Analysis of clean water distribution systems using EPANET 2.0 (Case study of Uma Sima Village, Sumbawa Regency)

E Kurniati, Kamariah and T Susilawati
Department of Civil Engineering, Universitas Teknologi Sumbawa, Jl. Raya Olat Maras Kecamatan Moyo Hulu Kabupaten Sumbawa 84371, Indonesia

Corresponding author: tri.susilawati@uts.ac.id

Abstract. The need for clean water is very important for humans because it is one of the benchmarks of successful development in an area. Where every area, especially Uma Sima Urban Village, Sumbawa Sub-district will experience an increase in population every year so that the need for clean water will increase. The purpose of this study is to determine the need for clean water and the distribution system of clean water pipelines in Uma Sima Urban Village for the next 20 years until 2037 by using the method of analyzing clean water needs with projected population numbers using the exponential regression formula and network simulations pipeline distribution with Epanet 2.0 software. Based on the results of the analysis carried out, it can be obtained the need for clean water at peak hours of 16.99 liters / second with a max day factor of 1.15 and 18,446 liters / second with a max of 1.25 days factor. Whereas for the distribution network simulation it was found that the distribution network is still effective for carrying water for the next 20 years, namely in 2037.

1. Introduction
Water as one of the basic human needs certainly requires a good and sustainable distribution system. A good distribution certainly requires a number of supporting factors such as a good distribution network system and a good pipeline. PDAM (Regional Water Supply Company) Batulanteh as the only regional company providing clean water distribution services in Sumbawa Regency

Uma Sima Urban Village is one of the villages in Sumbawa Subdistrict which has an area of 2.00 km² with a population of 2017 which is 7004 inhabitants and a population density of 3,502 per km². Uma Sima Urban Village has a different topography, which is flat and hilly. However, aside from being a settlement of Uma Sima Urban Village, it is also one of the villages for the center of government, education and economy in the Sumbawa District, Sumbawa Regency. Then in the current stage of development such as housing construction and so on in Uma Sima Urban Village, it is more likely to use water distribution by pipeline from PDAM Batulanteh, because it is used faster than making wells.

The main function of the distribution pipeline is to deliver clean water to all customers while paying attention to quality, quantity and continuity factors, as well as water pressure [1]. The Regional Water Company (PDAM) functions as a local government-owned company that provides services in the field of clean water and one of the ways to distribute water is by piping systems. The need for clean water will increase along with the increase in population. Thus the distribution system will be more complex and require special handling. Where the provision of clean water by the PDAM uses an
open-close system because the demand for clean water by the community is greater than the production of clean water in Batulanteh PDAM so that clean water does not flow to the houses of the community every time. In addition, population growth occurs dynamically in society both in terms of density, social and economy, so that the need for clean water also increases. A high density environment will reduce the ease of access to clean water because people who previously could get clean water from dug wells, became difficult due to limited land. In addition, natural conditions also affect access to clean water, certain areas due to contour and soil conditions are difficult to get clean water. So that with the increase in population each year followed by an increase in the need for clean water, but the supply of clean water from PDAM Batulanteh, Sumbawa Regency is still lacking to meet the water needs of the community. Therefore, it is necessary to calculate the need for clean water for the next 20 years until 2037 and simulate the pipeline distribution network whether it is still able to distribute water until 2037 with a case study in Uma Sima Urban Village.

One of the software to help analyze the piped water distribution network is the EPANET 2.0 program. This software is easy to use because it does not require high computer specifications [2]. EPANET conducts hydraulic simulations and water quality behavior in pressurized pipelines, such as urban water supply systems. A network can consist of pipes, pipe connections, pumps, valves, storage tanks and reservoirs [3]. The advantage of EPANET 2.0 software for distribution network analysis is that the flow rate in the network is obtained using the linear method, and the pressure loss due to friction is calculated using the Darcy-Weisbach or Manning formula [4]. Another advantage of this software is that it has the ability to consider minor loses, can duplicate demands that vary from time to time, and can handle different request patterns for each node [5].

The purpose of this research is to find out the need for clean water and the distribution system of clean water pipelines until 2037 so that the need for clean water can be known and whether the distribution network is appropriate or not with the limitation of the problem. The calculation of the amount of clean water needs (PDAM) of Uma Sima Urban Village, Sumbawa Subdistrict until 20 years to come, namely in 2037, the analysis was only done on the clean water distribution pipeline in Uma Sima Sub-District, Sumbawa Subdistrict using Epanet 2.0 software.

2. Experimental method
Several stages of this research method, namely: (a) preparation, where a literature review is carried out to determine the research reference and the supporting theoretical basis; (b) collection of primary and secondary data. Supporting data for this study are data on population, customer data of PDAM Batulanteh, Uma Sima Sub-district, data on the distribution system of PDAM Batulanteh, PDAM Batulanteh pipeline condition data and other supporting data.; (c) the stage of population projection, projected demand and loss of domestic and non-domestic water in the next 20 years using the exponential regression method; (d) the analysis phase, where the water pressure and water velocity parameters are analyzed in the pipeline network model created using EPANET 2.0 by calculating the peak hour factor then adjusting the distribution pipe criteria based on the Minister of Public Works Regulation No. 18/2007.

3. Result and discussion
Based on the Projection of the population of Uma Sima Urban Village in the next 20 years using the exponential method, the population number projection is obtained as shown in Table 1 below:

| Year | N  | Total population (Jiwa) |
|------|----|-------------------------|
| 2017 | 0  | 7,004                   |
| 2022 | 5  | 7,587                   |
| 2027 | 10 | 8,219                   |
| 2032 | 15 | 8,904                   |
| 2037 | 20 | 9,645                   |
Domestic water needs are the needs needed by humans for daily life such as drinking, cooking, cleaning, and others. Because the projected population of Uma Sima Urban Village for the next 20 years is still below 20,000 people which is 9,645 people, the need for clean water is based on a table of clean water planning criteria that is 60 liters / person / day. The results of the calculation of domestic water needs in Uma Sima Kelurahan until 2037 can be seen in Table 2 below:

**Table 2. Domestic clean water needs Uma Sima Urban Village**

| Year | Total Population (Person) | Total clean water needs (liters/days) | Clean Water Needs (liters/seconds) | Clean Water Needs (m³/seconds) |
|------|---------------------------|--------------------------------------|----------------------------------|--------------------------------|
| 2022 | 7,587                     | 455,220                              | 5.27                             | 0.00527                        |
| 2027 | 8,219                     | 493,140                              | 5.71                             | 0.00571                        |
| 2032 | 8,904                     | 534,240                              | 6.18                             | 0.00618                        |
| 2037 | 9,645                     | 578,700                              | 6.70                             | 0.00670                        |

Non-domestic water needs are used for commercial activities such as industry, offices and social activities such as schools, hospitals, places of worship and commerce [6]. The results of the calculation of non-domestic domestic water needs Uma Sima until 2037 is based on a table of clean water planning criteria that is 5% of non-domestic domestic water needs can be seen in Table 3 below.

**Table 3. Non domestic water needs in Uma Sima Urban Village**

| Year | Domestic Water Needs(liters/seconds) | Non Domestic Water Needs (liters/seconds) |
|------|-------------------------------------|------------------------------------------|
| 2022 | 5.27                                | 0.263                                    |
| 2027 | 5.71                                | 0.285                                    |
| 2032 | 6.18                                | 0.309                                    |
| 2037 | 6.70                                | 0.335                                    |

From Table 3 above, it can be seen that with increasing population each year where domestic water needs are increasing is directly proportional to the demand for non-domestic water that is getting bigger every year even though it is much smaller than non-domestic water needs, namely until 2037 Non-domestic clean water 0.335 liters / second. Based on clean water planning criteria in the clean water planning criteria table, water leakage or loss is 20% of the average, where the average needs are the sum of domestic water needs and non-domestic water needs. The results of the calculation of water loss in Uma Sima Urban Village can be seen in Table 4 water loss in Uma Sima Urban Village below.

**Table 4. Water loss Uma Sima Urban Village**

| Year | Water Loss (liters/seconds) |
|------|-----------------------------|
| 2022 | 1,106                       |
| 2027 | 1,199                       |
| 2032 | 1,298                       |
| 2037 | 1,407                       |

Total daily clean water needs in Uma Sima Kelurahan are the sum of domestic water needs, non-domestic water needs and water losses. Then for max daily clean water requirements are daily water needs times 1.15-1.25 and water needs at peak hours ie max daily water needs times 1.75. Values from
1.15 to 1.25 are the max day factor and 1.75 is the peak hour factor for a population of between 3,000 and 10,000 people which can be seen in the table of clean water planning criteria.

**Table 5.** Total clean water needs in Uma Sima Urban Village with a maximum day factor 1.15 and peak hour factor 1.75

| Year | Domestic Needs (l/s) | Non Domestic Needs (l/s) | Loss (20%) Needs (l/s) | Daily Needs Max Needs (l/s) | Peak Hour Needs (l/s) |
|------|----------------------|--------------------------|----------------------|-----------------------------|----------------------|
| 2022 | 5.27                 | 0.263                    | 1.106                | 6.639                       | 7.635                | 13.36                |
| 2027 | 5.71                 | 0.285                    | 1.199                | 7.194                       | 8.273                | 14.48                |
| 2032 | 6.18                 | 0.309                    | 1.298                | 7.787                       | 8.955                | 15.67                |
| 2037 | 6.70                 | 0.335                    | 1.407                | 8.442                       | 9.708                | 16.99                |

**Table 6.** Total clean water needs in Uma Sima Urban Village with a maximum day factor 1.25 and peak hour factor 1.75

| Year | Domestic Needs (l/s) | Non Domestic Needs (l/s) | Loss (20%) Needs (l/s) | Daily Needs Max Needs (l/s) | Peak Hour Needs (l/s) |
|------|----------------------|--------------------------|----------------------|-----------------------------|----------------------|
| 2022 | 5.27                 | 0.263                    | 1.106                | 6.639                       | 8.299                | 14,523               |
| 2027 | 5.71                 | 0.285                    | 1.199                | 7.194                       | 8.992                | 15,736               |
| 2032 | 6.18                 | 0.309                    | 1.298                | 7.787                       | 9.734                | 16,404               |
| 2037 | 6.70                 | 0.335                    | 1.407                | 8.442                       | 10.552               | 18,446               |

From Table 5 and Table 6 above, it can be seen that the amount of clean water needs of the population in Uma Sima Sub-district, Sumbawa Subdistrict is increasing every year, which means that water is one of the most important for the survival of the community in Uma Sima Sub-District, Sumbawa Subdistrict, namely until 2037. need peak hours of 18,446 liters / second. The distribution network simulation results with Epanet 2.0.

![Figure 1. Uma Sima Urban pipeline simulation using Epanet 2.0 Software](image-url)
Table 7. The pressure that occurs at each node

| Node ID | Elevation | Head Pressure | m | m | m |
|---------|-----------|---------------|---|---|---|
| Ju 2    | 94        | 130.76        |   |   | 36.76 |
| Ju 3    | 94        | 130.72        |   |   | 36.72 |
| Ju 4    | 99        | 130.50        |   |   | 31.50 |
| Ju 5    | 93        | 130.13        |   |   | 37.13 |
| Ju 6    | 103       | 117.88        |   |   | 14.88 |
| Ju 7    | 76        | 117.15        |   |   | 41.15 |
| Ju 8    | 27        | 106.18        |   |   | 79.18 |
| Ju 9    | 27        | 100.49        |   |   | 73.47 |
| Ju 10   | 27        | 99.85         |   |   | 72.85 |
| Ju 11   | 71        | 107.33        |   |   | 36.33 |
| Ju 12   | 71        | 106.35        |   |   | 35.35 |
| Ju 13   | 70        | 104.02        |   |   | 34.02 |
| Ju 14   | 27        | 100.04        |   |   | 73.04 |
| Ju 15   | 27        | 92.14         |   |   | 65.14 |
| Ju 16   | 27        | 92.33         |   |   | 65.33 |
| Ju 17   | 25        | 95.63         |   |   | 70.63 |
| Ju 18   | 25        | 94.57         |   |   | 69.57 |
| Ju 19   | 25        | 92.78         |   |   | 67.78 |
| Ju 20   | 25        | 92.12         |   |   | 67.12 |
| Ju 21   | 25        | 91.67         |   |   | 66.67 |
| Ju 22   | 27        | 85.95         |   |   | 58.95 |
| Ju 23   | 25        | 91.53         |   |   | 66.53 |
| Ju 24   | 25        | 95.47         |   |   | 70.47 |
| Resvr 1 | 131       | 131.00        |   |   | 0.00 |

Based on Table 7 above it can be seen that the lowest pressure is located at junction 6 at 14.88 m, while the highest pressure is located at junction 8 at 79.18 m. Overall the pressure that occurs at all junctions ranges from 14.88 m - 79.18 m. This indicates that the pressure is in accordance with the Minister of Public Works Regulation regarding SPAM Number 18 / PRT / M / 2007, which is between 10 m - 100 m for PVC pipes.

Based on Table 8 above which is the result of distribution network simulation with Epanet 2.0 software, it can be seen that the lowest speed of 0.07 m / sec is occurred in pipe 25, this is because pipe 25 is mounted on a relatively flat topography. So the speed that occurs in pipe 25 does not meet the criteria of the Minister of Public Works Regulation regarding the Implementation of SPAM Development Number: 18 / PRT / M / 2007 which is between 0.3 m / sec - 5.0 m / sec. While the highest speed is 2.38 m / sec in pipe 5, this happens because pipe 5 is close to the reservoir and has a smaller pipe diameter with the previous pipe from the reservoir, the amount of water supplied from this reservoir causes the flow to flow smoothly. The first solution is to change the pipe diameter 25 from 50 mm diameter to 40 mm diameter and water requirements at junction 24 are added from 0.145 lps to 0.500 lps. After re-simulation, the results obtained for the pressure and speed values can be seen in Table 9 and Table 10 below.
Table 8. The speed that occurs at each node

| Link ID | Length | Diameter | Roughness | Velocity |
|---------|--------|----------|-----------|----------|
| Pi 1    | 160    | 300      | 120       | 0.59     |
| Pi 2    | 25     | 300      | 120       | 0.59     |
| Pi 3    | 150    | 300      | 120       | 0.59     |
| Pi 4    | 250    | 300      | 120       | 0.59     |
| Pi 5    | 280    | 150      | 120       | 2.38     |
| Pi 6    | 136    | 150      | 120       | 0.77     |
| Pi 7    | 650    | 150      | 120       | 1.47     |
| Pi 8    | 330    | 150      | 120       | 1.44     |
| Pi 9    | 171    | 150      | 120       | 0.63     |
| Pi 10   | 2500   | 150      | 120       | 0.65     |
| Pi 11   | 366    | 150      | 120       | 0.53     |
| Pi 12   | 1387   | 150      | 120       | 0.41     |
| Pi 13   | 620    | 100      | 120       | 0.65     |
| Pi 14   | 1334.5 | 75       | 120       | 0.52     |
| Pi 15   | 63     | 100      | 120       | 0.44     |
| Pi 16   | 2200   | 150      | 120       | 0.63     |
| Pi 17   | 1334.5 | 100      | 120       | 0.56     |
| Pi 18   | 1217   | 150      | 120       | 0.60     |
| Pi 19   | 321    | 150      | 120       | 0.59     |
| Pi 20   | 556    | 150      | 120       | 0.58     |
| Pi 21   | 623    | 50       | 120       | 0.51     |
| Pi 22   | 213    | 150      | 120       | 0.57     |
| Pi 23   | 146    | 150      | 120       | 0.56     |
| Pi 24   | 150    | 150      | 120       | 0.30     |
| Pi 25   | 630    | 50       | 120       | 0.07     |

Table 9. Water pressure of each node

| Node ID | Elevation | Base Demand | Head | Pressure |
|---------|-----------|-------------|------|----------|
| Ju 2    | 94        | 0           | 130.76 | 36.76    |
| Ju 3    | 94        | 0           | 130.72 | 36.72    |
| Ju 4    | 99        | 0           | 130.49 | 31.49    |
| Ju 5    | 93        | 0           | 130.11 | 37.11    |
| Ju 6    | 103       | 2.48        | 117.67 | 14.67    |
| Ju 7    | 76        | 2.1         | 116.94 | 40.94    |
| Ju 8    | 27        | 0.592       | 105.71 | 78.71    |
| Ju 9    | 27        | 3.225       | 99.88  | 72.88    |
| Ju 10   | 27        | 0.412       | 99.21  | 72.21    |
| Ju 11   | 71        | 2.1         | 107.07 | 36.07    |
| Ju 12   | 71        | 2.1         | 106.07 | 35.07    |
| Ju 13   | 70        | 2.1         | 103.72 | 33.72    |
| Ju 14   | 27        | 2.82        | 99.69  | 72.69    |
| Ju 15   | 27        | 5.785       | 91.55  | 64.55    |
| Ju 16   | 27        | 3.225       | 91.75  | 64.75    |
| Ju 17   | 25        | 0.145       | 94.74  | 69.74    |
Node ID  | Elevation  | Base Demand | Head   | Pressure   \\
--- | --- | --- | --- | --- \\
Ju 18  | 25  | 0.145  | 93.69  | 68.69  \\
Ju 19  | 25  | 0.145  | 91.91  | 66.91  \\
Ju 20  | 25  | 0.145  | 91.24  | 66.24  \\
Ju 21  | 25  | 3.58   | 90.80  | 65.80  \\
Ju 22  | 27  | 5.38   | 85.31  | 58.31  \\
Ju 23  | 25  | 5.38   | 90.65  | 65.65  \\
Ju 24  | 25  | 0.500  | 90.04  | 65.04  \\
Resvrl | 131 | 0.00   | 131.00 | 0.00   \\

Table 10. The speed that occurs at each node

| Link ID | Length | Diameter | Roughness | Velocity |
|---------|--------|----------|-----------|----------|
| Pi 1    | 160    | 300      | 120       | 0.60     |
| Pi 2    | 25     | 300      | 120       | 0.60     |
| Pi 3    | 150    | 300      | 120       | 0.60     |
| Pi 4    | 250    | 300      | 120       | 0.60     |
| Pi 5    | 280    | 150      | 120       | 2.40     |
| Pi 6    | 136    | 150      | 120       | 0.77     |
| Pi 7    | 650    | 150      | 120       | 1.49     |
| Pi 8    | 330    | 150      | 120       | 1.46     |
| Pi 9    | 171    | 150      | 120       | 0.65     |
| Pi 10   | 2500   | 150      | 120       | 0.65     |
| Pi 11   | 366    | 150      | 120       | 0.53     |
| Pi 12   | 1387   | 150      | 120       | 0.41     |
| Pi 13   | 620    | 100      | 120       | 0.66     |
| Pi 14   | 1334.5 | 75       | 120       | 0.53     |
| Pi 15   | 63     | 100      | 120       | 0.44     |
| Pi 16   | 2200   | 150      | 120       | 0.63     |
| Pi 17   | 1334.5 | 100      | 120       | 0.56     |
| Pi 18   | 1217   | 150      | 120       | 0.62     |
| Pi 19   | 321    | 150      | 120       | 0.59     |
| Pi 20   | 556    | 150      | 120       | 0.58     |
| Pi 21   | 623    | 50       | 120       | 0.50     |
| Pi 22   | 213    | 150      | 120       | 0.57     |
| Pi 23   | 146    | 150      | 120       | 0.56     |
| Pi 24   | 150    | 150      | 120       | 0.30     |
| Pi 25   | 630    | 40       | 120       | 0.40     |

Based on Table 10 above which is the result of distribution network simulation with Epanet 2.0 software, it can be seen that the velocity on pipe 25 is 0.40 m / s. So the speed that occurs in pipe 25 already meets the criteria of the Minister of Public Works Regulation regarding the Implementation of SPAM Development Number: 18 / PRT / M / 2007 which is between 0.3 m / sec - 5.0 m / sec. If seen in reality, the people who are in the pipeline 25 around the Sumbawa Regent's Office are still able to get clean water, because in addition to the clean water sources from the Batulangeth PDAM, Sumbawa Regency, there are also those who use other water sources namely boreholes or dug wells.
4. Conclusion
The conclusion is that from the results of the analysis that has been carried out on the clean water network of Batulanteh PDAM, Sumbawa Regency in Uma Sima Village, Sumbawa District, it can be concluded that:

a. The need for clean water in the Uma Sima Kelurahan clean water service area in the next 20 years is 16.99 liters / second and 18.446 liters / second. This means that the required clean water is increasing every year along with the increase in population, although not so large. While the discharge in the reservoir for all clean water service areas served by PDAM Batulanteh, Sumbawa Regency, namely Sumbawa Subdistrict, Labuhan Badas Subdistrict, Unter Iwes Subdistrict, Moyo Hilir Subdistrict and North Moyo Subdistrict are 80 liters / second which is still not sufficient for 20 years future so that it can be anticipated by the addition of raw water sources so that the discharge from the reservoir that flows into the house connections can be fulfilled.

b. Based on the evaluation results using the Epanet 2.0 program simulation it can be concluded that the high value of the pressure generated at the node (junction) in the simulation is still in accordance with the Permen PU standard on the Implementation of SPAM Development No: 18 / PRT / M / 2007 which is between 10 m - 100 m. Overall the pressure that occurs at all junctions ranges from 14.88 m - 79.18 m, so the area is still able to supply water. While the high value of flow velocity in the pipe is found that there is one pipe section that does not fit the criteria for running Epanet 2.0 is pipe 25 with a flow velocity value of 0.07 m / s, it is not in accordance with the Permen PU standard regarding Implementation of SPAM Development No: 18 / PRT / M / 2007 that is between 0.3 m / sec - 5 m / sec, then after re-simulation by replacing the diameter of the pipe 25 with 40 mm and the need for water at junction 24 by 0.500 lps at a speed of 0.40 m / s and is included in the criteria. Then in reality in the field, the pipeline section 25 can still get clean water from other sources, namely boreholes or dug wells.

5. References
[1] Novan Armanto R and Indarjanto H, 2016 Distribution of drinking water in PDAM Plosowahyu Unit Hydraulic J. ITS 5, 2 p. 116–121. (In Bahasa)
[2] Amin M, 2011 Analysis computation of drinking water pipeline networks Pros. Semin. Nas. Geo 2011 p. 3–18. (In Bahasa)
[3] Ahmadullah R and Dongshik K, 2016 Designing of hydraulically balanced water distribution network based on GIS and EPANET Int. J. Adv. Comput. Sci. Appl. 7, 2 p. 118–125.
[4] Venkata Ramana G Sudheer C V S S and Rajasekhar B, 2015 Network analysis of water distribution system in rural areas using EPANET Procedia Eng. 119, 1 p. 496–505.
[5] Nugroho S Meicahayanti I and Nurdiana J, 2018 Analysis of clean water distribution piping network Engineering 39, 1 p. 62–66. (In Bahasa)
[6] Dewi K H and Muttaqien A Y, 2015 Water loss analysis pdam clean water distribution network pipes, Baki District, Sukoharjo Regency J. UNS 9, 1 p. 9–16. (In Bahasa)