EXPANDING POTENTIALS OF DISTRICT HEATING NETWORK AND ALTERNATIVE SOLUTIONS

Amel Husić dipl.ing.maš. | Centralno Grijanje d.d. Tuzla
Bosna i Hercegovina
• DHN from cogeneration Tuzla has been in use for 37 years.

• The system uses 145/75C temperature regime 1, originating a few kilometers away from the city at the thermal power plant Tuzla.

• Every building has its own substation with heat exchanger and flow regulator. In the area near the plant, every building has additional pressure regulator.

• The documents from 1981 allow connections to multi-family residential objects (4 or more flats) only, NOT for individual residential houses.

• District heating zones were limited to 265 elevation above sea level.
1967. • Conceptual design
1981. • Main project
1982. • Construction
2001. • District heating zones expand (39)
2003. • TPP block 3 reconstruction, and TS1 175 MWh
2010. • District heating zones expand 2 (55)
2017. • Decision for financing connections the private houses to DHN
2018. • Decision for cofinancing heat pumps for private houses (50 %)
2019. • Plans for district heating expansion
CAPACITY DEVELOPMENT FOR PERIOD 2001.-2018.

2008-2015 period of expansion of large areas; with multi-family residential, etc.
JZU UKC Tuzla –: 10000 KW; heating area 45300 m²
JZU UKC Tuzla – Hospital Slavinovići: Heat demand: 560 KW
Municipality Dragodol, Miladije, Kula, etc....
<table>
<thead>
<tr>
<th>Godina</th>
<th>Toplinska snaga u ICG (MW)</th>
<th>Toplinska snaga u TP (MW)</th>
<th>Broj toplinskih podstanica</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>157</td>
<td>192,0</td>
<td>209</td>
</tr>
<tr>
<td>2007</td>
<td>184</td>
<td>241,0</td>
<td>524</td>
</tr>
<tr>
<td>2009</td>
<td>191</td>
<td>248,0</td>
<td>591</td>
</tr>
<tr>
<td>2012</td>
<td>214</td>
<td>281,0</td>
<td>772</td>
</tr>
<tr>
<td>2013</td>
<td>221</td>
<td>288,0</td>
<td>847</td>
</tr>
<tr>
<td>2014</td>
<td>222</td>
<td>291,5</td>
<td>870</td>
</tr>
<tr>
<td>2015</td>
<td>228</td>
<td>297,0</td>
<td>921</td>
</tr>
<tr>
<td>2017</td>
<td>232</td>
<td>301,4</td>
<td>988</td>
</tr>
<tr>
<td>2018</td>
<td>238</td>
<td>308,0</td>
<td>1020</td>
</tr>
</tbody>
</table>

In period 2015-2019 we were oriented to residential houses connections, with system of central heating substations.
• District heating connection 145/75C
• Central heating substation 2,5 MW
• Secundar district heating network 90/60C with individual house connections
From 2001. to 2019. we invested over 20 milion EUR.
MZ KULA 2500 Kw /IN USE FROM 2014./
MZ BATVA 2500 kW /in construction phase/
MZ SKOJEVSKA 2500 kW /in construction phase/
MZ MEJDAN 1500 kW /in construction phase/
DISTRICT HEATING NETWORK EXPANSION IN TUZLA
TECHNICAL ASPECT OF IMPLEMENTATION DHN IN KULA
With this concept we have reduced hydraulics impact on whole district heating system, especially on east side of the city which is further away from TPP.

Simple and efficient management.

With this central substation we provide heat supply for 197 households,

Until today 105 households have connected.

And very important for our TPP...

32 m³/h from distribution network!!
TERMIS SIMULATION

- Termis is a hydraulic modeling tool that simulates flow, pressure and temperature behavior in a district heating distribution network.
- Unlike other tools, Termis uses real-time data to analyze the system and monitor its current state.
- This allows operators to make better and smarter decisions to optimize heat distribution.
WITH CONSTRUCTION OF ONE CENTRAL SUBSTATION FOR INDIVIDUAL HOUSES 2MW
• WITH RECONSTRUCTION OF ONE PART OF MAIN DISTRICT HEATING NETWORK K9A-K13
## Financial Aspects of the MZ Kula Project

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Investment City</th>
<th>Investment Residents</th>
<th>Investment MRS - Thermal Power Station (approx. 3,000 KM)</th>
<th>Total Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA KNJIGA 1: VRELOVODNA MREŽA 145/75</td>
<td>69285,0</td>
<td>14000,0</td>
<td>0,0</td>
<td>83285,0</td>
</tr>
<tr>
<td>2.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA KNJIGA 2: TOPLINSKA PODSTANICA</td>
<td>89937,0</td>
<td>25424,8</td>
<td>10841,8</td>
<td>126203,6</td>
</tr>
<tr>
<td>3.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA KNJIGA 3: SEKUNDARNA VRELOVODNA MREŽA</td>
<td>551156,0</td>
<td>242177,0</td>
<td>0,0</td>
<td>793333,0</td>
</tr>
<tr>
<td>4.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA KNJIGA 4: SEKUNDARNA VRELOVODNA MREŽA GOLI BRIJEG</td>
<td>183677,0</td>
<td>75409,0</td>
<td>0,0</td>
<td>259086,0</td>
</tr>
<tr>
<td>5.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA, SEKUNDARNA VRELOVODNA MREŽA ZA OBJEKTE 16. MUSLIMANSKE BRIGADE 14,20,240I26.</td>
<td>20100,0</td>
<td>13293,0</td>
<td>0,0</td>
<td>33393,0</td>
</tr>
<tr>
<td>6.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA, SEKUNDARNA VRELOVODNA MREŽA ZA OBJEKTE FILIPA KLJAJIĆA FIĆE - LJEVO(KNJIGA 6.)</td>
<td>19649,0</td>
<td>17690,0</td>
<td>0,0</td>
<td>37339,0</td>
</tr>
<tr>
<td>7.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA, SEKUNDARNA VRELOVODNA MREŽA ZA OBJEKTE 16. MUSLIMANSKE BRIGADE - ĆAMILA SIJERIĆA (KNJIGA 5.)</td>
<td>93783,0</td>
<td>77822,0</td>
<td>0,0</td>
<td>171605,0</td>
</tr>
<tr>
<td>8.</td>
<td>IZVEDBENI PROJEKAT TOPLIFIKACIJE MZ KULA, SEKUNDARNA VRELOVODNA MREŽA ZA OBJEKTE FILIPA KLJAJIĆA FIĆE - DESNO(KNJIGA 8.)</td>
<td>14000,0</td>
<td>5 130,0</td>
<td>27000,0</td>
<td>30000,0</td>
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<tr>
<td></td>
<td></td>
<td>1041587</td>
<td>478816</td>
<td>10842</td>
<td>1531244,6</td>
</tr>
</tbody>
</table>

**Total Investment: 785,000 €**
ECONOMIC ASPECT OF THE PROJECT

<table>
<thead>
<tr>
<th>Date</th>
<th>Investment Description</th>
<th>Value</th>
<th>Number of Households</th>
<th>Cost per Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020. (105 connected):</td>
<td>Investment of Local Government (without decision 10/17):</td>
<td>1558244.6</td>
<td>105</td>
<td>14840.4</td>
</tr>
<tr>
<td></td>
<td>Investment of Residents (Connection and Substation):</td>
<td>525000.0</td>
<td>105</td>
<td>4000.0</td>
</tr>
<tr>
<td></td>
<td>Investment Per Household:</td>
<td>1978244.6</td>
<td>105/150</td>
<td>18840.4</td>
</tr>
</tbody>
</table>

**9400 EUR** → **53%**
ENVIRONMENTAL IMPACT OF PROJECT

- Exact environmental impact of each project can be evaluated only with measurements before and after construction.
- With number of households and their heat supply demand we evaluate coal consumption:

\[
D = \frac{\Lambda}{0.21} \times \frac{C'}{12} \times \beta \times \left( \frac{\frac{H'}{4} + \frac{O'}{32} + \frac{\bar{N}}{28} + \frac{\bar{v}}{18}}{\left( \frac{H'}{4} + \frac{O'}{32} + \frac{\bar{N}}{28} + \frac{\bar{v}}{18} \right)} \right)
\]

\[\Lambda = 1.6 - 2 \text{ usually}\]
\[\beta = \text{fuel characteristics (for coal)} 1.2 - 1.2\]

Waste gases:
\[\Lambda\text{-factor of pressure for coal boilers } \Lambda = 1.6 - 2\]
\[\beta\text{-fuel characteristics (for coal) } 1.2 - 1.2\]

Waste gases components:

\[CO_2 + H_2O + N_2 + O_2 = 1 \text{ m}^3/\text{m}^3 \text{ waste gases}\]
\[S + O_2 = SO_2\]
\[2C + O_2 = 2CO\]

During incomplete combustion we produce CO, CH4 and other. Their content can be determined by chemical analysis. (e.g., Orsat apparatus)
We evaluated that this project reduced the total emissions by 4000-5000 t of CO2.
## ENVIRONMENTAL IMPACT OF PROJECT

### 4.2.2. Emisije u zrak iz stambenog sektora

U tabeli 4.2.2. su prikazane emisije iz stambenog sektora Tuzlanskog kantona.

*Tabela 4.2.2. Emisija iz stambenog sektora po općinama Tuzlanskog kantona (tona godišnje)*

<table>
<thead>
<tr>
<th>Općina</th>
<th>SO₂</th>
<th>NOₓ</th>
<th>CO₂</th>
<th>CO</th>
<th>NH₃</th>
<th>N₂O</th>
<th>CH₄</th>
<th>NMVOC</th>
<th>C₆H₆</th>
<th>PM10</th>
<th>PM2,5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banovići</td>
<td>588</td>
<td>46</td>
<td>26.413</td>
<td>1.443</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>58</td>
<td>0</td>
<td>75</td>
<td>68</td>
</tr>
<tr>
<td>Čelić</td>
<td>111</td>
<td>19</td>
<td>5.182</td>
<td>753</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>53</td>
<td>0</td>
<td>72</td>
<td>69</td>
</tr>
<tr>
<td>Doboj-istok</td>
<td>238</td>
<td>22</td>
<td>10.717</td>
<td>742</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>37</td>
<td>0</td>
<td>49</td>
<td>46</td>
</tr>
<tr>
<td>Gračanica</td>
<td>1.095</td>
<td>103</td>
<td>49.279</td>
<td>3.520</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>180</td>
<td>0</td>
<td>240</td>
<td>225</td>
</tr>
<tr>
<td>Gradačac</td>
<td>993</td>
<td>94</td>
<td>44.888</td>
<td>3.215</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>165</td>
<td>0</td>
<td>220</td>
<td>207</td>
</tr>
<tr>
<td>Kalesija</td>
<td>1.069</td>
<td>84</td>
<td>48.410</td>
<td>2.605</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>103</td>
<td>0</td>
<td>134</td>
<td>122</td>
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<tr>
<td>Kladanj</td>
<td>66</td>
<td>18</td>
<td>2.984</td>
<td>782</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>61</td>
<td>0</td>
<td>83</td>
<td>80</td>
</tr>
<tr>
<td>Lukavac</td>
<td>1.291</td>
<td>103</td>
<td>58.136</td>
<td>3.242</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>133</td>
<td>0</td>
<td>174</td>
<td>158</td>
</tr>
<tr>
<td>Sapna</td>
<td>82</td>
<td>17</td>
<td>4.010</td>
<td>733</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>55</td>
<td>0</td>
<td>74</td>
<td>72</td>
</tr>
<tr>
<td>Srebrenik</td>
<td>1.097</td>
<td>92</td>
<td>49.601</td>
<td>2.968</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>132</td>
<td>0</td>
<td>173</td>
<td>160</td>
</tr>
<tr>
<td>Topočak</td>
<td>199</td>
<td>16</td>
<td>8.970</td>
<td>514</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>0</td>
<td>29</td>
<td>26</td>
</tr>
<tr>
<td><strong>Tuzla</strong></td>
<td>1.684</td>
<td>155</td>
<td>76.031</td>
<td>5.210</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>259</td>
<td>0</td>
<td>345</td>
<td>322</td>
</tr>
<tr>
<td>Živinice</td>
<td>1.844</td>
<td>148</td>
<td>83.199</td>
<td>4.635</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>190</td>
<td>0</td>
<td>249</td>
<td>227</td>
</tr>
<tr>
<td><strong>Tuzlanski Kanton</strong></td>
<td><strong>10.355</strong></td>
<td><strong>917</strong></td>
<td><strong>467.821</strong></td>
<td><strong>30.360</strong></td>
<td><strong>124</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td><strong>1.447</strong></td>
<td><strong>0</strong></td>
<td><strong>1.917</strong></td>
<td><strong>1.782</strong></td>
</tr>
</tbody>
</table>

Može se konstatovati da su emisije SO₂ i CO₂, iz stambenog sektora najznačajnije u općini Živinice, dok su emisije NOₓ, CO, NH₃, NMVOC, PM10 i PM2,5 najveće na području Grada Tuzle.

Source: Study of air pollution in Tuzla region (2016. Ceteor)
REGISTER OF COAL STOVES

• In 2016 and 2017 we made a map of coal stoves for new district heating expansion, with this concept.
• We made register for municipalities:
  - MZ Ši Selo
  - MZ Solana (Moluhe)
  - Miladije
  - MZ Mosnik

Collected data:
- Square footage
- Number of residents
- Method of heating (coal, pellet, wood, gas, electric power)
- Insulation
Number of households: 855

Households with coal stoves: 465 (54 %)

Insulated households (with >5 cm insulation): 405 (47 %)

Estimated peak heat demand (-17°C) (100 W/m²): 21 MW
ALTERNATIVE SOLUTIONS

- 2019. local government of city Tuzla votes for new law with cofinancing measures of air pollution reduction (installing heat pumps, and external insulation of objects)

- Installing heat pumps (for objects q≤100W/m², A++-C):
  - water-water
  - earth-water
  - air-water

- External insulation of objects (for objects 100 ≤ q≤230W/m²):

- All objects are cofinanced with 2500 EUR or 50% investment.
FINANCIALLY ON MONTHLY BASIS....

• Without exact data about square footage, heat consumption etc., it is very difficult to estimate consumption of el. Energy for heat pumps.
• With 67 objects that are connected on DHN in Tuzla /MZ Kula/ we assumed that they were heated by heat pumps. For these objects we have measured exact heat consumption, and we took monthly average temperature, and adopt COOP sr for 2,9. With that data we get imaginary electric for example January 2018 consumption for these households.
• 67 analysed objects, during January (coldest month in year) 2018., with average COOP factor, would pay:
  • 0,686 EUR/m2 + PDV
In the streets where we collected data on households, we have also made a survey collecting data on household income, and method of heating.
CONCLUSIONS

Before construction of district heating systems for individual households, we must consider all aspects:

- Economic
- Technical (heat consumption, energy efficiency of houses, make all simulations)
- Environmental impact
- Urban plan
- Social

District heating system has no competition when it comes for comfort, maintenance and service costs.

In this presentation we didn`t analyse other pollutants (industry, traffic, etc.)

District heating system can be a part of the solution for air pollution by individual houses, but not the only one.

„Affordability“ unfortunately is a limit for abolition of coal use in individual households.

Energy class of an object plays a crucial role in financial expense on monthly basis regardless of fuel.

There is huge potential for savings in individual houses, but also in collective buildings.

Illegal building is big legal obstacle in financing or co-financing all air pollution reductions.

PLAN: Create a detailed register of Tuzla with heating source component, and with strict zones for different ways of heating: zones for heating with DHN, zones for heating with other sources like heat pumps, pellet, etc,...
We didn`t inherit enviroment from our grandparents, we borrowed it from our grandchildren.