# CHAPTER 4

## Study Results and Discussion

This research is analyzed by DIgSILENT PowerFactory V.15 software to create the simulation model for the generation planning and the reliability improving power system in North and Central 1 area, which data is used the technical data of EDL. This research aims to plan the hydropower plant, which will be connected to the EDL grid for finding the suitable case under fundamental technical criteria of EDL. The procedure of the analysis process is switching the 12 hydropower plant respectively. This study is divided into several cases to analyze of each case as: considered the power loss minimum case, the overloading minimum case, the optimization both the power loss and the overloading case, and other case. The simulation results from the DIgSILENT model, it will be revised for useful appropriateness such as the overloading, voltage, and power loss.

### 4.1 Simulation results of case study

This research aims to plan the hydropower plant, which will be connected to the EDL grid for finding the suitable case under fundamental technical criteria of EDL. The procedure of the analysis process is switching the 12 hydropower plant respectively.

Case A is the base case of EDL, which follows the existing generation planning of EDL. It will be switched initially from project No.1 until project No.12.

Case B, the order of generation from project No.2 until project No.12 and project No.1. The analysis result has shown the overloading and power loss is 13 Times and 706.61 MW,

Case C, the order of generation from project No.3 until project No.12, project 1 and project No.2. The case D until case L are the same pattern of cases B and case C.

Case M has the order of generation from project 8, 7, 2, 11, 6, 1, 10, 12, 3, 4, 9 and 5, which shown the analysis result of the overloading is minimum compared to the other cases and it is the suitable case for generation planning in consideration of overloading.

Case N has the order of generation from project 11, 7, 2, 12, 9, 6, 8, 10, 1, 3, 4 and 5, which shown the analysis result that the power loss is minimal compared to the other cases and it is the suitable case for generation planning in consideration of power loss.

As shown Figure 4.1 and Table 4.1.

Table 4.1 The order of projects connects and simulation result.

| Case | Overloading (Times) | Power loss (MW) | Order of project connects to grid EDL |
|---|---|---|---|
| A | 17 | 707.61 | 1, 2, 3……………………………12 |
| B | 13 | 706.61 | 2, 3, 4…………………….....…..12, 1 |
| C | 18 | 781.57 | 3, 4, 5 ………………………12, 1, 2 |
| D | 16 | 727.66 | 4, 5, 6……………………12, 1, 2, 3 |
| E | 14 | 585.41 | 5, 6, 7…………………12, 1, 2, 3,4 |
| F | 13 | 538.50 | 6, 7, 8…………………12, 1, 2,…. 5 |
| G | 18 | 613.48 | 7, 8,9 ……………….…12, 1, 2,…. 6 |
| H | 21 | 600.54 | 8, 9, 10…12, 1, 2,……………… 7 |
| I | 12 | 619.74 | 9, 10, 11, 12, 1, 2,…….....………… 8 |
| J | 16 | 629.23 | 10, 11, 12, 1, 2,……...………….… 9 |
| K | 14 | 681.30 | 11, 12, 1, 2,……...………………..10 |
| L | 20 | 681.30 | 12, 1, 2,……...………………...……11 |
| M | 10 | 512.57 | 8, 7, 2, 11, 6, 1, 10, 12, 3, 4, 9 and 5 |
| N | 15 | 507.47 | 11, 7, 2, 12, 9, 6, 8, 10, 1, 3, 4 and 5 |

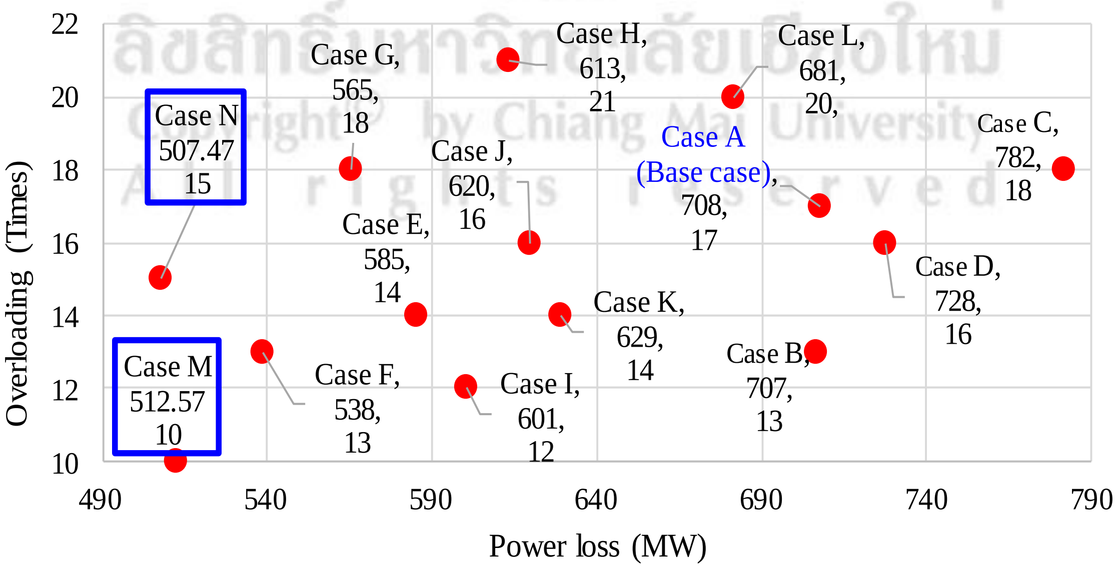




Figure 4. 1 The simulation result of cases study.

## 4.2 Simulation results of the power flow analysis

### 4.2.1 The overloading minimum case (Case M)

The simulation model of the overloading minimum is used the analysis result of each hydropower plant connected to EDL grid, which initially from the minimum overloading value until maximum overloading value of each project. The result of this case is the suitable case for generation planning in consideration of overloading. When compares result between case M and base case of EDL. That will see the overloading value decrease from the case EDL, which shown in Table 4.2 and Figure 4.2.

Table 4. 2 The simulation result of overloading minimum case.

| **Projects** | **Base case** | **Case M** |
|---|---|---|
| | (Times) | (Times) |
| 1 | - | - |
| 2 | - | - |
| 3 | - | - |
| 4 | - | - |
| 5 | 1 | - |
| 6 | 1 | 1 |
| 7 | 1 | 1 |
| 8 | 1 | 1 |
| 9 | 1 | - |
| 10 | 1 | - |
| 11 | 5 | 1 |
| 12 | 6 | 6 |
| **Total** | **17** | **10** |

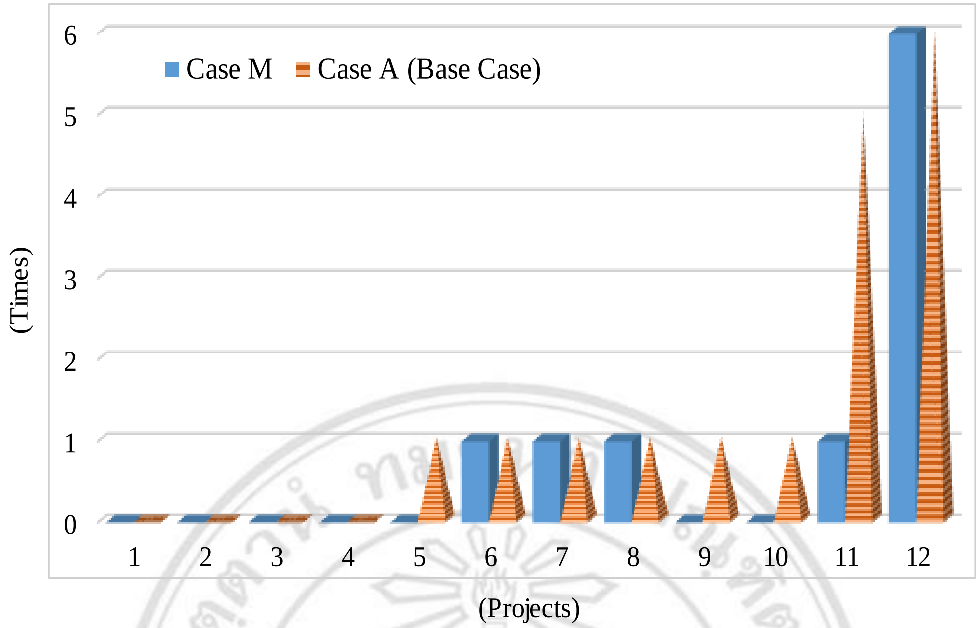


Figure 4. 2 The result of overloading minimum case.

4.2.2 The power loss minimum case (Case N)

The simulation model of the power loss minimum is used the analysis result of each hydropower plant connected to EDL grid, which initially from the minimum power loss value until maximum power loss value of each project. The result of this case is the suitable case for generation planning in consideration of power loss. When compares result between case N and the base case of EDL. That will see the power loss value decrease from the base case (case A), which shown in Table 4.3 and Figure 4.3.

Table 4. 3 The simulation result of power loss minimum case.

| **Projects** | **Case A (Base case)** | **Case N** |
|---|---|---|
| | (MW) | (MW) |
| 1 | 29.55 | 25.57 |
| 2 | 30.24 | 25.07 |
| 3 | 39.75 | 26.35 |
| 4 | 32.45 | 34.25 |
| 5 | 61.28 | 35.26 |
| 6 | 62.00 | 43.62 |
| 7 | 61.98 | 45.54 |
| 8 | 66.57 | 44.49 |
| 9 | 72.05 | 43.37 |
| 10 | 79.36 | 42.23 |

| Projects | Case A (Base case) | Case N |
|---|---|---|
| | (MW) | (MW) |
| 11 | 81.80 | 51.15 |
| 12 | 90.57 | 90.57 |
| **Total** | **708** | **507** |

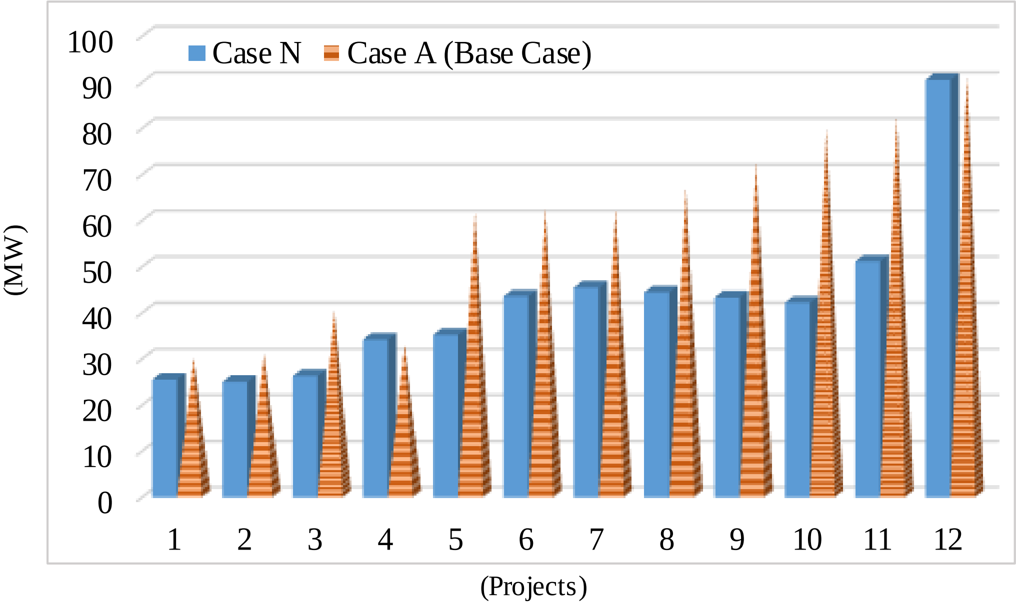


Figure 4. 3 The result of power loss minimum case.

4.2.3 Optimization between the overloading and the power loss cases

From analysis result of each case in Table 4.1 show the overloading and power loss value is a different result. That the case M is the overloading minimum case value and the case N is the power loss minimum case value. So the optimization analysis between the overloading and power loss can be analyzed such a finding the minimum sum value of the overloading and power loss, which will be case N is the optimization between the overloading and power loss. As shown in Table 4.4 and Figure 4.4.

Table 4. 4 The simulation result of overloading and power loss minimum case.

| Case | Overloading (Times) | Power loss (MW) | Optimizations |
|---|---|---|---|
| A | 17 | 708 | 725 |
| B | 13 | 707 | 720 |
| C | 18 | 782 | 800 |
| D | 16 | 728 | 744 |
| E | 14 | 585 | 599 |
| F | 13 | 538 | 551 |
| G | 18 | 613 | 631 |
| H | 21 | 601 | 622 |
| I | 12 | 620 | 632 |
| J | 16 | 629 | 645 |
| K | 14 | 681 | 695 |
| L | 20 | 681 | 701 |
| M | 10 | 513 | 523 |
| N | 15 | 507 | 522 |

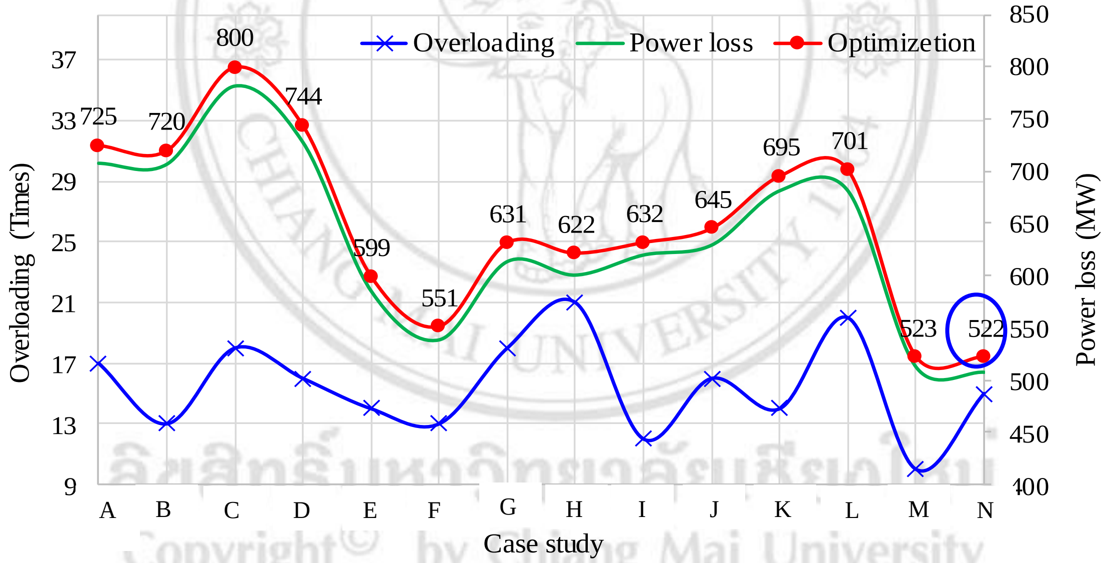


Figure 4. 4 The result of overloading and power loss minimum case.



## 4.3 Simulation result of reliability improving

- System average interruption frequency index (SAIFI)

SAIFI is designed to give information about the average frequency of sustained interruptions per times per year [Times/year]. Which analysis is used DIgSILENT PowerFactory V.15 software in the study because the system is networked large. The analysis result of SAIFI as shown in Table 4.5 and Figure 4.5.

Table 4. 5 The simulation result of SAIFI.

| Projects | SAIFI | | |
|---|---|---|---|
| | Base Case or Case A | Case M | Case N |
| | Times/year | Times/year | Times/year |
| 1 | 0.004352 | 0.004349 | 0.004347 |
| 2 | 0.00427 | 0.004268 | 0.00425 |
| 3 | 0.00427 | 0.004257 | 0.004242 |
| 4 | 0.004114 | 0.004105 | 0.004083 |
| 5 | 0.004098 | 0.004098 | 0.004066 |
| 6 | 0.003643 | 0.00364 | 0.003629 |
| 7 | 0.003636 | 0.00363 | 0.003614 |
| 8 | 0.003631 | 0.003621 | 0.0036 |
| 9 | 0.003621 | 0.003614 | 0.003597 |
| 10 | 0.003616 | 0.003607 | 0.003586 |
| 11 | 0.00361 | 0.003596 | 0.003574 |
| 12 | 0.003599 | 0.003573 | 0.00343 |
| Total | 0.04646 | 0.046358 | 0.046018 |

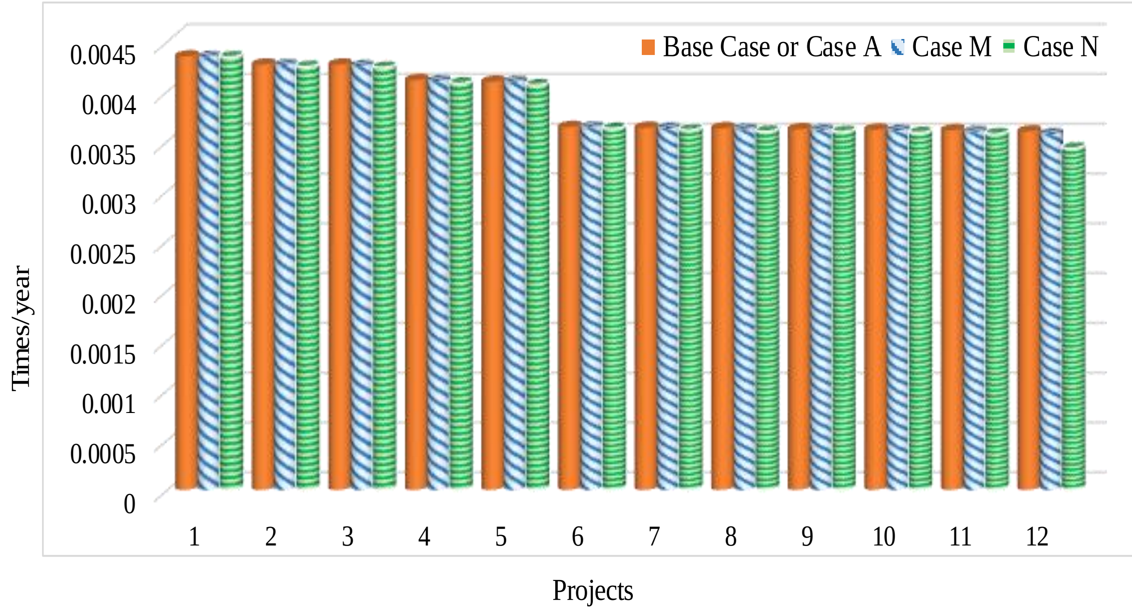


Figure 4. 5 The result of SAIFI.

Figure 4.6 is indicated that the share of SAIFI. The share of case A, case M, case N has the SAIFI value are 33.46 %, 33.39 %, and 33.15 % respectively. From the ratio of three cases is show the case N is minimum ration more than the case. As the display in Figure 4.6 bellowing.

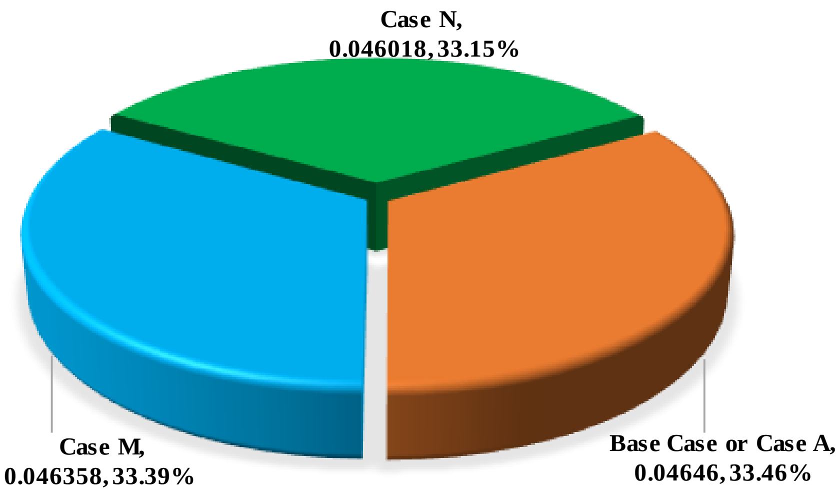


Figure 4. 6 The ratio of SAIFI.

- System average interruption duration index (SAIDI)

SAIDI is shown the total duration of interruption for the average customer during the period in the calculation. Which analysis is used DIgSILENT PowerFactory V.15 software in the study because the system is networked large. The detail of analysis result SAIDI as shown in Table 4.6 and Figure 4.6. That case N has the SAIDI minimum.

Table 4. 6 The simulation result of SAIDI.

| Projects | SAIDI | | |
|---|---|---|---|
| | Base Case or Case A | Case M | Case N |
| | h/Ca | h/Ca | h/Ca |
| 1 | 0.032 | 0.03 | 0.029 |
| 2 | 0.031 | 0.029 | 0.028 |
| 3 | 0.03 | 0.028 | 0.027 |
| 4 | 0.028 | 0.026 | 0.025 |
| 5 | 0.027 | 0.024 | 0.023 |
| 6 | 0.024 | 0.021 | 0.02 |
| 7 | 0.023 | 0.02 | 0.019 |
| 8 | 0.021 | 0.019 | 0.018 |
| 9 | 0.02 | 0.018 | 0.016 |
| 10 | 0.019 | 0.016 | 0.015 |
| 11 | 0.017 | 0.015 | 0.014 |
| 12 | 0.016 | 0.013 | 0.012 |
| Total | 0.288 | 0.259 | 0.246 |

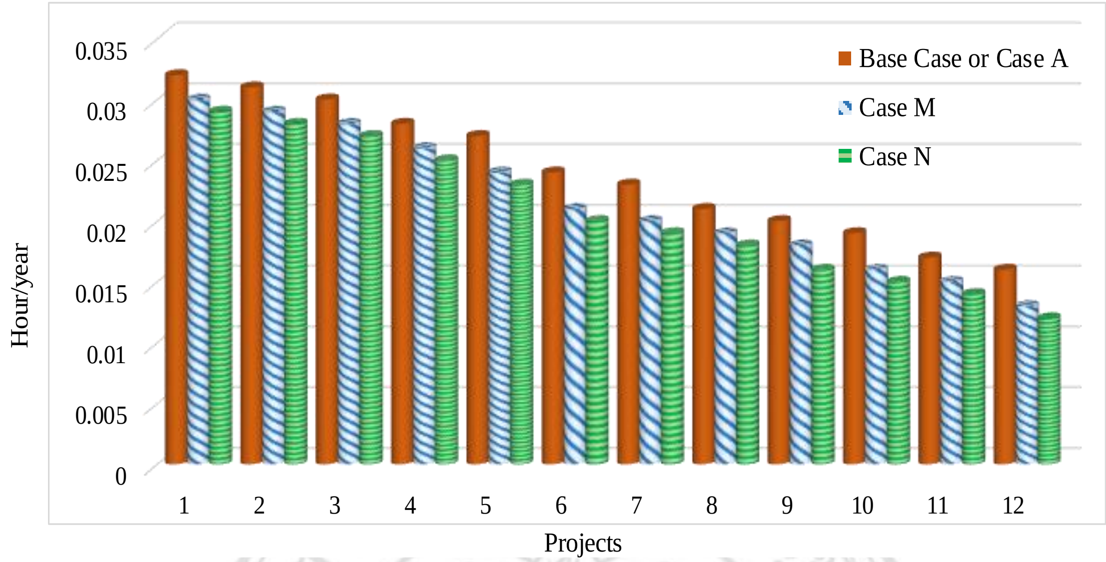


Figure 4. 7 The result of SAIDI.

Figure 4.8 is indicated that the share of SAIDI. The share of case A, case M, case N has the SAIDI value are 36.32 %, 32.66 %, and 31.02 % respectively. From the ratio of three cases is show the case N is minimum ration more than the case. As the display in Figure 4.8 bellowing.

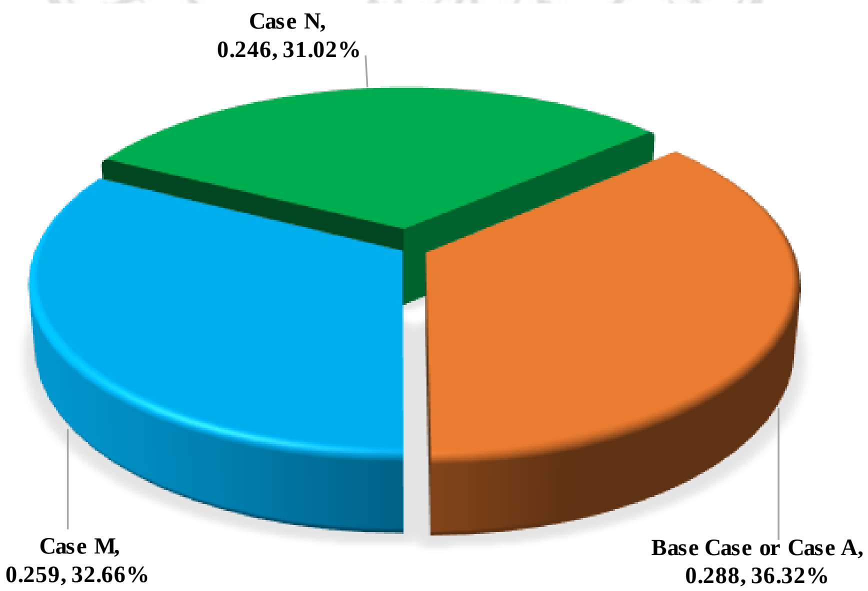


Figure 4. 8 The ratio of SAIDI.

- Energy not supplied index (ENS)

ENS is an average energy that is not delivered to the load system. The analysis is used DIgSILENT PowerFactory V.15 software in the study. Table 4.6 and Figure 4.6 shown detail analysis result of ENS. That case N has the ENS minimum.

Table 4. 7 The simulation result of ENS.

| Projects | ENS | | |
|---|---|---|---|
| | Base Case or Case A | Case M | Case N |
| | MWh/a | MWh/a | MWh/a |
| 1 | 9.841 | 9.16 | 8.887 |
| 2 | 9.703 | 8.999 | 8.692 |
| 3 | 9.433 | 8.84 | 8.434 |
| 4 | 9.291 | 8.463 | 8.019 |
| 5 | 8.718 | 7.712 | 7.386 |
| 6 | 8.718 | 7.599 | 7.201 |
| 7 | 8.567 | 7.217 | 6.584 |
| 8 | 7.755 | 6.867 | 6.495 |
| 9 | 7.334 | 6.454 | 5.96 |
| 10 | 6.923 | 5.87 | 5.45 |
| 11 | 6.247 | 5.561 | 5.067 |
| 12 | 5.962 | 4.604 | 4.294 |
| Total | 98.492 | 87.346 | 82.469 |

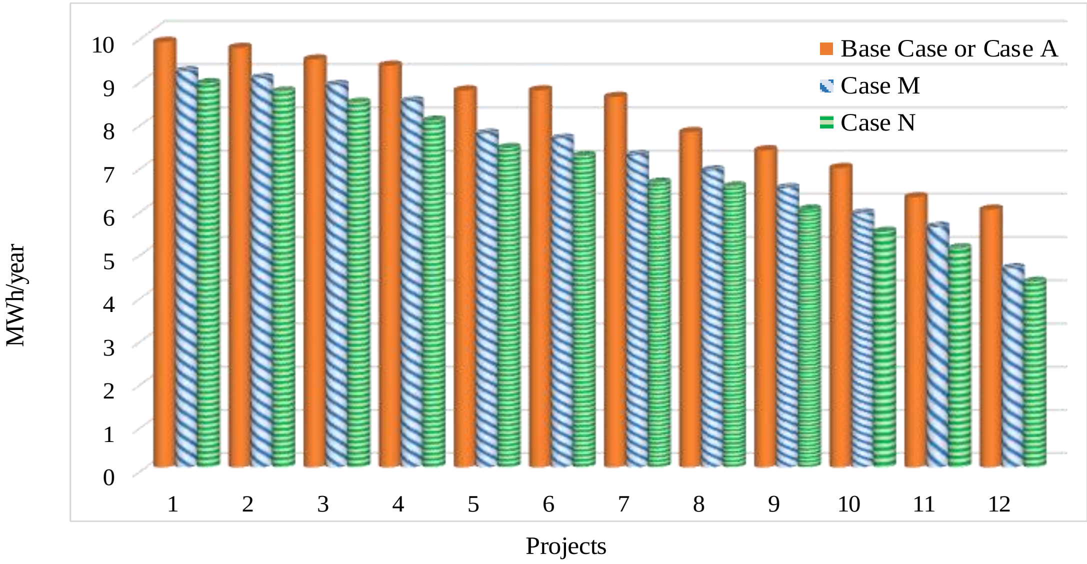


Figure 4. 9 The result of ENS.

Figure 4.10 is indicated that the share of ENS. The share of case A, case M, case N has the SAIFI value are 36.71 %, 32.55 %, and 30.74 % respectively. From the ratio of three cases is show the case N is minimum ration more than the case. As the display in Figure 4.10.

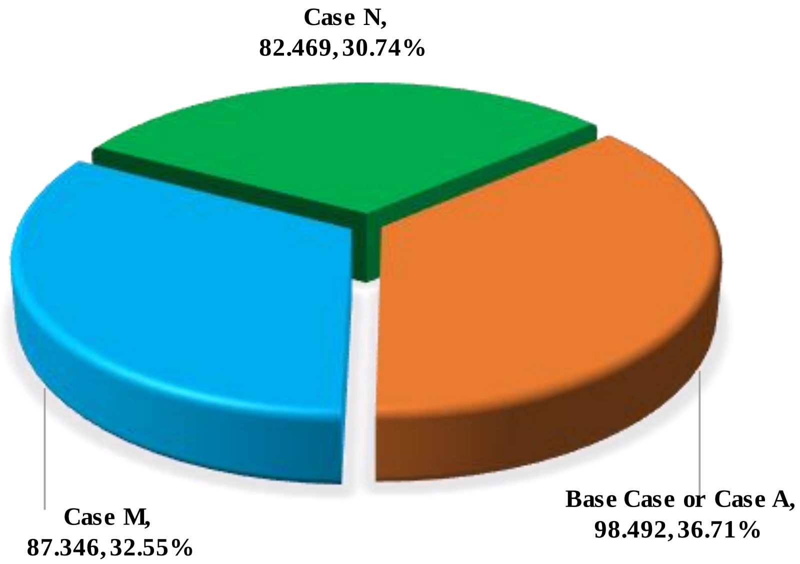


Figure 4. 10 The ratio of ENS.