following equation:

\[ \text{Centroid} = \frac{(y_{L} + y_{R})}{2} \] (8)

III. FLOWER POLLINATION ALGORITHM

Flower Pollination Algorithm (FPA) is an optimization method which is taken based on characteristics of flower pollination. In using this method, there are rules of flower pollination phenomenon characteristic, flower constancy phenomenon, and pollination behavior as follows:

1. Biotic pollination and cross-pollination are considered as global pollination process where pollinator carries pollen (pollen-carrying) doing Lévy Flights movement.
2. Abiotic pollination and single pollination are considered as local pollination.
3. Flower constancy is considered as chance (probability) reproduction which is proportional with similarity from two involved flowers.
4. Local and global pollinations are regulated by switch probability \( \varepsilon \in [0, 1] \)

There are two fundamental things on this algorithm that is global and local pollinations. On global pollination, pollen from flower is carried by an animal pollinator such as insect and pollen can do long-distance travel because insect can fly and move in large area. This process plus flower constancy phenomenon can be represented mathematically as:

\[ x_{t+1} = x_{t} + \gamma_{L}(x_{t} - g) \] (9)
with, declares pollen or vector solution, on iteration, and, is the best solution non-ongoing iteration. Parameter $L$ is pollination power. Because insect can move into long-distance with different step, we can use Lévy Flights to imitate this characteristic efficiently, that is we take $L > 0$ from Lévy distribution.

\[
L(t) = \frac{\lambda(t) \sin \left( \frac{\pi}{s} \right)}{s} \frac{1}{s + \lambda(s)}, (s \gg s_0 > 0)
\]

$\Gamma(\lambda)$ is gamma standard function, and this distribution is applied to step. Then, local pollination and flower constancy can be represented as:

\[
x_{i,t+1} = x_{i,t} + \varepsilon (x_{j,t} - x_{k,t})
\]

with $x_{i,t}$ and $x_{j,t}$ are pollen from different flowers of similar plant species. This rule imitates flower constancy phenomenon in limited environment. Mathematically, if $x_{i,t}$ and $x_{j,t}$ come from similar population, then this rule becomes random walk local if we take $\varepsilon$ from uniform distribution $[0,1]$.

IV. PEAK LOAD FORECASTING ON NATIONAL HOLIDAY USING IT2FL-FLOWER POLLINATION ALGORITHM

There are three steps which is done to apply fuzzy type 2-flower on peak load forecasting on holiday national that is pre-processing, processing and post-processing [7].

A. Pre-Processing

Pre-Processing is preparation of peak load data on national holiday to obtain Load Difference (LD), Typical Load Difference (TLD), Maximum Weekdays (max WD) and Variation Load Difference (VLD). Load Difference (LD) is the difference of load 4 days before holiday which is given by:

\[
LD_{\text{Max}}(i) = \frac{\text{MaxSD}(i) - \text{MaxWD}(i)}{\text{MaxWD}(i)} \times 100
\]

\[
\text{MaxWD}(i) = \frac{\text{max WD}(i) + \text{max WD}(i-4) + \text{max WD}(i-3) + \text{max WD}(i-2) + \text{max WD}(i-1)}{4}
\]

$\text{maxSD}(i)$ is peak load on holiday and $\text{max WD}(i)$ is the average of maximum load 4 days before holiday. After that calculate the Typical Load Difference (TLD$\text{Max}$(i)) that is averaging the peak load of LD$\text{Max}$(i) which is similar in previous year. Then looking for Variation Load Difference that is the difference between Load Difference (LD) from Typical Load Difference (TLD$\text{Max}$(i)) with following equation:

\[
VLD_{\text{Max}}(i) = LD_{\text{Max}}(i) - TLD_{\text{Max}}(i)
\]

\[
TLD_{\text{Max}}(i) = \frac{LD_{\text{Max}}(i-1) + LD_{\text{Max}}(i-2) + LD_{\text{Max}}(i-3)}{3}
\]

To calculate Max WD and LD max based on (12) and (13) equations can be seen on Table 1 and Table 2.

### Table 1. Peak Load In 2013

| National Holidays | Peak Load in 2013 (MW) |
|-------------------|------------------------|
| WD(i)\text{d-4}  | WD(i)\text{d-3}       | WD(i)\text{d-2}  | WD(i)\text{d-1}  | MaxSD(i) |
| 19782.00          | 18608.00               | 17525.00          | 16872.00          | 15780.00  |
| 17094.00          | 18296.00               | 18968.00          | 19424.00          | 17354.00  |
| 22146.00          | 20961.00               | 19903.00          | 19764.00          | 18650.00  |
| 21276.00          | 20643.00               | 19568.00          | 21315.00          | 19477.00  |
| 18309.00          | 20350.00               | 20134.00          | 19735.00          | 18307.00  |
| 19099.00          | 21123.00               | 21734.00          | 21506.00          | 19071.00  |
| 17337.00          | 17151.00               | 16201.00          | 14942.00          | 13777.00  |
| 17151.00          | 16201.00               | 14942.00          | 13777.00          | 14058.00  |
| 21252.00          | 21380.00               | 20828.00          | 18496.00          | 18853.00  |
| 18897.00          | 21910.00               | 21968.00          | 21592.00          | 19914.00  |
| 20120.00          | 18429.00               | 20732.00          | 20627.00          | 18782.00  |
| 20768.00          | 19744.00               | 18612.00          | 20299.00          | 18723.00  |
| 20333.00          | 20730.00               | 20953.00          | 19293.00          | 17875.00  |
| 21862.00          | 21677.00               | 21327.00          | 21428.00          | 18662.00  |

### Table 2. VLD max for Idul Fitri I 2012 and 2013

| Year   | Max WD | LD Max | TLD max | VLD max |
|--------|--------|--------|---------|---------|
| 2013   | 16407.8| -16.034| -14.926 | -1.1077 |
| 2012   | 15994.5| -17.628| -14.385 | -3.2425 |
B. Processing

The operation of FLS Type-2 is similar with operation on fuzzy type-1, but FLS Type-2 has FOU whichismembership functionthat is limited by Upper Membership Function (UMF) and Lower Membership Function (LMF).

![FOU fuzzy type 2](image)

The rule of fuzzy IF-THEN is used in this method to forecast peak load which is declared as follows:

\[ IF \ X \ is \ A, \ AND \ Y \ is \ B, \ THEN \ Z \ is \ C_1 \]

X and Y inputs by using IT2MF Editor in fuzzification design, there are 11 membership functions which are used [7], that is:

- Negative Very Big (UNVB and LNVB)
- Negative Big (UNB and LNB)
- Negative Medium (UNM and LNM)
- Negative Small (UNS and LNS)
- Negative Very Small (UNVS and LNVS)
- Zero (UZE and LZE)
- Positive Very Small (UPVS and LPVS)
- Positive Small (UPS and LPS)
- Positive Medium (UPM and LPM)
- Positive Big (UPB and LPB)
- Positive Very Big (UPVB and LPVB)

Examples of fuzzy rules can be seen in Table 3.

| No. | Antecedent | Consequent |
|-----|------------|------------|
| 1   | NVS        | NVS        | NVS        |
| 2   | PVS        | PVS        | PVS        |
| 3   | ZE         | NVS        | NVS        |
| 4   | PVS        | ZE         | ZE         |
| 5   | PVS        | PVS        | PVS        |
| 6   | NVS        | PM         | PM         |
| 7   | NVS        | PS         | PS         |
| 8   | ZE         | PS         | PS         |
| 9   | ZE         | ZE         | ZE         |
| 10  | ZE         | PM         | PM         |
| 11  | NVS        | NVS        | NVS        |
| 12  | PVS        | NVS        | NVS        |
| 13  | ZE         | PVS        | PVS        |
| 14  | ZE         | PVS        | PVS        |
The rule of rule editor intable 3 can be seen as follows:

[R1] IF X is NVS AND Y is NVS THEN Z is NVS
[R2] IF X is PVS AND Y is PVS THEN Z is PVS
[R14] IF X is ZE AND Y is PVS THEN Z is PVS

In choosing fuzzy set using max rule is by taking the biggest value which is appropriate with membership degree (μ) of input variable (X, Y) and output (Z) on New Year can be seen in Table 4. Value which is made into input to X, Y and Z variables are VLDmax from holiday data. X is VLDmax (i) from similar holiday before forecasting year. Y is VLDmax (i) from holiday which is adjacent forecasting year. Z is forecast of VLDmax (i).

Variable value of X, Y and Z is made as divided to LMF and UMF parameters. After that, parameter value of LMF and UMF on FOU is optimized by using flower pollination algorithm. X, Y and Z variables can be seen in figure 6, 7 and 8. Flowchart of fuzzy type 2–flower pollination algorithm on peak load forecasting on national holiday can be seen in figure 5.

C. Post-Processing

The next process is looking for forecast load difference value which can be declared as follows:

\[
\text{Forecast } LD_{MAX}(i) = \text{Forecast } VLD_{MAX}(i) + TLD_{MAX}(i)
\] (16)

Then peak load forecasting on national holiday can be calculated as follows:

\[
P_{MAX}(i) = \text{MaxWD}(i) + \left(\text{Forecast } LD_{MAX} \times \text{MaxWD}(i)\right)\frac{100}{1}
\] (17)

To find out the accuracy of the proposed method then used absolute error equation. The smaller error which is obtained indicates the used method is better. Absolute error equation as follows:

\[
\text{Error} = \left| \frac{P_{\text{forecast}} - P_{\text{actual}}}{P_{\text{actual}}} \right| \times 100\%
\] (18)

\[
\text{Error} = \left| \frac{P_{\text{MAX}(i) - \text{MaxSD}(i)}}{\text{MaxSD}(i)} \right| \times 100\%
\] (19)
Fig5. Flowchart IT2FL-Flower for Peak Load Forecasting on National Holidays
TABLE IV. Establishment Of Rule Base For Input X in 2013

| Holidays Name | Variable | VLD max | Membership Function (μ) | Set of |
|---------------|----------|---------|-------------------------|--------|
| Tahun Baru Masehi | X        | -3.278377375 | 0.819594344 0.1804 | NVS    |
|               | Y        | -2.900956448 | 0.725239112 0.27476 | NVS    |
|               | Z        | -2.900956448 | 0.725239112 0.27476 | NVS    |

Antecedent (X, Y) and consequent (Z) T2FIS figures as follows:

Fig6. Membership Function for Variable Input X T2FIS

Fig7. Membership Function for Variable Input Y T2FIS

Fig8. Membership Function for Variable Input Z T2FIS
### TABLE V. Results of VLD Forecast on National Holidays in 2013

| No | Holidays Name                          | VLD Target | IT2 VLD | Error(%) | IT2-BBBC VLD | Error(%) | IT2-FPA VLD | Error(%) |
|----|--------------------------------------|------------|---------|----------|--------------|----------|------------|----------|
| 1  | Tahun Baru Masehi                    | -0.4991174 | -8.33E-17 | 0.4991174 | 2.60E-06     | 0.49912  | 2.40E-01   | 0.73912  |
| 2  | Proklamasi Kemerdekaan RI            | 7.7473500  | 6.3359489 | 1.4114002 | 4.44         | 3.30735  | 6.21751    | 1.529836 |
| 3  | Idul Adha                            | 1.7980963  | 3.8370748 | 2.0399784 | 1.6641         | 0.136681 | 3.98961    | 2.19152  |
| 4  | Tahun Baru Hijriyah                  | 1.4891024  | 2.0017456 | 0.5126432 | 1.53604       | 0.04694  | 1.42431    | 0.607847 |
| 5  | Maulid Nabi Muhammad SAW             | 2.1110236  | 0.4947342 | 1.6612894 | 0.40111       | 1.71098  | 0.63739    | 1.473632 |
| 6  | Isra Mi'raj                          | -3.1637548 | -4.3819774 | 1.2182226 | -3.50451      | 0.34051  | -3.10850   | 0.05525  |
| 7  | Idul Fitri I                         | -1.1076963 | -1.2426000 | 0.1349037 | 0.96         | 0.27716  | 1.01909    | 0.33625  |
| 8  | Idul Fitri II                        | -1.4037836 | -0.8860522 | 2.2898358 | -2.09673      | 0.69253  | 1.13379    | 0.26999  |
| 9  | Wafatnya Yesus Kristus               | 0.6828415  | 2.0046369 | 1.3217953 | 0.96         | 0.27716  | 1.01909    | 0.33625  |
| 10 | Kenaikan Yesus Kristus               | -0.7062478 | 1.1598159 | 0.4535681 | 1.70364       | 0.997394 | 0.89444    | 0.188194 |
| 11 | Natal                                | 2.9014656  | 2.0041220 | 0.8973436 | 1.68571       | 1.21575  | 2.05528    | 0.846185 |
| 12 | Nyepi                                | 2.9175867  | 3.9973639 | 6.9149507 | 1.79171       | 1.12857  | 2.05219    | 0.865391 |
| 13 | Tahun Baru Imlek                     | 3.0973818  | 4.9994811 | 1.9020993 | -4.08        | 0.982618 | 3.33133    | 0.233956 |
| 14 | Waisak                               | 5.9735988  | 1.1609765 | 4.8126313 | 3.38509       | 2.58851  | 3.78215    | 2.19144  |
|    | Mean Average Percentage Error (MAPE) |           | 1.8588413 | 1.1557759 | 0.9755238    | 0.57     |

### TABEL VI. Results of Peak Load forecasting on National Holidays in 2013

| No | Holidays Name                           | Actual (MW) | IT2 Forecast (MW) | IT2-Error(%) | IT2-BBBC Forecast (MW) | Absolute Error(%) | IT2-FLOWER Forecast (MW) | Error(%) |
|----|----------------------------------------|-------------|------------------|--------------|------------------------|-------------------|--------------------------|----------|
| 1  | Tahun Baru Masehi                      | 15780.0     | 15780.8          | 0.57556      | 15870.8                | 0.57556           | 15914.4                  | 0.85232  |
| 2  | Proklamasi Kemerdekaan RI              | 17354.0     | 17093.6          | 1.5002       | 16743.9                | 3.5154            | 17071.8                  | 1.6261   |
| 3  | Idul Adha                              | 18650.0     | 19071.9          | 2.26239      | 18621.7                | 0.1517            | 19103.5                  | 2.43165  |
| 4  | Tahun Baru Hijriyah                    | 19477.0     | 19583.1          | 0.54485      | 19486.7                | 0.04989           | 19463.5                  | 0.0689   |
| 5  | Maulid Nabi Muhammad SAW               | 18307.0     | 17989.6          | 1.7333       | 17971.1                | 1.8347            | 18017.6                  | 1.5803   |
| 6  | Isra Mi'raj                            | 19071.0     | 18816.8          | 1.3329       | 18999.9                | 0.3728            | 19082.5                  | 0.06045  |
| 7  | Idul Fitri I                           | 13777.0     | 13754.8          | 0.1607       | 13406.3                | 2.6902            | 13338.6                  | 3.182    |
|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   |   |   |   |   |   |   |
| 8 | Idul Fitri II | 14058.0 | 0 | 14413.3 | 31 | 2.52761 | 69 | 0.7649 | 14099.8 | 96 | 0.29802 |
| 9 | Wafatnya Yesus Kristus | 18853.0 | 0 | 19123.8 | 23 | 1.4365 | 87 | 0.30121 | 18921.8 | 95 | 0.36543 |
| 10 | Kenaikan Yesus Kristus | 19914.0 | 0 | 19818.3 | 35 | 0.4804 | 32 | 1.0564 | 19874.3 | 07 | 0.1993 |
| 11 | Natal | 18782.0 | 0 | 18602.7 | 35 | 0.9544 | 3 | 1.2931 | 18612.9 | 58 | 0.9 |
| 12 | Nyepi | 18723.0 | 0 | 17349.9 | 85 | 7.3333 | 5 | 1.194 | 18551.1 | 7 | 0.9177 |
| 13 | Tahun Baru Imlek | 17875.0 | 0 | 17488.3 | 56 | 2.163 | 61 | 1.1714 | 17827.4 | 43 | 0.2661 |
| 14 | Waisak | 18662.0 | 0 | 19700.2 | 53 | 5.56346 | 31 | 2.99234 | 19134.7 | 71 | 2.53334 |

Mean Average Percentage Error (MAPE)  

|   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |

**Fig 9. Results of VLD Forecasting on National Holidays in 2013**

**Fig 10. Results of VLD Error Forecasting on National Holidays in 2013**
V. RESULT AND ANALYSIS

The calculation results of forecasting error Type-2 Fuzzy Logic-Flower Pollination Algorithm using data from various types of load conditions on holidays where this result is just a case of forecasting in 2008 show in Table 5 and 6. Figure 9-12 show the results of the plotting. Interval Type-2 Fuzzy Logic-Flower Pollination Algorithm (IT2FPA) method and several methods such as the Interval Type-2 Fuzzy Logic (IT2FL), Interval Type-2 Fuzzy Logic-Big Bang Big Crunch (IT2FL-BBBC) as a comparison.

The test results by using IT2FPA method as a proposed method for load forecasting have Mean Absolute Percentage Error (MAPE) is 1.091543571%. By using IT2FL, MAPE is 2.040612143%. By using IT2FLBBBC, MAPE is 1.279257143%.

VI. CONCLUSIONS

Interval Fuzzy Logic Type-2 method which is optimized by using Flower Pollination Algorithm proposed in this research can be used to forecast the peak load during some holidays in Jawa-Bali system, Indonesia. The method has MAPE which is less than 2%. The method is very useful for operators to set up different scenarios for forecasting method.

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**AUTHOR PROFILE**

Andi Imran was born in Makassar in 1985. He received bachelor degree from State University of Makassar in Electrical Engineering, and then master degree from Hasanuddin University in Electrical Engineering. His research is about Power System Operation and Control especially in Load Forecasting using artificial intelligence method. Since 2013, he is assistant in Electrical Engineering Department at Sepuluh Nopember Institute of Technology (ITS Surabaya) in Indonesia. Email: andi.imran13@mhms.ee.its.ac.id

I Made Yulistya Negara was born in Bali, Indonesia on 12 July 1970. He received the B.Sc. and M.Sc. degrees in electrical engineering from Sepuluh Nopember Institute of Technology in Indonesia and Karlsruhe University in Germany in 1994 and 2001, respectively. From 1994 to 1997, he worked as a field engineer in Wijaya Karya Construction Co., Indonesia. From 2001 to 2003, he has been working as an Assistant Lecturer at Sepuluh Nopember Institute of Technology in Indonesia. Since 2004 he has been enrolled in doctoral program at Kyushu University, Fukuoka in Japan. He is a member of the Institute of Electrical Engineers, Japan (IEEJ). Email: yulistya@ee.its.ac.id

Imam Robandi received Doctor of Design and Information Engineering at Tottori University in Japan. Since 2008, he has been Professor in Electrical Engineering Department at Sepuluh Nopember Institute of Technology. His research is about Dynamic Stability problem of large scale electrical power system with intelligent control, optimization control, adaptive control and intelligent control. He has awarded for encouragement of research and development from Institute of electrical engineer of Japan (IEEJ) in 2000. Email: robandi@ee.its.ac.id.