UNIVERSITY OF WEST-HUNGARY

THESIS OF PHD DISSERTATION

CONTEMPLATION OF RAW MATERIAL OF DENDROMASS-BASED DECENTRALIZATED ENERGY PRODUCTION

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1. PRELIMINARIES OF THE RESEARCH

In the last decades, it become clear for the developed countries that their stability of economy and policy is depended significantly on import of the non-renewable, fossil fuels. Therefore the IEA (International Energy Agency) was established in the first half of the 1970's, after the first oil crisis, which organization engaged in sustainable energy managment.

In the 1980's and the 1990's, as well as in the begining of the XXI. century, FAO and IEA established several international research programs of biomass production for energy purposes, (FAO CNRE Biomass for energy purposes program; IEA Bioenergy, different short rotation coppice researches: IEA Task 30 Short Rotation Crops for Bioenergy Systems), involving many world-famous, biomass researchers in. Large-scale researches are in progress in cultivation and utilization of biomass and dendromass for energy purposes.

The researchers agreed that the increasing of community, economy, industry require more and more wood material. Affects of developments of energy sector, the natural forests cannot satisfy the increasing basic wood material, that's why the production of short rotation crops almost the single solution for the discharge of the natural forests. The requirements are strongly growing, which cannot be supplied by the natural forests. Industry and energetics need unified quality, large quantity wood material. The conditions of satisfaction of the energetical and other requirements are that the price of wood decreasing as well as possible, which can be solved by utilization of short rotation woody crops.

Utilization of dendromass, as a biological energy carrier directly and indirectly issue in economical affects. Decrease of unit energy production costs have directly economic affect, and the reduction of the influence of global, healthy and enviromental problem connected to dendromass production and utilization has indirectly economical affects.

In the European Union, and also in Hungary, like the previous sentences, the main aims are the increasing of production and utilization of the dendromass sources, and use it in up-to-date decentralizated energy production systems.

2. AIMS OF THE RESEARCH

The PhD-dissertation contents the author's research results from the last 5 years in the topic of dendromass utilization and production. The PhD-dissertion prestented the wood potential of the tradditional silviculture, the process-modell which can determinate the forecast this wood material, and also presented the technology and economy aspect of short rotation woody crops, and the contemplantion, economical analysis, logistic, system measurement of dendromass supply.

The consultant of University of West-Hungary, Department of Energetics, firstly in Hungary, in the course of researching of dendromass production for energetical supply, and establishment of decentralizated energy production system made research and development activities.

The author has the following exercises in scientific research aims:

- Analysis of the Hungarian and the EU energy policy from the point of view of the utilization of dendromass for energy purposes.

- Definition of raw material contemplation of dendromass-based decentralizated energy production, system-conformation, and determination of its exercises.

- Determination of amount of silvicultural wood for energy purposes, and establishment process-modell of its forecasting.

- Development of process-modell for measurement of enlargement of raw material for dendromass-based decentralizated energy production.

- Elaboration of economic process-modell for insurement, contemplation, sustainability of short-term raw-material supply, modelling and economic analysis of dendromass-based decentralizated energy production.

- Development of assessment system for logistic segment of raw material insurement of dendromass-based decentralizated energy production.

In the previous themes, exercises, the main aim was that in the field of the connected special themes develop researches and modells to make conditions of new scientific results.

The main goal of the dissertation is to develop the area of the contemplation raw material of dendromass-based decentralizated energy production, establishment of systems with the solution of the previous exercises and to make more effectiveness utilization of dendromass-based energy production.

3. HYPOTHESIS

Hypothesis of researches are the followings:

- Renewable energy resources of interest is permanently rising in the World, the Eurpean Union have assentuated consideration and directives in this theme. In Hungary the renewable energy utilization is remarkable underdeveloped, so that there are many action to do in the future energy production, in which dendromass can be the first in the renewable energy resources.

- The future dendromass-based energy production demands new system-approach, new energy resources, and decentralizated energy production.

- Elaborate a complex, raw material contemplation system for decentralizated energy production, which can safety gratify the pretention of future dendromass-based energy production for long-term.

- In the conventional silviculture the energy wood can be insured for better utilization level with using new database manipulation, modification of natural values, and new computer-based methods. Economical utilization can be guaranteed with comprehensive logistic and economic analysis, so that thes wood material can be the future raw material of decentralizated energy production, and can assure more incomings for the farmer.

- The energetical wood plantations, the short rotation woody crops can be expansion possibility of raw material for dendromass-based decentralizated energy production segments with modelling, optimalization of natural and economical values.

- Raw material insurement segments for dendromass-based energy production have largely different parameters, which parameters essentially determinate the safety energy production. At present and in the future, there are sections for service energy wood, which sections are not able to supply adequate exercises, and not service the future decentralizated energy production systems.

4. METHODS OF THE RESEARCH

Adjusting to the research aims, the research method was partly theoretical, laboratory, data-collecting, experimental, scientific cooperation and exchange of information.
The research tend to analysis of european union and hungarian dendromass-besed energy production, determination of requirements and evaluation of dendromass-based decentralizated energy production, and to research of present imperfactions, and to make solutions with software engineering.

The research was in theoretical-style in the following general themes:

- Diagnostic the present and future role of renewable energy, dendromass for energy.
- Determination the aims of systemdevelopment.
- Measurement the utilization of database, and determination of database evaluation.
- Analysis and evaluation of extant short rotation woody crops in Hungary and in abroad.
- Evaluation systemdiagnostic adapted to analysis of values of decentralizated energy production.

The research was in trial-style:

- Potencial determination in convetional forestry and trend analysis based on extant data, in order to real state analysis.
- Determination of wood stocks' value with software to analys it based on logistic and economic roles, and experimental data-collection, measurements in order to controlling results.
- Complex modelling of short rotation woody crops as the way of different real facilities.

The research was in laboratorium-style:

- Determination of higher and lower heating value, moisture content and their collective changing of different kind of wood for energy from conventional forestry.
- Determination of higher and lower heating value, moisture content and their collective changing of different kind of wood from short rotation woody crops.

Laboratory reseach was made in University of West-Hungary, Faculty of Forestry, EMKI Department of Energetics Laboratory, and in Ministry of Agriculture, Agricultural Engineering Institute Agorenergetical Laboratory with other reseach.

Data-collecting was in:

- Sortiment's data-collecting of tradditional silviculture, and amount data-collecting of previous produced sortiments to establish sortiment-system in species.
- Technical and economical data-collecting of different kind of machines to modell the short rotation woody crops' technology.

Experimentation was in:

- In several program to use in practise and to alterate demands to the real development.
- Engagement of established programs based on real requirements for correction in the practise.

The research was in scientific cooperation and exchange of information:

- Determination of exercises in system of raw material contemplation.
- Potential- and forecast-development, evaluation of basic data.
- Modelling of complex evaluation of short rotation woody crops, in yield and technology results.
- Method-measurements of laboratory analysis of wood for energy purposes from different sources.
- Determination of forest-stand value in measurement process and in evauation.

In the doctoral research in the context of directives, political aims and best practises, and economic situation, technology-development, hungarian changings of renewable energy resources were monitored to state the future role of dendromass, as renewable energy resource. The modell-processes were separately made, because in the future they can be used altogether in one program, they can be compatilbility of each other. In every case the development started from the requirements of practise, because the different results can be used fastly and the results can be implemented.

5. SUMMARY OF THE NEW SCIENTIFIC RESULTS, RESEARCH FIELDS FOR THE FUTURE

5.1. SUMMARY OF THE NEW SCIENTIFIC RESULTS

1. **On the basis of analysis and evaluation of hungarian energetical, agricultural and enviromental connected to EU tendency and directives, the author considers, that the biomass-based energy production has the significant role in the renewable energy. The present dendromass-based energy production can be developed on the basis of new dendromass-materails and systemtheory, so that these new assumption are required to widely disseminate in the future dendromass-based energy production.**

   The author stated that the future dendromass-based energy production can be developed in decentralizated systems to the purpose, and the energy requirements ought to be supplied by renewable energy resources in the present gas-based systems (connected to the EU directives for 2020).

2. **On the basis of statements of dissection, the author evaluated the methods connected to present used contemplation, evaluaton and efficiency increasing of technologies, and he stated that the contemplation-analysis way of different area of silviculture are hardly available to make developments, its computer using are so low, and the sharepart of the methods are not possible vertical and horizontal connection, because partly content and software problems. There are no database for the different aims, that's why the author determinated the assumptions for the systemanalysis, which were the basis of the modell-developments.**

   The author definiated the raw material supply-system of decentralizated dendromass-based energy production, determinated the exercises, directives of the system with which the modell can be established. On the basis of the earlier analysis, the contemplation, modelling, evaluation and service of decentralizated dendromass-based energy production system can be insured.

3. **Modell-program and its directives of engagement of raw material supply system for dendromass-based energy production were established by the author.**

   3.1. **Process-modell of exploited whole woodmass of conventional silviculture and wood potencial analysis and forecast for energy purposes were established.**

   The modell is suitable for the ammount of raw material of dendromass-based energy production analysis in the conventional silviculture, near different kind of assumption: energy requirements, using areas, complex forestry strategy.

   In a region it is able to determinate that areas, points, where the section of decentralizated, dendromass-based energy production can be the most optimal.

A woodutilization strategy can be done for the dendormass requirements for long-term.

Affects of forest establishment, assumpted and changing woodutilization strategy, woodspecies-changing, natural limitations, and conservation directives could be forecasted.

The results are suitable to use in practise. Foresters can contract sure and valid long-term engagements for the energy wood, without changing any other sortiment of the production.

3.2. **Process-modell was established for the modelling, complex economic analysis, systemdevelopment of short rotation woody crops. The author systematized the most important technologies of energetical wood plantations for the process-modell utilization.**

The decision-prepearer modell is able to have possibilities for measure any solution for technology. A system with different kind of solutions in a determinated area can be measured. The real possibilities can be analysed in any kind of combination to have the highest increment, near the most suitable solution-combination.

The modell have two important functions. The either is the decision-prepearing for the contemplation, the other is the datacollecting and evaluation of the established short rotation woody crops for the additional planning, mistake srceening to choice the adequate solution. Under the operation the yields have to be controlled to reach the planned value. Real costs (mechanical weed-control, etc.) can be controlled in the maintenance to see the most important economical values to make any kind of treatment-changing. For supply of these exercise the modell have connection with the digital map databasem, where the modell use the recorded data for the determinations.

So that the modell is adapted for complex economic analysis, systemdevelopment and decision-making of any sort of short rotation woody crops.

Special technology, techniques data of the short rotation woody crops were collected by the author to make the most adequated modelling and system development, connected to it, and the possible harvesting technologies were analysed, too.

3.3. **Process-modell were established for the economical and logistic analysis of wood stock evaluation based on sortiment-measurement, ecpecially for the energy sortiment chanings. The modell is suit for planning, modelling, economical analysis of logistic system for raw material of decentralizated dendromass-based energy production**

It is adequate for determination of woodmass from woodutilization section, and analysation of costs and benefits, and it is suit for allocating wood-stock value of a forest section for wood marketing, renting and other forester exercises.

The whole logistic system could be modelled and determinated, so that any kind of costs can be allocated most accorate. The modell takes into account the different kind of costs of logistic, harvesting, etc. Modell can allow for export, marketing costs in the wood marketing.

In the modell there is a separate modul to plan own logistic system, with which parameters of economical analysis, raw material supply and requirements can be determinated.

4. **The author made a complex modell-system to connect all of the process-modells to have the possibility of further developments. Especially contemplation and evaluation process-modells are suit for screening, evaluating logistic sections of raw material of decentralizated, dendromass-based energy production to make the most adequate solution in the logistic system developments.**

   The results are suit for strategy determination of logistic section of dendromass-based energy production to make adequate long-term raw material supply, and decentralizated energy operation.

5.2. THE UTILIZATION OF THE NEW SCIENTIFIC RESULTS

The modells are suit for contemplatation, systemdevelopment and operation of raw material of dendromass-based decentralizated energy production. It is also adequate for analysis of expansion possibilities of raw material, in any kind of region to make the energy production area or points, and capacity determination, and logistic system controlling, and economic analyzation.

Adaptation of modells' parts the modells can be used in foriegn country, so that the modells are able to use in international research and developments.

Complex modell system utilization:

- Any region of Hungary can be analizated to establish a dendromass-based decentralizated energy production system, which is under development.
- There is an initition – in a EU international project – to establish a system for raw materail insuring of biomass-based power plant with the modell system.

Utilization of potential-measurement and forecast of conventional forestry process-modell:

- The following analysis were partly done, so that the modell is suitable for the practise:
  - Forest-stock potential measurement were done in the SEFAG PLC area in the whole sortiment.
  - Forest-stock forecast were done in the SEFAG PLC area in the whole sortiment for 2030 connected to the real marketing parameters with the present strategy using.

    - Forest-stock forecast were done in the SEFAG PLC area in the whole sortiment for 2030 connected to the real marketing parameters with sustainable forestry directives.
    - Determinated the value difference between the previous two solution.

- National analysis of NKFP Forest-Wild Program,
- 7 different analysis for 7 forestry firm on distinction requirements,
- Analysis for 1 great performance biomass power plant contemplation,
- 2 low performance biomass power plant planning,
- 1 new biomass heating-centre contemplation,
- 3 biomass heating-centre biomass-changing development.

- Modell adaptation, and contemplation of a great performance biomass power plant is under development for Austria.

Utilization of complex economic analysis, systemdevelopment and modelling of short rotation woody crops process-modell:

- Several economic analysis were made in different kind of energetical wood plantations.
- Several optimal technology system determination were done in different kind of energetical wood planatations.
- Comparative studies were done on energyplants and energetical woody crops.
- Modelling and analysis of R&D exercises, ways of harvesting technology for short rotation woody crops.

Utilization of process-modell for forest-stock evaluation, complex logistic and economic analysis:

- At present two unofficial forester and several official forestry apply in the daily practise for the special requirements.
- Digital measurement connection is under development to make forest-stock evaluation analysis in the forest, which can help the conventional forestry works in great quantity.
- Process-modell is under development to solve the new and classic forest evaluations.

5.3. POSSIBLE NEW RESEARCH FIELDS

In the effect of the legal system of the European Union and the global, international enviromental prescriptions, the renewables, and the dendromass-based energysources and dendromass-based energy production was significantly increased, and results of present researches, it can be expexted presumably that it will increase in.

In the dissertation the result development, and new scientific research fields need to be required connected to the dendromass-based decentralizated energy production, so that the author make a motion the following exercises:

- Wood-store process-modell ought to be established to make adequate logistic system for decentralizated, dendromass-based energy production for complex economic analysis, contemplation, operation, and system-controlling and -development.

- Hungarian forest-stock database controlling, mistake intervallum determinating, and nominating exercises, directives are reasonable to make adequate and more accurate analysis for great area analization.

- Datasbase expansion ought to be done in the process-modell of short rotation woody crops on the basis of new researches in this field. In the future land parameters have to be emphasized in the contemplataion of energetical wood plantations. Certainly, the present database have to be controlled and increased, and ought to make a non-line database to make real-time and real planning of short rotaiton woody crops.

- Further developments are reasonable in the wood-stock determinataion process-modell in two ways. On the one hand, the complex forest-evaluation system insuring to have an innovative forest-evaluation system for Hungary. On the other hand, present wood-utilization system modelling to make sure analysis for marketing and energy sortimenting to have adequate requirements. These developments are under contemplation, so that many exercises will be solved by it.

- A logistic section process-modell have to be developed to make adequate analysis and evalutations of logistic and economic systems in decentralizated energy production for criterium-system insuring.

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