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# Management of Transport Flows of Biomass and Wood Waste From the Urban Part of Cacak

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**Abstract**: The biomasses collected or stored by municipal utility systems are hardly ever used today. But these materials, collected from both urban and rural environments, are very important renewable energy sources.

This study presents the possibilites of using biomass and waste wood for energy production and their amounts originating from the urban parts of Cacak.

**Key words**: energetic potential, biomass, waste wood, renewable energy sources.

## Introduction

In developed world countries and in the European Union great attention has been given to renewable energy sources for years now, the reason being a global energy crisis and the fact that the use of solar energy, wind power, geothermal and biomass energy results in much lower contamination of nature and the environment.

The paper has resulted from the engagement in the National Energy Efficiency Program project "*Development and Application of Logistics Systems for the Use of Biomass and Wood Waste Fuels by Industry and Households*", under the EB contract 451-10-03059/2005-01/EE243005 funded by the Ministry of Science and Technology of the Republic of Serbia.

Numerous scientific and practical investigations have been focused on the very possibilities of using plant residues - biomass as a potential fuel.

What is, in fact, biomass?

In line with the EU directives, biomass stands for biologically degradable matter generated in agriculture, livestock production and related industry, as well as biologically degradable fraction of industrial and urban waste.

In order to rationally use biomass and wood waste originating from the urban part of Cacak as, e.g., a suitable fuel, it is necessary to define specific transport flows which should contribute to minimum transport costs and duration.

## Material and Method

*Biomass and wood waste quantities being collected on an annual basis in the urban part of Cacak*

The Public Utility Company "GRADSKO ZELENILO" in Cacak collects on an annual basis the following biomass quantities the highest percentage of which is being deposited in dumpsites.

1. grass from the urban part of the city - about 450 $m^3$,
2. city cemetary, green material (grass, decayed flower) - about 450 $m^3$,
3. brushwood and tree trimmings - about 175 $m^3$,
4. thicker wood waste - about 100 $m^3$,
5. leaves - about 180 $m^3$,
6. ornamental shrub and hedge biomass - about 45 $m^3$.

Based on the data collected, the total biomass amounts are as follows:

1. grass, decayed flower, leaves and shrubs - about 1100 $m^3$,
2. branches and thicker wood waste - about 275 $m^3$.

If the PUC "GRADSKO ZELENILO" maintained the whole city, schools, pre-school institutions and other areas in the urban part of Cacak, the biomass quantity might be considerably increased, by about 3-5 times.

The Public Utility Company "KOMUNALAC"collects on an annual basis the following biomass quantities the highest percentage of which is being deposited in dumpsites.

1. grass from the urban part of the city- about 250 $m^3$,
2. brushwood and tree trimmings - about 100 $m^3$,
3. thicker household furniture wood waste - about 70 $m^3$,
4. fallen leaves - about 400 $m^3$,
5. ornamental shrub and hedge biomass - about 100 $m^3$,
6. industrial waste - about 30 waste containers.

Based on the data collected, total biomass amounts are as follows:

1. grass, leaves, ornamental shrubs and hedge - about 750 $m^3$,
2. branches and thicker wood waste - about 170 $m^3$
3. industrial waste - about 5000 kg.

If the PUC "KOMUNALAC" Cacak maintained the whole city, schools, pre-school institutions and other areas in the urban part of Cacak, the biomass quantity could be increased (2-3 times).

In order to secure minimum transport costs for the biomass collected, according to expressions (1) and (2), [2], the selected location for all biomasses collected should be within the Livestock Market in Cacak.

$$X_B = \frac{\sum X_i \cdot Q_i}{\sum Q_i} \quad (1)$$

$$Y_B = \frac{\sum Y_i \cdot Q_i}{\sum Q_i} \quad (2)$$

where:

$X_i$, $Y_i$ - coordinates of the i-th biomass source in km,

$Q_i$ - biomass quantity in the i-th source.

There are several different cost analysis methods all known by a common name of PERT/COST. In process planning, total cost forecasting is of high importance. Furthermore, it is essential to adequately distribute available resources, particularly when these are limited.

## Research Results

*Time and cost analyses for biomass and wood waste collection and transport from the urban part of Cacak*

Time analysis by using the network planning method provides reduction in the duration of certain activities. It should also involve data characterising financial capacities, labour and resources used for a specific process.

The cost analysis after the PERT method cannot be approached independently from the time analysis. The costs of conducting different activities of the process are dependent both on the duration of the activities and on the duration of the project as a whole.

By using the PERT/COST method it is possible to obtain a more realistic cost estimate and achieve explicit improvement in control and efficiency of spending planned resources. Until the introduction of the PERT/COST method, a standard method of graphic representation of planned and actual costs was used.

The PERT/COST method is aimed at establishing a relationship between costs and duration of the process. It is necessary to estimate the costs of each activity as a function of its duration or the costs of a group of related activities. The way to group the activities is to group the ones performed by a single executor. If the project cost analysis is monitored through grouping of specific activities it is necessary to determine the initial and final event for each group of activities.

Each activity is also characterised by its mean optimum duration called normal activity duration. The costs of implementing the activities of normal duration are minimum.

The dependency between the duration and the costs of the project can be presented by figure 1. The dependency can be:

- curvilinear – with cost increases (resource investments), project duration is reduced (figure 1a),
- continuous – for instance, when overtime work is introduced, work hours are paid at a regular rather than increased pay rate (figure 1b),
- discontinued – when an activity is of normal duration, but when extra resources are used it is of constrained duration (figure 1 c).

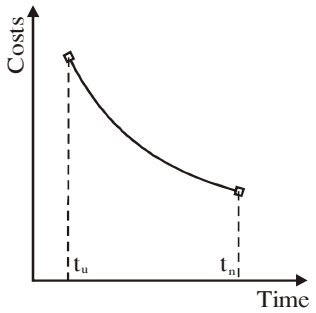


*Figure 1a*

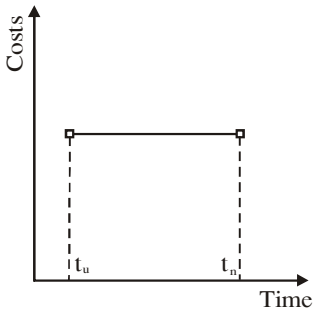


*Figure 1b*

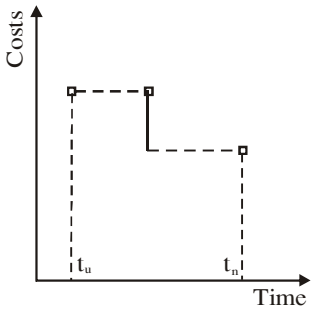


*Figure 1c*

When reducing the activity duration, the following rules should be observed:

1. Reduce the critical path activities until the criticality is transferred, i. e. until the occurrence of yet another critical path.
2. First, the duration of the cheapest activities should be reduced.
3. In a network diagram with several critical paths, a reduction in each critical path takes place for an equal number of units of time, with the cheapest activities being reduced, first.
4. This process is prolonged until the desired project completion deadline is reached or until all the activities in a critical path are of constrained duration.

The PERT/TIME method in minor processes with few activities (max =30) can be employed manually and in a higher number of activities canned computer programmes should be used.

Extra costs that occur due to the use of the PERT/COSTS method are several times higher than the ones induced by the use of the PERT/TIME method. Compared with the PERT/COSTS method, the use of the PERT/TIME method causes additional costs.

For an efficient project cost analysis, it is necessary to employ the cost analysis after the PERT/COSTS and PERT/TIME methods because these two methods are interdependent. The use of extra resources, as a rule, results in an increase in costs for certain activities and a simultaneous project duration reduction.

*Determination of the duration of biomass and wood waste collection and transport from the urban part of Cacak*

Table 1 presents biomass quantities (by locations), location distance and total number of work hours.

Table 1.

| Ord. no. | Quantities (work hours) | Distance (work hours) | Total (work hours) |
|---|---|---|---|
| 1 | 30 | 6 | 36 |
| 2 | 27 | 3 | 30 |
| 3 | 33 | 3 | 36 |
| 4 | 24 | 2 | 26 |
| 5 | 24 | 9 | 33 |
| 6 | 45 | 7 | 52 |
| 7 | 30 | 5 | 35 |
| 8 | 24 | 8 | 32 |
| 9 | 21 | 6 | 27 |
| 10 | 30 | 5 | 35 |
| 11 | 27 | 7 | 34 |

If the following relationships are introduced:

1 ton = 0.3 work hours and 1 km = 1 work hour, the values for quantities (in work hours) and distance (in work hours) by locations are obtained, as presented in figure 2.

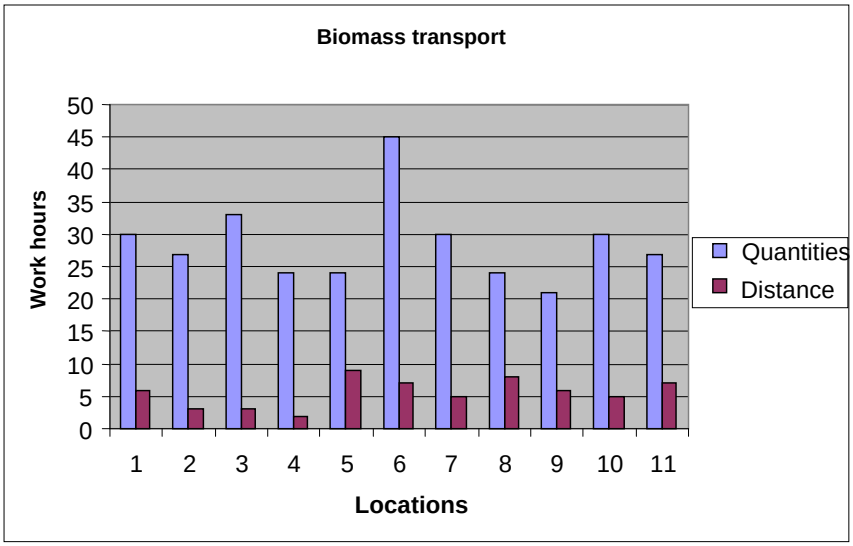


*Figure 2*

The locations in Figure 2 in the urban part of Cacak are as follows:

1. Trbusani, 2. Ljubic Polje, 3. Kulinovacko Polje, 4. Avladzinica, 5. Loznica, 6. Spomen Park, 7. Konjevici, 8. Jezdinsko Polje, 9. Bijeljina, 10. Kulinovci, 11.Atenica

If the values from figure 2. are recomputed using the collection and transport load values, and with respect to the limiting factors (time, resources and labour), the required number of work hours by locations is presented in figure 3.

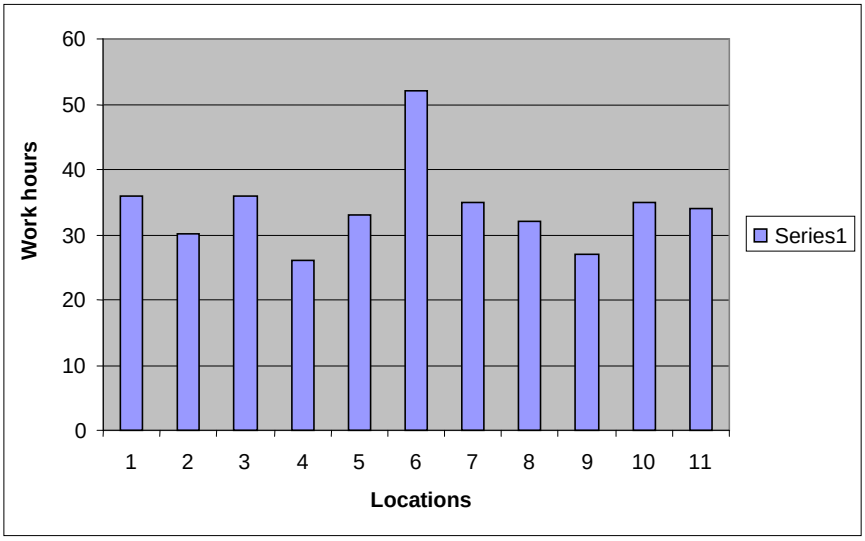


*Figure 3*

Figure 4. presents the required work-hour number by locations (a decreasing order).

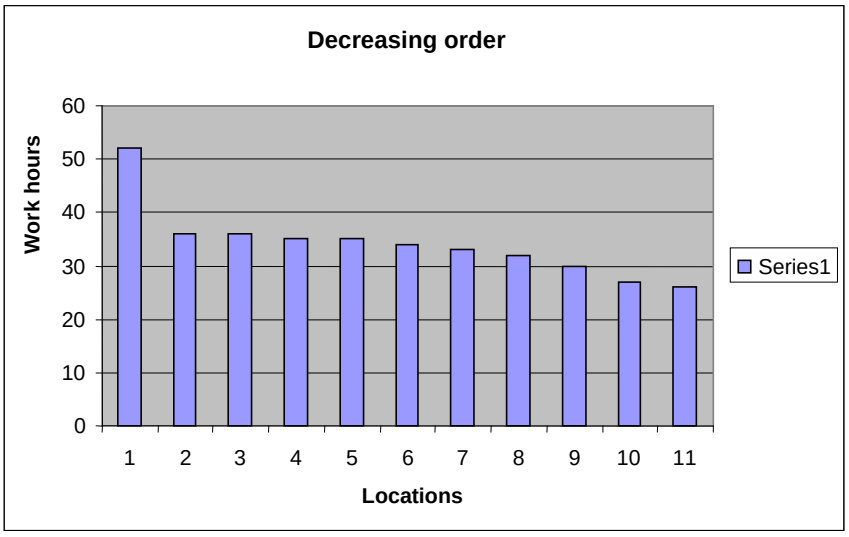


*Figure 4*

The locations in figure 4 are as follows (presented in a decreasing order):

1. Spomen park (52), 2. Trbusani (36), 3. Kulinovacko Polje (36), 4. Konjevici (35), 5. Kulinovci (35), 6. Atenica (34), 7. Loznica (33), 8. Jezdinsko Polje (32), 9. Ljubic Polje (30), 10. Bijeljina (27), 11. Avladzinica (26)

## Conclusion

Based on the investigations conducted on the registered biomass types collected from the urban part of Cacak on an annual basis, if all of the quantities were used for composting they would amount to about 1850 $m^3$, and the amount of the wood waste used as a heating fuel would be about 450 $m^3$. If the PUCs Komunalac and Gradsko Zelenilo maintained all biomass areas in the urban part of Cacak and if all biomass quantities were used for composting, they could amount to as much as 5000 $m^3$. Furthermore, the amount of the wood waste collected on an annual basis might be about 1000 $m^3$.

In order for the biomass and wood waste to be evenly collected and transported from the urban part of Cacak, the dynamics to be designed should take place according to diagram 4 so as to avoid bottlenecks in their collection and transport. This is a prerequisite for achieving maximum biomass and wood waste efficiency as a function of energetic efficiency.

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# UPRAVLJANJE TOKOVIMA TRANSPORTA BIOMASA I OTPADNOG DRVETA IZ URBANOG DELA ČAČKA

- prethodno saopštenje -

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**Rezime**

Danas se vrlo malo ili uopšte ne koriste biomase koje sakupljaju i skladište komunalni sistemi. One predstavljaju veoma značajan obnovljiv energentski potencijal kako iz urbanih tako i iz ruralnih sredina. U ovom radu su prikazane mogućnosti korišćenja biomase i otpadnog drveta za proizvodnju energije, kao i količine koje se mogu iskoristiti iz urbanog dela Čačka.