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ON WATER MANAGEMENT MODELING

CHI ICWMM

KU KASETSART UNIVERSITY

AN ENERGY ASSESSMENT ON THE WATER DISTRIBUTION NETWORK WITH DEFICIENT DATA QUALITY: A CASE STUDY IN SAMUTPRAKARN, THAILAND

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Profile

- Natchapol Charuwimolkul

- Master Student

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- Research Interests:
  - Water Network Calibration
  - Energy Assessment
  - Quality Assessment

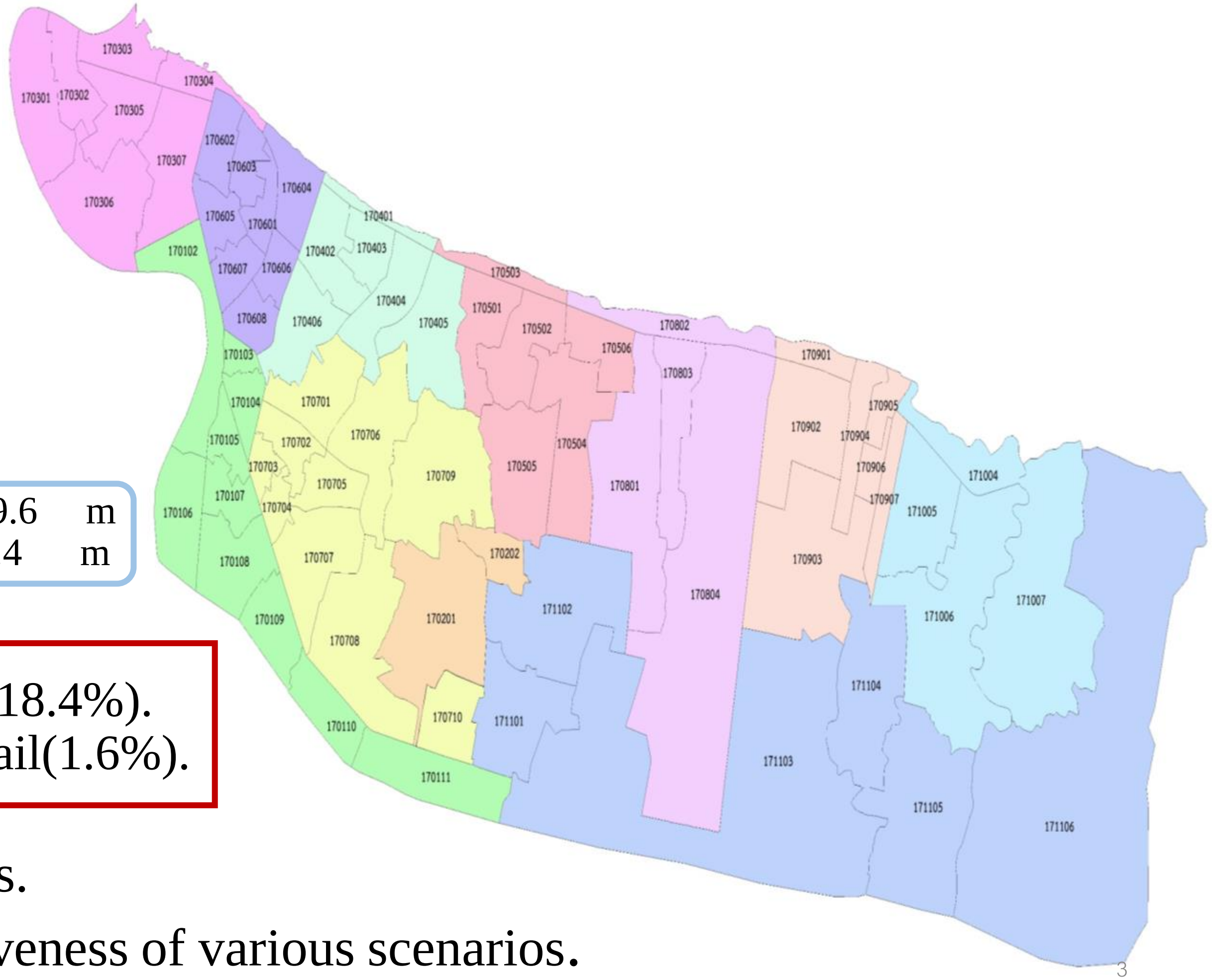
Introduction : Overview

- SAMUTPRAKARN's Water Distribution Network is managed by Metropolitan Waterworks Authority (MWA), Thailand.

- Basic Information:

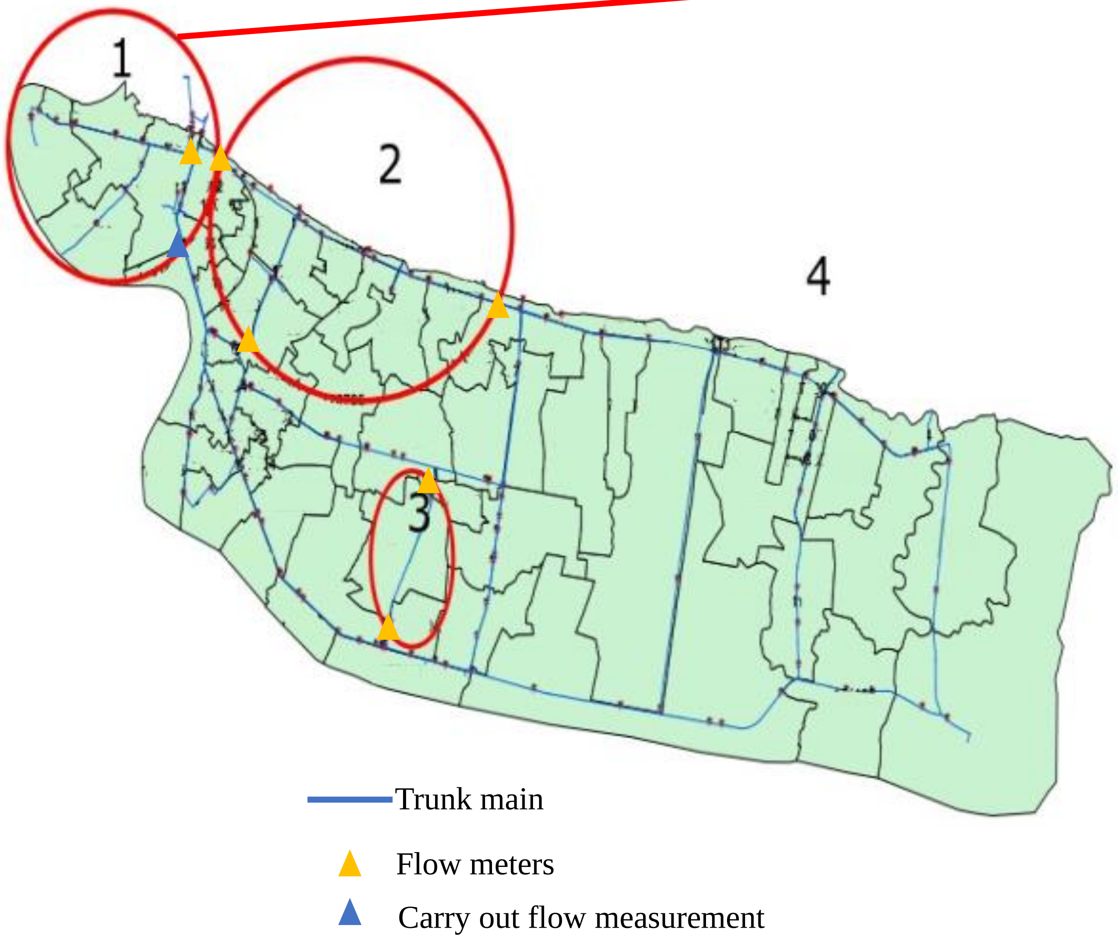
274.6 km^2	3070.605 km
195,872 users	70 DMAs
28.64 %	MAX avg. P at DMA inlets: 9.6 m MIN avg. P at DMA inlets: 2.4 m

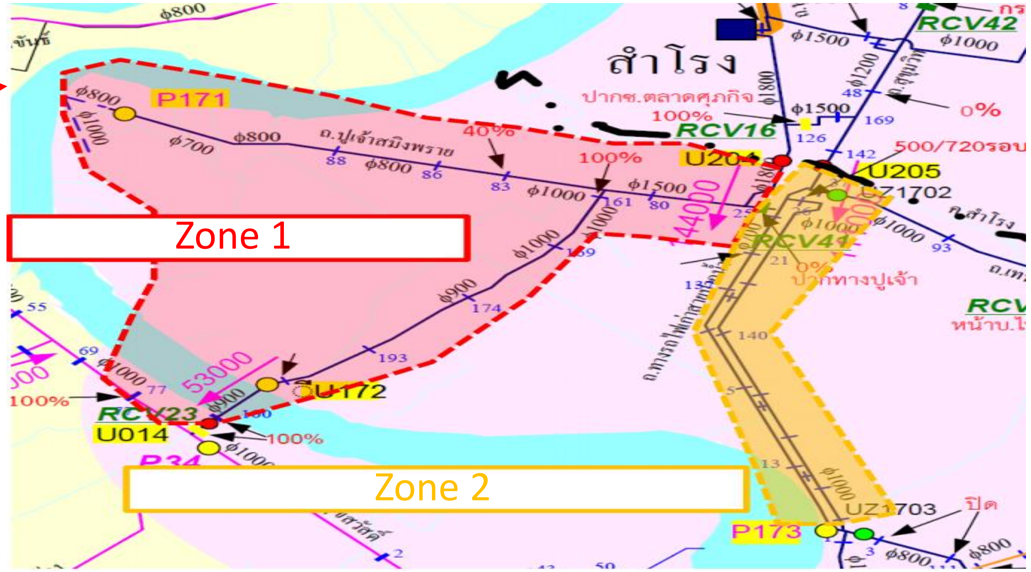
125 meters at DMA inlets : 23 flow measurements fail (18.4%).
2 pressure measurements fail(1.6%).



- Due to the low pressure, it is difficult to locate leaks.
- Energy assessments will help to decide cost-effectiveness of various scenarios.

Introduction : Trunk Main Network

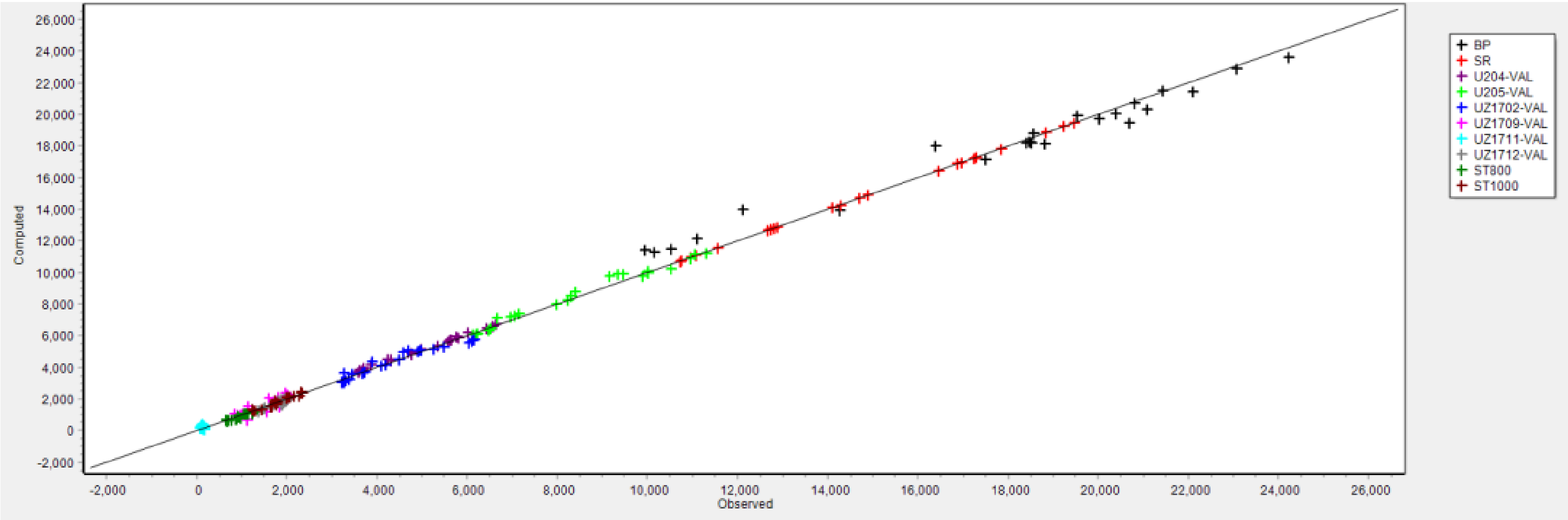




- Due to incomplete measurements, it is difficult to calibrate the network model.

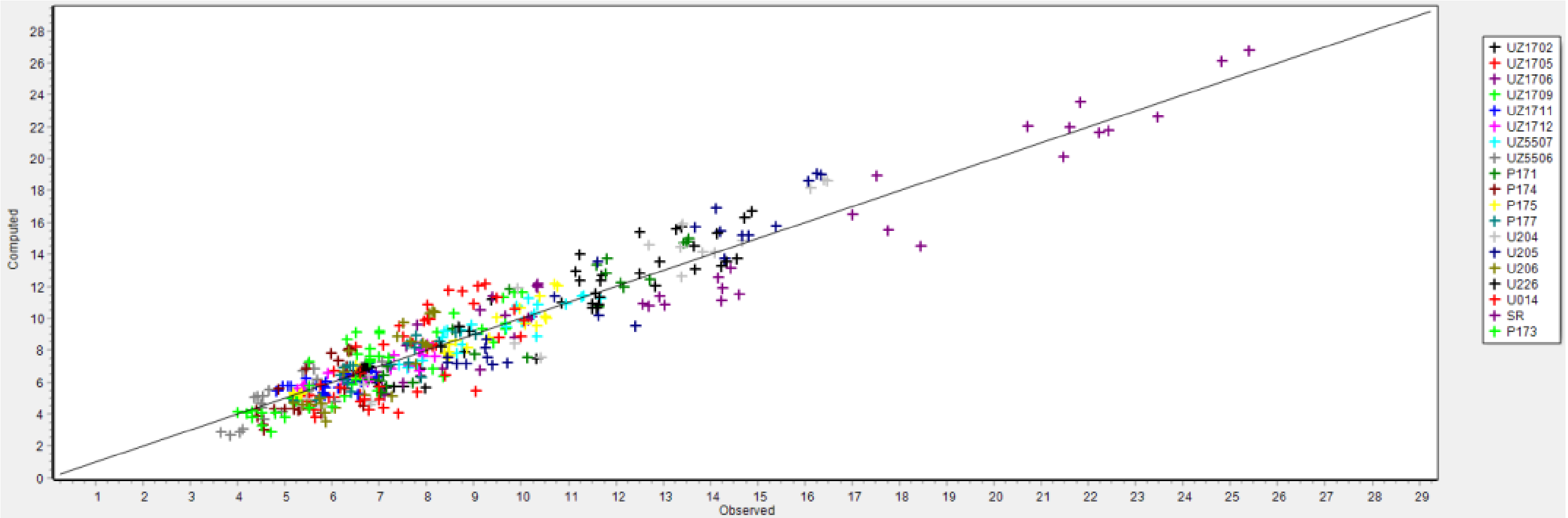
- To give an example, we divided the trunk main into 4 routes to perform water balance according to flow meters on the trunk main.

Trunk Main Network Model Calibration (Validation)



Adjusted parameters are emitter coefficient, flow pattern of failed flow meter and valve minor loss coefficient.

Comparison between measured flow and simulated flow after model calibration



Comparison between measured pressure and simulated pressure after model calibration

Energy Assessment

- An energy assessment employs the energy balance approach which is applied on the hydraulic model simulation result.

<table>
<tr><td rowspan="3">Input Energy (E_{in})</td><td rowspan="2">Energy exiting the system (E_{out})</td><td>Energy delivered to water users (E_U)</td></tr>
<tr><td>Energy exiting the system in a water loss form (E_{wl})</td></tr>
<tr><td>Energy Dissipated ($E_{dissipated}$)</td><td>Energy lost due to friction (E_F)</td></tr>
</table>

(Cabrera et al., 2010)

- Energy equation

$$E_{in}(t_p) = \gamma \cdot \sum_{t_k=0}^{t_k=t_p} \left[\sum_{i=1}^{n_{in}} Q_{in,i(t_k)} \cdot H_{i(t_k)} \right] \cdot \Delta t$$

$$E_U(t_p) = \gamma \cdot \sum_{t_k=0}^{t_k=t_p} \left[\sum_{i=1}^{n_{in}} Q_{u,i(t_k)} \cdot H_{i(t_k)} \right] \cdot \Delta t$$

$$E_F(t_p) = \gamma \cdot \sum_{t_k=0}^{t_k=t_p} \left[\sum_{i=1}^{n_{in}} Q_{i(t_k)} \cdot \Delta h_{i(t_k)} \right] \cdot \Delta t$$

$$E_{wl}(t_p) = \gamma \cdot \sum_{t_k=0}^{t_k=t_p} \left[\sum_{i=1}^{n_{in}} q_{i(t_k)} \cdot H_{i(t_k)} \right] \cdot \Delta t$$

- Leak flow equation

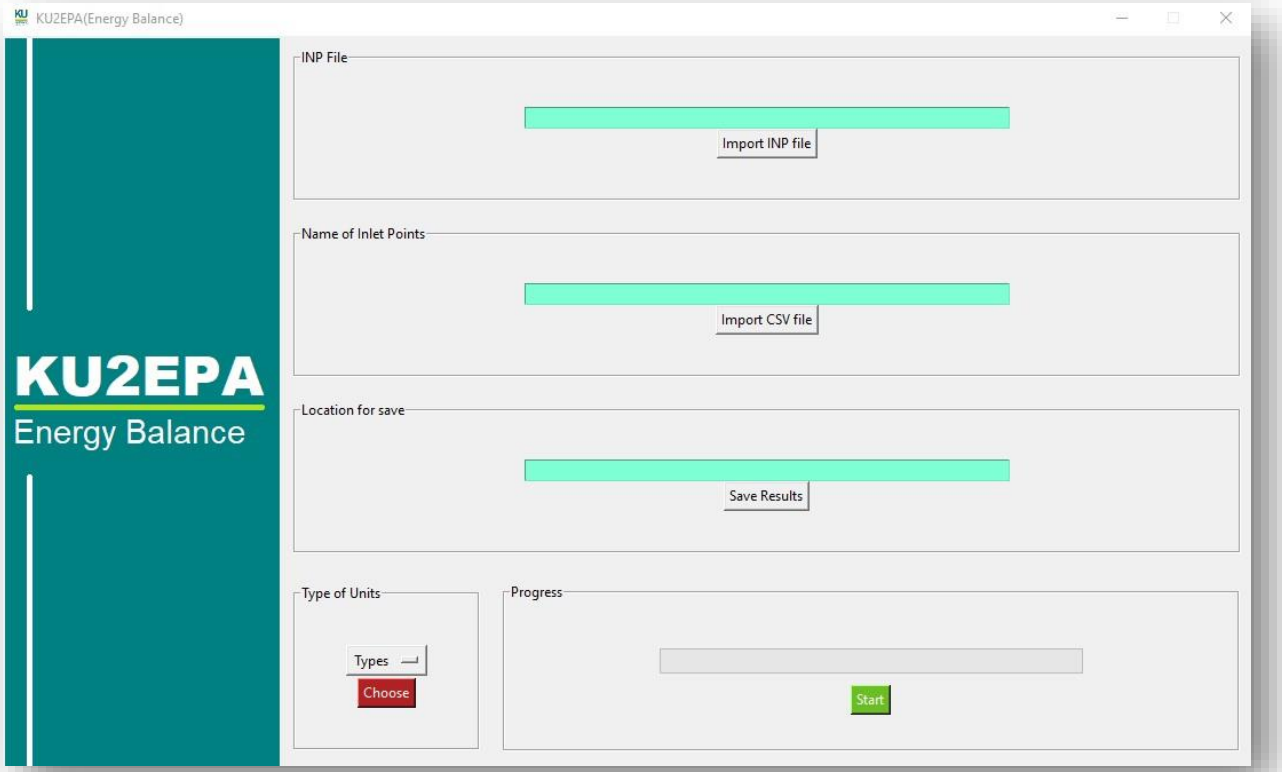
$$q_i = C P_i^{N_1}$$

C is Emitter Coefficient
N_1 is Emitter Exponent

Software for energy assessment

- Software (KU2EPA) is developed based on Python language.

- Water Network Tool for Resilience (WNTR) is a package on python, it's developed U.S. Environmental Protection Agency (EPA).



Software input:

- INP file from EPANET Program.

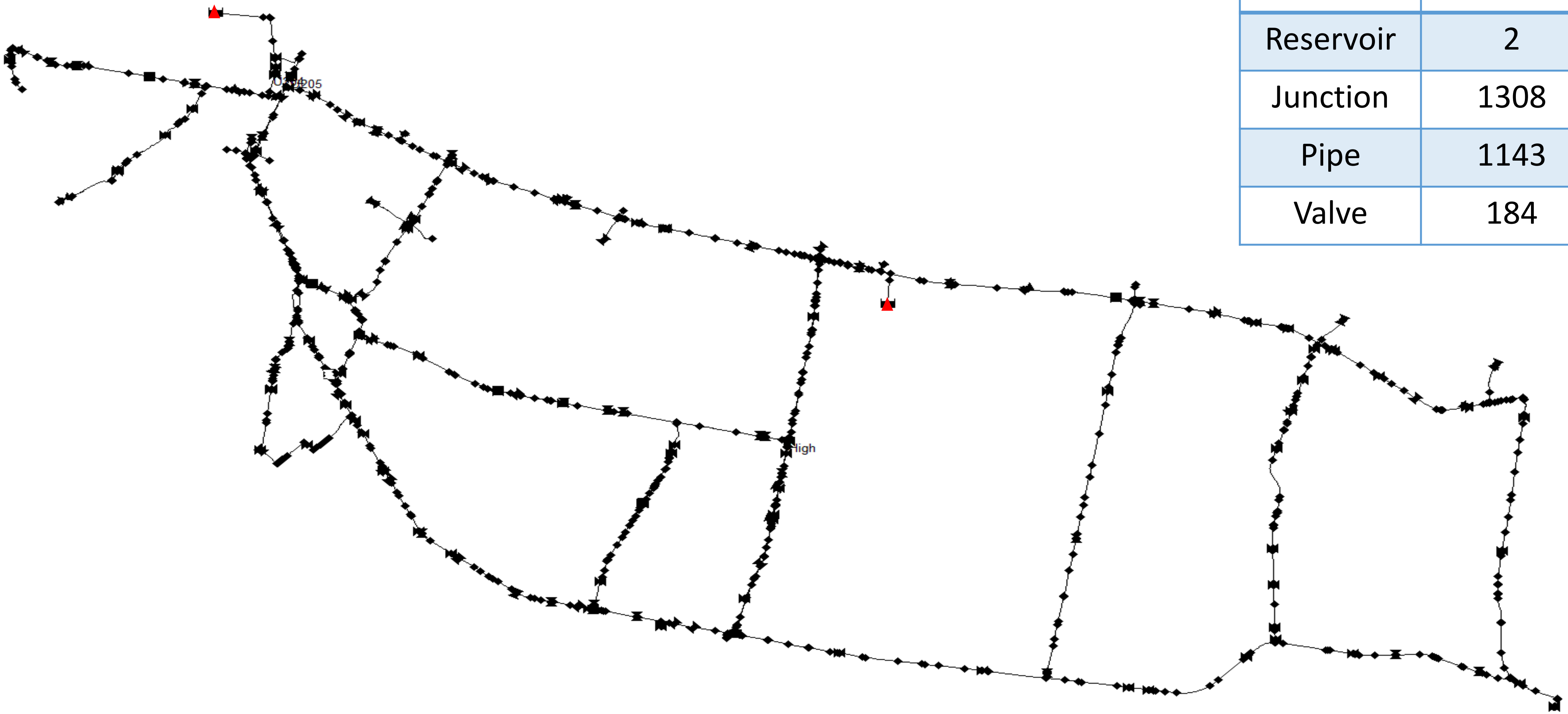
- Name of an input node.

- The file location to saves results.

- Preferred unit type.

**The result is in kWh format.

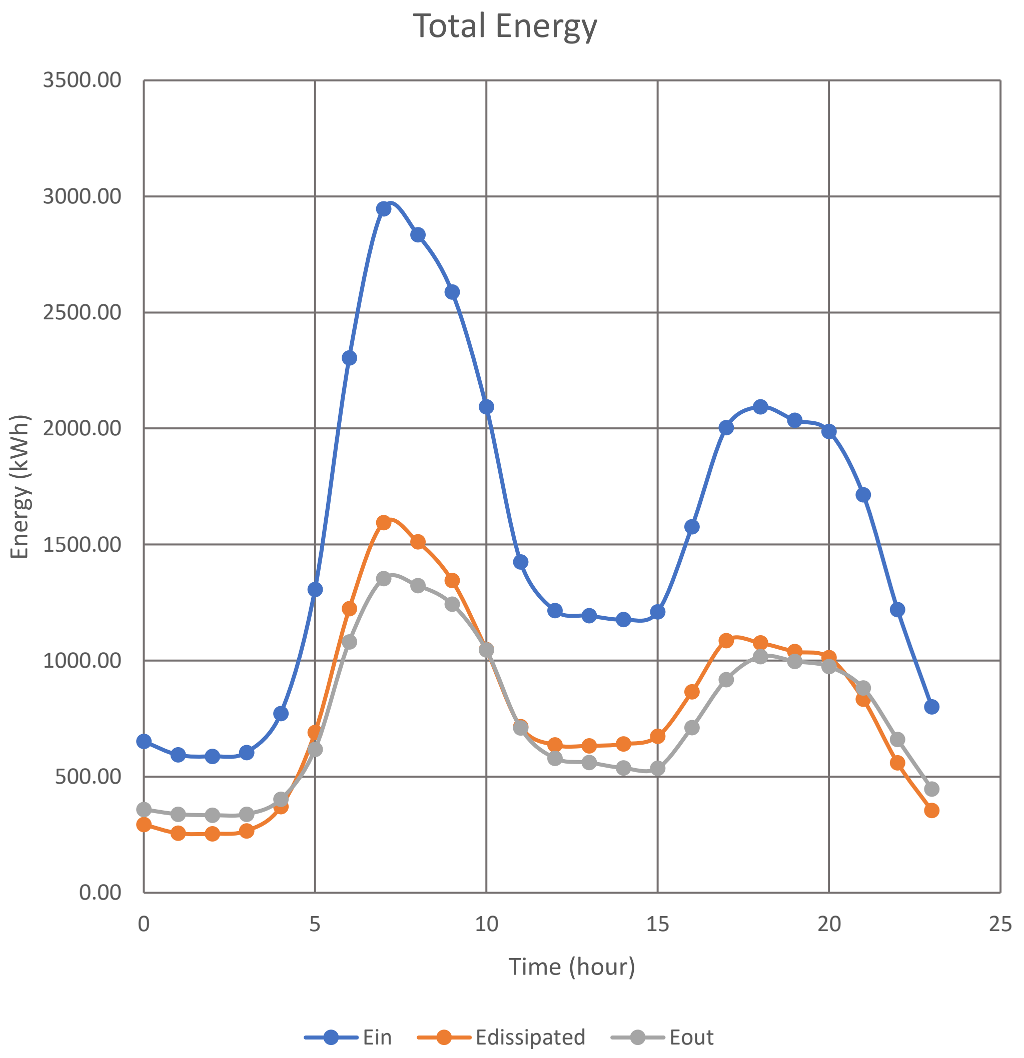
SAMUTPRAKRAN’s Trunk Main Network

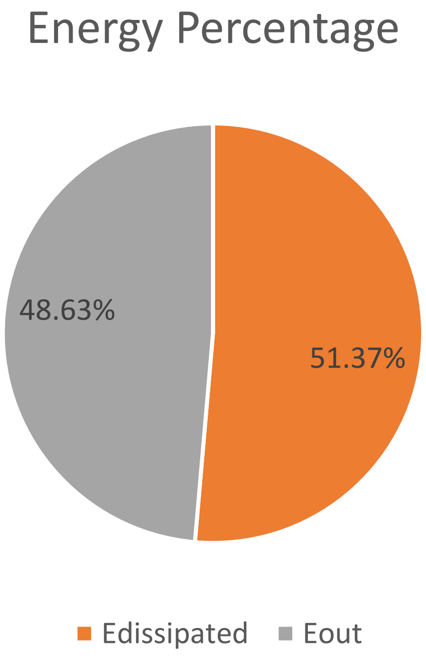


Types	Numbers
Reservoir	2
Junction	1308
Pipe	1143
Valve	184

Energy Result

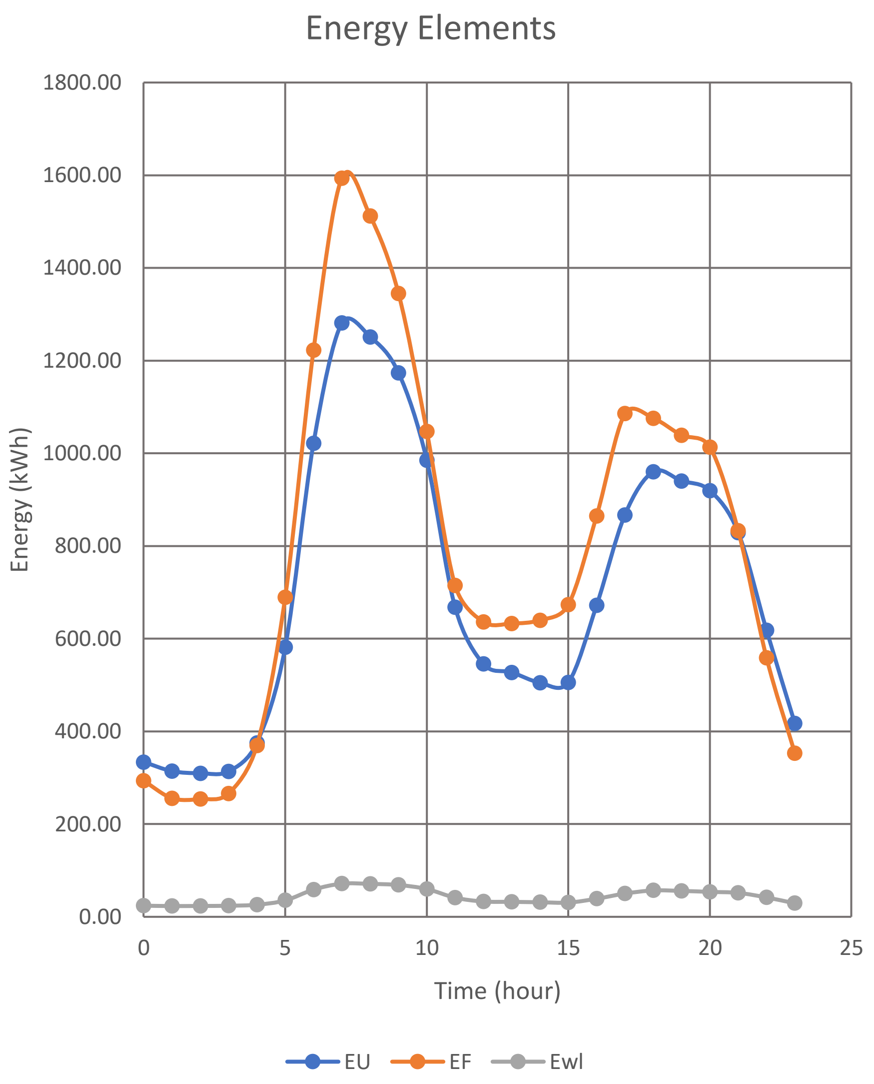
Time (hr)	Total E_{in}	Total $E_{dissipated}$	Total E_{out}
0	651.44	293.36	358.08
1	593.46	255.79	337.68
2	587.19	253.85	333.34
3	603.77	266.03	337.74
4	771.34	369.83	401.51
5	1306.61	689.50	617.11
6	2303.08	1222.69	1080.40
7	2946.08	1593.53	1352.55
8	2834.29	1511.76	1322.53
9	2587.67	1345.04	1242.62
10	2092.14	1047.11	1045.03
11	1424.29	714.93	709.35
12	1214.92	636.16	578.76
13	1192.64	632.69	559.94
14	1176.40	639.95	536.45
15	1209.39	673.17	536.22
16	1575.85	864.88	710.97
17	2003.12	1085.49	917.63
18	2092.40	1075.42	1016.98
19	2034.89	1038.62	996.27
20	1986.33	1013.02	973.31
21	1714.09	832.95	881.15
22	1219.21	558.85	660.35
23	799.90	353.17	446.73
kw-h/day	36920.48	18967.79	17952.69
%	100.00	51.37	48.63

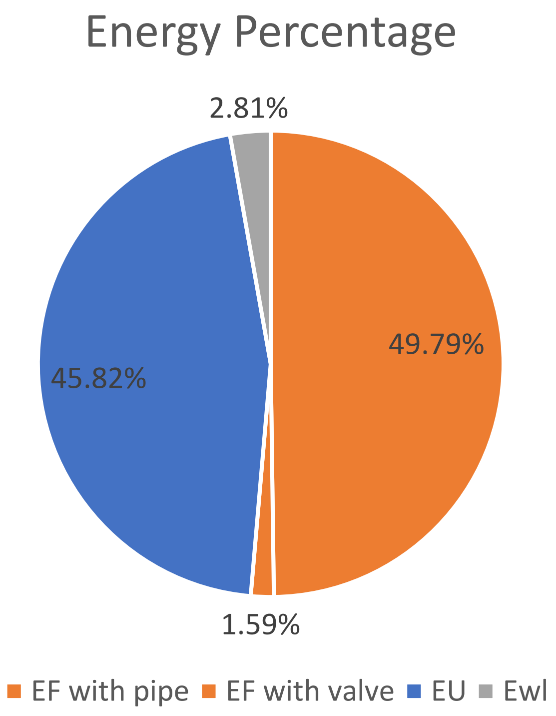




Energy Result

Time (hr)	E_{in}	E_F with pipe	E_F with valve	E_U	E_{wl}
0	651.44	282.73	10.63	333.83	24.24
1	593.46	245.77	10.02	314.20	23.48
2	587.19	242.99	10.86	309.63	23.71
3	603.77	253.97	12.06	313.61	24.12
4	771.34	355.41	14.42	375.20	26.31
5	1306.61	666.12	23.39	581.56	35.55
6	2303.08	1182.10	40.58	1021.62	58.78
7	2946.08	1544.21	49.31	1281.06	71.50
8	2834.29	1465.71	46.05	1251.45	71.08
9	2587.67	1303.28	41.76	1173.95	68.67
10	2092.14	1015.42	31.69	985.01	60.02
11	1424.29	694.62	20.31	667.89	41.46
12	1214.92	619.35	16.81	545.49	33.26
13	1192.64	615.62	17.07	527.42	32.52
14	1176.40	622.55	17.40	504.84	31.62
15	1209.39	654.30	18.87	505.31	30.92
16	1575.85	839.29	25.59	671.77	39.20
17	2003.12	1053.10	32.39	867.34	50.29
18	2092.40	1042.05	33.37	960.00	56.98
19	2034.89	1007.77	30.84	940.31	55.96
20	1986.33	983.92	29.11	919.42	53.88
21	1714.09	808.29	24.66	829.40	51.74
22	1219.21	541.40	17.45	618.38	41.97
23	799.90	341.19	11.98	417.42	29.31
kw-h/day	36920.48	18381.16	586.63	16916.13	1036.56
%	100.00	49.79	1.59	45.82	2.81

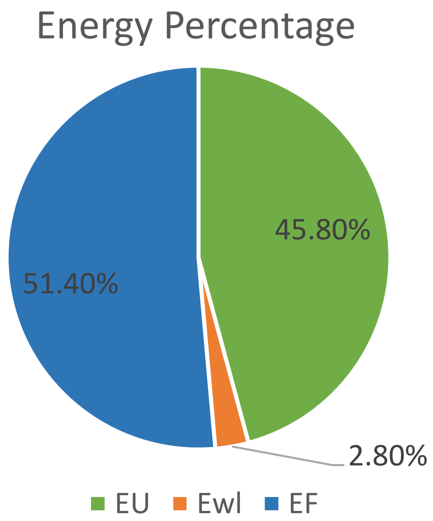




Energy Result :Critical pressure is 10 m.

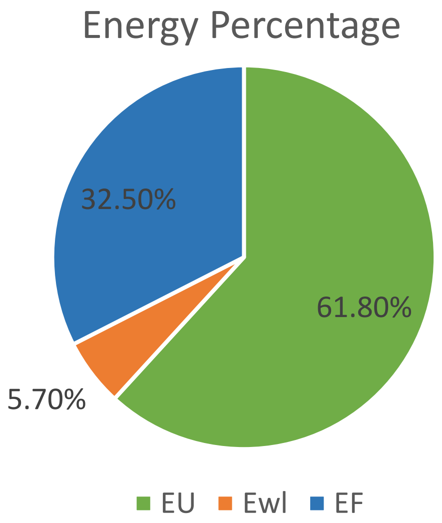
- No minimum pressure criterion

E_{in} *36,920 kW-h/day (100%)*	E_{out} *17,593 kW-h/day (48.6%)*	E_U *16,916 kW-h/day (45.8%)*
		E_{wl} *1,037 kW-h/day (2.8%)*
	$E_{dissipated}$ *18,968 kW-h/day (51.4%)*	E_F *18,968 kW-h/day (51.4%)*



- With 10 m. minimum pressure criterion

E_{in} *63,480 kW-h/day (100%)*	E_{out} *42,828 kW-h/day (67.5%)*	E_U *39,179 kW-h/day (61.8%)*
		E_{wl} *3,650 kW-h/day (5.7%)*
	$E_{dissipated}$ *20,651 kW-h/day (32.5%)*	E_F *20,651 kW-h/day (32.5%)*



Conclusions

- The energy assessment can be used to reveal the energy efficiency of the WDN and can assist in selecting a scenario to improve the network.
- The case study show that the energy efficiency is significantly improved if the network has minimum pressure criterion of 10 m.
- The software called KU2EPA facilitates energy balancing and can calculate hourly energy balance

Thank you