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AN APPROACH TO USE LINEAR PROGRAMMING IN PEAT TRANSPORTATION

LINEAARISEN OHJELMOINNIN KÄYTTÖ TURPEEN KULJETUSTEN OPTIMOINNISSA

The problems in the production, storing and transportation of material like peat are numerous. Ruling the total situation is extremely difficult if data involved in these actions are handled separately at different locations without a combination of subtotals. The difficulties in handling peat and several problems arising in the measuring of the material render the situation even more troublesome. There are, however, efficient mathematic models and their computer applications developed for the problems like this.

We present one solution for the total system covering the storage control, the cost control of the transportations and the optimization of the material transportation. This solution is intended to help in planning the production, storing and transportation. The reduction of the total costs arising from the several subactivities has been the principal idea throughout the work.

Figure 1 shows one model for the computer-based solution.

The control of the storages is an essential part of the activities. This provides the creation of an efficient system for the control of the peat stockpiles locating on the production sites all over the country. The data of the amount and the quality of peat should be continuous and actual. The important quality parameters of fuel peat viz., the moisture, the heat value and the volume weight are all important for the model. Additional attention has also been paid to the factors such as the volumes of the stock piles, their transportability and their self-heating tendency. By following the transportations, the costs caused will be collected. The total solution takes into account all the vehicle alternatives normally used in the transportations as well as in the loading the peat.

The data of the clients consists of the demand of peat during the heating season, the amounts transported and the quality of the material.

Based on the information supplied, the input data matrix necessary for the linear model will be automatically generated. The data in the matrix contains information from one peat production district consisting of several production sites. The modifications of the dimensions e.g. converting MWh/ton to MWh/m^3 are done at this stage. Furthermore, all other necessary

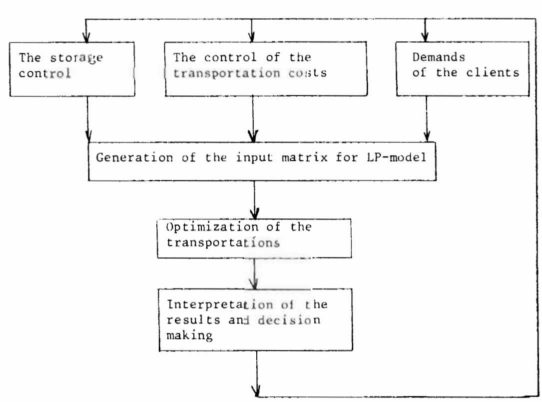

Fig. 1. A general scheme of the computer-based solution for the optimization of peat transportation.

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modifications on the matrix are allowed. The linear model is executed periodically, say once a month, but also if required due to the unexpected situations. The convenient use of the linear model provides the reports with an easily readable form.

The LP-model has been constructed keeping in mind the simplicity but not forgetting the usability. The cost coefficients include the influence of various transportation means, the year seasons and the difference in alternative transport routes. The peat at the production sites and in the intermediate storages can be divided into three groups:

1. peat, that must be transported in this month (e.g. due to the self-heating tendency),

2. peat, that is transportable at any time,

3. peat, that is transportable only at certain periods.

Following indices are used throughout the linear model:

I =	the number of the stockpile; 1,2,3,. . ., A	
J =	1,2; lorry = 1, train = 2	
K =	1,2,3,4,; direct transport	= 1
	internal transfer	= 2
	internal transfer with a tractor	= 3
	internal transfer with a lorry	= 4
L =	consumer; 1,2,3, . . . T	
M =	1,2,3,4,5; this month = 1, autumn = 2, winter = 3, spring = 4, summer = 5	

The variables take the following form: IJKLM, where the variables are the cubic meters to be transported.

The constants are as follows:

CIJKLM	= the transportation costs, mk/m^3
VI	= the volume of the stockpile, m^3
HI	= the heating value of peat, MWh/m^3
WLM	= the energy demand of the consumer L, e.g. MWh

The mathematic form of the linear model is given by

Object (min)	$\sum\sum\sum\sum\sum_{IJKLM} CIJKLM \cdot IJKLM$	(1)
The stockpiles that must be transported in this month	$\sum\sum\sum_{JKL} IJKL1 = VI; \forall\ I \in$ group 1	(2)
The stockpiles that can be transported when required or only at certain periods	$\sum\sum\sum\sum_{JKLM} IJKLM \leq VI; \forall\ I \in$ group 2, $\forall\ I \in$ group 3	(3)
The constraints of the demand	$\sum\sum\sum_{IJK} HI \cdot IJKLM = WLM; \forall L\ \forall M$	
$IJKLM \geq 0\ \forall\ I,J,K,L,M$		(4)

The most sensitive factor for the total accuracy of the model is the determination of cost coefficients of the object function.

The results can be inspected in the light of the sensitivity analysis.

The optimization of the peat transportations is intended to prevent situations where peat with low energy content is transported too far. The model also serves the consumers, since information about the peat to be monthly transported can be given in advance. Thus the alterations in peat quality can be taken into consideration in time. The model is still under development in order to improve its reliability.

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SELOSTE

Turpeen kuljetukseen liittyviä ongelmia on tarkasteltu sekä laiteteknisesti että myös kustannusten kannalta, mutta toistaiseksi matemaattisten mallien käyttäminen näihin ongelmiin on ollut vähäistä (Salonen, 1979). Olemme kehittäneet yksinkertaisen lineaarisen mallin, jolla turpeen kuljetuksia voidaan tarkastella matemaattista lähestymistapaa noudattaen.

Kokonaisratkaisu koostuu kuvassa 1 esitetyssä kaaviossa.

Varastojen valvonta, kuljetuskustannuksien seuranta ja käyttäjien vaatimukset ovat tarvittavaa perustietoa.

Tämän jälkeen generoidaan lineaarisen mallin vaatima syöttötietomatriisi. Kuljetusten optimointi tapahtuu käyttäen yhtälöitä 1—4 ja laskennan antamia tuloksia käytetään hyväksi päätöksenteossa. Mallissa otetaan huomioon kuljetustavat, vuodenajat ja eri kuljetusreittien vaikutus. Tuloksia tarkasteltaessa ja tulkittaessa käytetään hyväksi herkkyysanalyysiä.