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THE ADMINISTRATIONAL ASPECTS AND ECONOMICAL EXAMINATION OF THE ADATPABILITY OF THE LEAN-MODEL IN BIOGAS FACTORIES

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TABLE OF CONTENTS

TABLE OF CONTENTS 3
1. INTRODUCTION 4
2. MATERIAL AND METHOD 7
2.1. Hypotheses 8
2.2. The circumstances of the examination 8
2.3. Methods of the examination 8
3. MAJOR DIAGNOSES AND RESULTS OF THE DISSERTATION 11
3.1. Introducing the Lean biogas model 11
3.2. New and recent scientific results 14
4. CONCLUSIONS, SUGGESTIONS 15
5. SUMMARY 19
6. BIBLIOGRAPHY 23
7. PUBLICATION NOTE 24

„It is not the strongest of the species that survives,
nor the most intelligent. It's the one that is
the most adaptable to change. ”
(DARWIN 1859)

1. INTRODUCTION

The world's population is continuously growing using the energy resources in an accelerating tempo. At present, the Earth's population is over 7 milliard people, and the capitation of humanity can rise over 9 milliard people by 2050. The explosion of the population will result in a 22-27% excess demand of energy – and resource usage even at the present level of energy using. (FUTÓ 2012)

Since our fossil energy resources are running low, the application of the biomass is more frequent. Biogas is a versatile, renewable energy resource, which engenders from diverse substrates during the digestion of anaerobe. Since varied different input materials can be used, we can produce energy with biogas in a significant quantity. The average methane content of the biogas is 50-60%. We can get 9,94 kWh energy from $1m^3$ methane. The use of biogas is diverse, and can be used, besides for generating electricity, for producing hot-water, generating co-generational heat-energy and electricity, and creating bio-methane which has natural gas quality. (WELLINGER et. Al. 2013)

The goal of the European Union's energy politics is to increase until 2010 the renewable energy usage's current (average) 6,5% share of use up to 12%, to increase the rate of the renewable energy generation to 20% by 2020, and to increase the share of use of the electricity generated with renewable energy to 22,1% by 2010. It wishes to raise the share of use of the biofuel to 5,75% by 2010, and to 10% by 2020. (DIÓSSY 2007, KOVÁCS 2007). According to Thrän and his co-worker's estimation (2007) they could produce 250 billion cubic metres of bio-methane in the area of 28 EU member state in biogas powerhouses by 2020.Based on the data collected by Thrän and his co-workers this number can be doubled if we add the bio-methane which is generated through the thermochemical production of the synthetic natural gas. This altogether 500 billion cubic metre of bio-methane would be enough to cover the present natural gas consumption of the 28 member states. Even if it is not likely to be possible, according to the forecast of the study the production of the presently available bio-methane at the European level can make a contribution to the power supply in the future. The quantity of the biogas has an outstanding significance, as energy resource. (WELLINGER et al. 2013).

In my current research work I am going to present the latest statistical figures with respect to the renewable energies in the European Union. The renewable sources contain the wind-power, solar energy (thermal, photovoltaic and concentrated), hydroelectric power, tidal energy, geothermal energy, biomass and the renewables derive from waste.

The use of the renewable energies has many potential benefits, including the decrease of the gas emission which causes the greenhouse effect, the diversification of the power supply and the addiction of the petroleum due to the market (especially petroleum and natural gas). We can inspire the employers in the EU with the increase of the renewable energy resources to create the new green-technology workplaces.

After explaining the energetic goals of the European Union, I am going to present the renewable energy potential based on the Hungarian situation.

After this I am going to present the environmental conscious and pure technology of the biogas production, which is based on the use of oddments and by-products, decreasing the emission of the greenhouse gases and materials which are burden to the environment, by exploiting and converting the potential to green energy in them.

Operators have to face with numerous problems which are mostly due to implementation, and which derive from technology. Since biogas factories are not particularly supported in Hungary, they require special attention and interest, and even so their maintainable and economical operation is not assured. The operating expenses are rising gradually throughout the years, in some cases drastically. The basic commodity is continuously getting more expensive, and the significant part of the income derives from producing electricity, which had a decreasing purchase price in the past period. The production is bound to a strict schedule prognosis, which will result in a significant financial punishment in case of offending it. Amongst others after presenting the Lean-methodology and philosophy, I am going to present the solutions to these problems by the means of this methodology.

Throughout my research I have set my goal to be the maintainability of the productivity of the biogas factories and the examination of the efficiency of its maintenance by using the Lean methods. The factory production of the biogas has outgrown itself as industrial, so the production methods could become applicable, which adaptation will be based with scientific methods.

The goal of the examination is to access novel results with recent solutions throughout the adaptation. I would also like to expand my examinations to the design flexibility of the maintenance needs of the biogas factories managed in the traditional and Lean system as well. The Lean introduction is tested and widespread in the world and requires recent and new considerations in this branch.

The question of the research is the following: With the adaptation of the Lean production processes and organisational models what kind of positive changes can be achieved in the maintenance and operational areas of the biogas factories?

I think it is important to decrease the unexpected numbers of the malfunction of the facilities, and the time of their maintenance which I am examining in the case of traditional and Lean management as well. The research expands to the examination of the available time of the equipment of the biogas factories. The most important thing during the operation is the increase of the productivity and the decrease of the expanses, which possibility I am going to examine in relation to the maintenance and repair of the biogas factories after and before the Lean introduction.

2. MATERIAL AND METHOD

With the continuous development of the production technology of the biogas it has outgrown itself as industrial, which made it possible to introduce the methods which were used successfully throughout the industrial production. The management method of quality improvement which has widespread in the previous decades and which is currently effectively employed in the area of maintenance is the Lean method which requires recent and new considerations throughout the production of the biogas. During this adaptation solutions and results can be found which were unknown so far and this is why I have decided to examine effectively this method's scientific introduction and operation.

I have been researching the issue of the development and operation of the biogas systems, the issue of the Lean production processes and organizational models since 2009. Before this I have already got an insight into this area throughout my former jobs, which served as a good basis for me along with my studies, and which helped me to see through and understand the latter complex decisional, organizational and leading systems. During my job I regularly work together with managers and experts who are experienced and informed about the activities of our home country and other countries as well and we regularly share our experiences which mutually helps our job.

Before my inspections I have been looking for practical implementations and the typical research was the model-featured research. During the setup of the examination model I took into consideration the practice of these types of researches, like the researches of the NAIK Agricultural Machine Institute.

The research is organizational but applies to technology. I have examined the effect of the change of the technological items by taking into consideration the other, biological systems. I have not examined the influential effect of the human factor because I wished to manage its variability with standardising.

In this phase of the research I could not do durable service testing yet. Instead, the testing of the organizational, research and experimental model of technology took place. The durable service testing will be done later, after the results of the research, because it was not the subject of this research. I have followed those guidelines which were followed by the NAIK Agricultural Machine Institute.

I have used the in-depth interviews not for the elaboration of the technological model but for the uncovering of the problem and for the identification of the typical technological problems. Nor the occurrence of the re-annexation and not the adoption of the model was an expectation during the research in the participant factories.

It is possible that if the given factory has the same parameters then the same positive results should be got with the introduction of the methodology and model.

2.1. Hypotheses

Based on the overview of the specialized literature I have formed the following hypotheses, which I am willing to prove and reject with the examination of the given factory, as a system.

H1: The improvement of the productivity of the biogas factory is caused by the switch from the traditional methods of work organization to the use of Lean methods.
H2.1: By using the Lean management we can reduce the frequency of the occurrence of the losses which derive from the unexpected malfunction of the equipment of the powerhouse.
H2.2: By introducing the Lean management the available time of the equipment of the biogas factory is increasing.
H3: The appliance of the Lean management decreases the response time of the dysfunctions of the power plant units.
H4: By employing the Lean management the repair and maintenance costs of the biogas factory can be reduced.
H5: The planned maintenance need of time of the biogas factory, thus the downtime deriving from this can be shortened by using the Lean methods.

2.2. The circumstances of the examination

In this subsection of my dissertation I am going to describe the most important parameters of the factory which constitutes the basis of my examinations, and the primary and secondary methods of the research carried out by me.

2.3. Methods of the examination

Explaining the secondary research and its methods:

Based on the publications which are related to my topic and appeared in the major international and inland specialized literature I have reviewed the latest data (from 2016 November), the appropriations of the European Union in the renewable energy production, and the possibilities given by the interior biomass potential. I have continued my examinations with the system of the biogas production, then with the maintenance management and with the research of the Lean methodology, philosophy and means within it.
I have collected the data about the situation of the biogas and the renewable energy resources in Hungary from the system of the Eurostat. I have done the examinations with the linear correlation.

Explaining the primary research and its methods:

I have placed the data collection of the primary research on three pillars. One of them is the diary of the factory which is written from the beginning of the operation of the factory and which contains the expertly recorded events. The central operation control system gives us information about the occurrence of the events and about the period of their existence. To examine the malfunctions text reports were processed from these and a data base was created which contains categorized the nature of the mistakes, the frequency of them and the period of them. I have divided the technological system of the biogas factory into 13 operational areas, which provide us the 13 examination categories. I have also assigned the defaults to these and I have made the database which is the basis of the examinations of the malfunctions and the achieved efficiency. In my dissertation I differentiate between 3 periods. The first one is from the 7th of 2011 until 6th of 2012 which is the start-up period of the factory. The second one is from the 7th of 2012 until the 6th of 2014 which is the period before the Lean introduction and the third one is from the 7th of 2014 until the 6th of 2016 which is the period of the Lean introduction.
The second pillar of the data collection of the primary research is the IDSpecto system which is operated by the MAVIR Measurement Centre and which provides us the data about the output of the factory. (https://mkp.mavir.hu)

The third pillar of the data collection of the primary research is the operating management system from which operational maintenance costs have been collected which are necessary for the examinations. As a pre-test of the analysis of the variance, I have carried out a homogeneity examination with the help of the Levene test in order to examine the change of the response duration of the malfunctions and to examine the frequency and existence of dysfunctions at the 13 operational areas divided by me. I have done the

analysis of the variance in relation to the homogeneous data. I have presented the significant results on Box-plot diagrams.

Similarly as a pre-test of the variance analysis I have done an examination of homogeneity with the help of the Levene test in order to examine the efficiency and productivity of the factory. I have done the analysis of variance in relation to the homogeneous data. I present the significant result on box charts (Box-plot). I have also done an analysis of variance to examine the maintenance cost and the analyses of the corporation and plant economy.

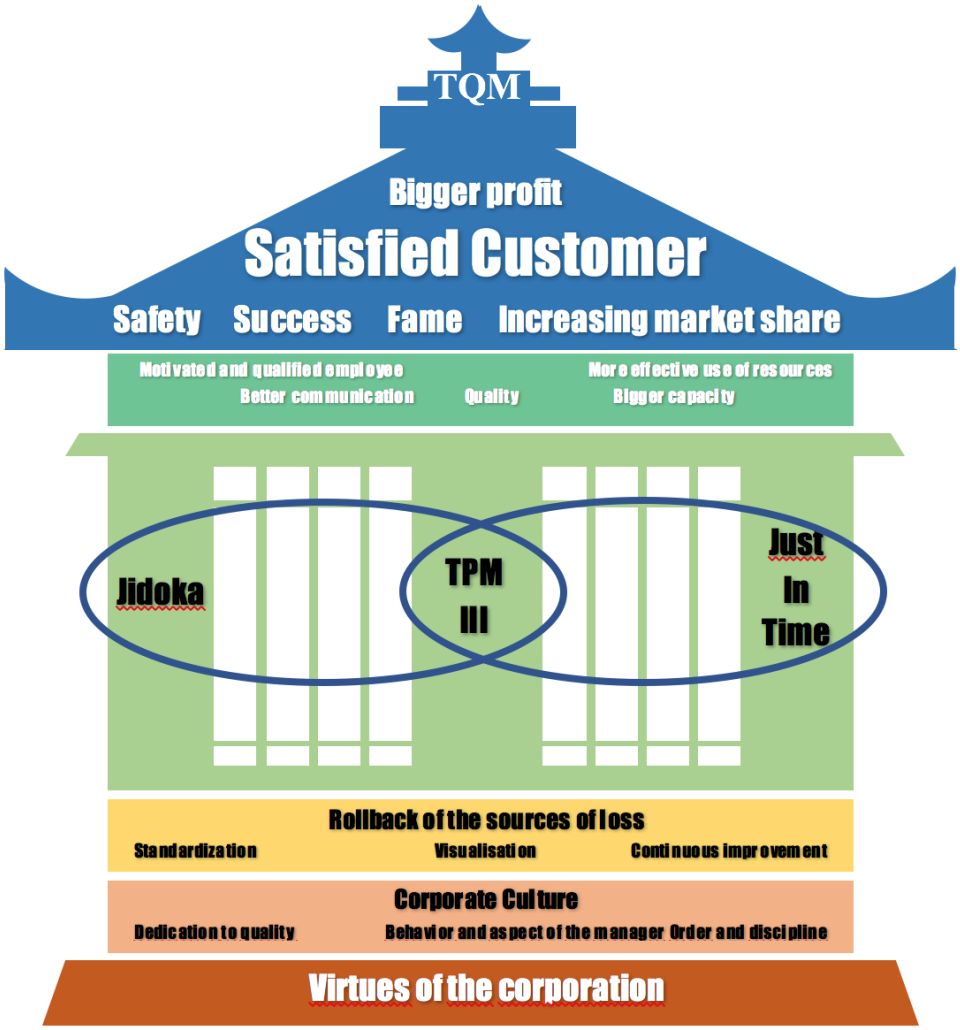
The measurement of the efficiency of the Lean-based maintenance happened with observations and empirical examinations.

The results I have gained through my research were confirmed by the experiences, data and information obtained during the in-depth interviews. The in-depth interview was made based on a semi-structured list of questions, which can be found in the dissertation's enclosure M7. I have made the in-depth interview with the help of 8 factories' 15 executive co-workers. These results are not presented in a separate chapter, since the other results of examination serve as further justification and explanation and they are built in the dissertation. At the evaluation I have identified the groups of problems and the root causes typical for them by text analysis. Based on the reports of the interviewees I have defined the best practices which I took into consideration at the elaboration on the model. The structures of the results can be found in the chapters of the introduction of the Lean biogas model, the exploration of the losses and the chapter of the 7 major losses, so I am not going to present them here one by one. Before I visited my interviewees I have informed them about the topic of the talk and I have made notes and reminders about what has been said. The time interval of the interviewing: 2014.08. - 2014.12. I have also done factory visits in relation to the in-depth interviews in order to collect further experiences and information.

3. MAJOR DIAGNOSES AND RESULTS OF THE DISSERTATION

I would highlight the Lean model elaborated by me and the Biogas Production System from the major diagnoses and results of my dissertation.

3.1. Introducing the Lean biogas model



1. graph: Biogas Production System
Resource: own edition based on PÉCZELY 2011

The most important pillar of the Biogas Production System elaborated by me is the TPM, since based on this the further methodology can work more effectively. (graph 49.) As a basis of the elaboration of my system I was examining and developing the theories of the PÉCZELY (2011) system,

which is based on VAJNA, CSAPÓ, KISARI (2012) and KISARI (2017) amongst others.

The virtues of the corporation work as a catalyser in my elaborated system. We can list here the human relationships, customs and the base of knowledge. It not only uses but continuously develops the knowledge of the employees, establishing with this the long term and continuous development of the corporation. The corporate culture is continuously being supported, built and developed consciously.

One of the most important elements in the converting of the corporate culture was the training, which meant preparing the employees to the tasks they have to carry out. Everybody was involved through the introduction at the corporation. The introduction can be successful with the use of the motivation and consistency and with the continuous controls.
With the help of the TQM the aim is to improve and perfect all the activities of the organization, to increase the dedication of the employees to quality and to achieve the satisfaction of the customers.

The aspect and behaviour of the manager must exceed the ordinary guide and support, and it must aid the process. In the creation of the order and discipline the breakthrough is brought by the application 5S. There is a tight relationship between purity, orderliness and quality. The controls which serve prevention, the purifications and the trouble-finder processes must come into prominence. The 5S insures the base for the company so that it could develop.

The key method of the prevention of the losses is the standardization applied in the model. It is used not as an aim but as the basis of the system. It enables the development and the progress. Through standardization we can identify the problem and its method of solution by the regular use of the PDCA cycles. The main point of the applied standardization is to get the best practise into writing, which clearly defines the work process by ceasing the variability and by making the processes repeatable.

Visualisation has a special role which evolving and maintaining requires efforts. It is a necessary method of the information communication and the development and easement of the communication.

The main driving force in the model is the Kaizen which represents continuous development. Its aim is to prevent the losses and to increase effectiveness. The applied principle is to go out to the place of the creation of the value, observe the objects and events and the real situations at that

place. We have to look for the losses and do continuous developments. We have to regard problems as unexploited possibilities of development. Employees should keep their eyes peeled and be sensitive to the losses. We should give them space for self-realization in order to motivate them.

Lean and TPM have a very tight relationship in the model since the process type losses (Muda, Mura, Muri) can be solved effectively with the Lean method while the losses related to the equipment can be sold with the TPM. The first step of the prevention of the source of losses is the data collecting. The secret of its success is that we can identify exactly what kind of losses we are looking for and we can consider problems globally.

The applied Lean methods in the Biogas Production System: Multi-Skilled Workers, Value Stream Mapping and the SMED (changeover).

One of the main pillars is the Jidoka which extends the limits of the sensation of the employees since it is a self-checking system. Less attention is needed from the employees because it signals the round of the duties and helps the people's work. This equipment stops when it recognises malfunction. The model validates the 'producing good at first' principle decreasing the quantity of the waste.

The aim of the Biogas Production System is the elimination of the sources of losses. In case of the prevention of the losses related to the equipment the TPM and Jidoka is applied while in case of the production-organisational-logistic losses JIT is used.

With the help of the Just in Time we can cease overproduction and we can assure the constant flow of material and information in the value stream. A more peaceful and stable production can be created. The work processes can become standard and continuously designable with respect to the machines and employees as well. The effectiveness of the customers is increasing and the total costs are decreasing.

With the TPM main pillar the elaborated model wishes to create such maintenance and production system which aim is to continuously increase the productivity and to produce without malfunctions and forced shutdowns.

The use of the Biogas Production system enables the introduction of the lean at the areas of the biogas factories thus contributing to the successful operating of those.

3.2. New and recent scientific results

1. I have elaborated the Biogas Production System which is based on the Lean philosophy. It is proven through the data collection that there is no biogas factory in Hungary in which the Lean model was used but I have not found similar implementation in the international context either during my search of sources.

2. I have justified with scientific methods that the Biogas Production System based on Lean philosophy decreases significantly the frequency of the malfunction of the power station's equipment.

3. I have also justified that in the Biogas Production System which is based on the Lean philosophy the recovery time in case of malfunction decreases to more than its half and the safety of operation and the available time of the equipment increase significantly.

4. I have proven that the time requirement of the maintenance processes which is elaborated and optimized by me and which is based on the Lean model has decreased without the increase of the technological risk.

5. I have proven with scientific methods that the maintenance costs of the biogas powerhouse have decreased to its half to the effect of the application of the Lean methods.

4. CONCLUSIONS, SUGGESTIONS

Based on my research experiences it can be said that using this kind of model is not typical at the operational area of the biogas factories. During my data collection I have not found similar implementation internationally for the use of this method, so I would recommend the biogas factories to start applying this system which is elaborated by me as an since it serves as an aim of development and possibility.

The results of the model examinations are generalizable if we consider that the managed processes are not specifies to place. In the case of the biogas factories, which operate on the similar principle and under similar conditions, the managed processes behave the similar way as the examined factories. By considering this my conclusions can be valued.

The switch to the Lean method and the introduction of my model, the Biogas Production System, causes the improvement of the productivity of the biogas factory compared to the traditional logistic methods. The incomes of the factory has already stabilized and increased in the initial period of the use of the method.

Another big advantage is that it decreases significantly the frequency of the occurrence of the losses deriving from the unexpected malfunctions of the powerhouses and it also increases the available time of the biogas factory achieving significant improvement in the reliability of the equipment and in the design flexibility of their operation.

The decreasing of the response time of the dysfunctions in the powerhouses was successful, thus I managed to achieve cost savings and additional revenue. It can be boosted by the decrease of the biogas factory's maintenance and repair costs. By applying the Lean method we can shorten the planned time requirement of the maintenance of the biogas, thus we can also shorten the downtime deriving from this.

The results can be boosted further by using the cost savings and a part of the released time to develop, to deepen the knowledge and to apply the model in a higher level.

The applying of the presented Lean method can bring similar positive results in the further factories. This research can be taken to other factories and the results due to it can be the base of the future researches. My present research is a good base of examining this method in other environments, and I am planning further examinations.

The significance of the results of my research is emphasized by the fact that the continuous increase of the world population causes the consumption of the surplus energy, which main part are the fossil sources of energy which we are running out of, and the use of the surplus energy means a threat to our environment. We can conclude from this that the headway of the biomass can be a solution since during the natural processes it is continuously available or reproduced. It can also facilitate the diversification of the resources, which is the necessary condition of the assurance of the competitive price. This is supported by the European Union with its objectives of energy policy. It is turned out from the studies that significant most countries reach their goals the set. I suggest considering Sweden, Latvia, Finland and Austria as a good example.

In Hungary the National Energy Strategy 2030 titled professional document contains elaborated plan for guaranteeing the all –time safe power supply by considering the economic competitiveness, the environmental sustainability and the bearing capacity of the consumers. It is aspiring to bring the rate of the renewable resources into harmony with the energy policy of the EU. It produces significant quantity of by-products from the Hungarian sylviculture and agriculture which can be used for numerous purposes to decrease the use of the presently predominant fossil energy sources. The renewable theoretical energy potential is 2600-2700 (PJ), the practical potential is 163 (PJ) and from this only 53.8 (PJ) is used. I suggest to exploit the available energy potential and to prefer the use of the renewable resources.

Biogas factories produce green energy by making the biological (animal and vegetable) waste harmless. The organic created during the process can supply the soil with nutrition in an economic-friendly way. Since biogas and its production is a renewable source less polluting materials can get into the air, the quantity of methane in the air decreases and it can cause the use of the fossil resources. In Hungary the support and the purchase prices are behind the other countries, thus it makes their operating harder and blocks the willingness to invest. I suggest to modify the support system and to make the purchase prices catch up with the level of the neighbouring countries.

The biological process is complex and the operation of the factory systems requires big expertise. Their operation helps the rural employment and qualification supplementing the operation of the agricultural factories. It is I necessary to choose the appropriate raw material base and during the use of the basic commodities it is very important the optimal preparation in order to operate effectively. My suggestion is to establish more biogas

powerhouse based on the unused base of commodities and on the appropriate supports and purchase prices and I also suggest consider the use of the waste heat. During the selection of the technology the basic commodities need to be determining since they have an effect on the technology of the gasification of the anaerob. Fermentors can have different types depending on the circumstances and the fermentation processes of the factories can also be diverse. We should not ignore the environmental effects and the availability of the basic commodities during the establishment of the factories.

Hungary's natural gas supply is around 95% and major part of the population heats and cooks with natural gas. It would be worthy to exploit the potential it has by the biogas factories. It is indispensable to form a positive public opinion so that the biogas powerhouses would be accepted by society. We can experience in many places where there are biogas factories that action groups have been formed against them. Biogas industry and the government should focus on the communication in connection with the positive role of the biogas and in the interest of the maintenance of the future power supply system.

Through the years maintenance has gone through a continuous development. The fire strategy of the 1950s is nowadays on the level of comprehensive effective maintenance. Maintenance has a big effect on the major parts of the losses deriving from the operation of the biogas factories. It is important in case of the already existing factories to have appropriate maintenance. The Toyota production system, the Lean method has made a hit from the 1970s in the automotive industry. Lean management has gone through continuous development. It has a wide range of methods which covers the previous conceptions (JIT, TQM, TPM, AMT) and it expands to the organization of the workforce. The operation demands thorough preparation and consideration because those who want to make this work have to face with many hardships and risks.

My Biogas Production System facilitates the use of the Lean method in the biogas factories. Its most important pillar is the TPM since other methods work effectively based on this. In the loss exploration the examination of the 7 major losses were successful. Identifying the symptoms of the problems is not enough, we have to collect data about them and evaluate them with analysing methods because this is the only way we can cease them. I have carried out the examination of the maintenance- and operating processes on the 13 main unit of the technology of the Szarvas Biogas factory. I have made the map of the factory's value stream which basis is represented by the previous division. The steps of the problem solving

happened with the TPM method by considering the 5M x PQCDSM categories. Every time I have used fishbone chart to find the root causes and in order to review it easily I have summarized them in a chart.

I suggest the revision and development (in case of the lack of them the establishing) of the existing surveillance systems and the more exact defining of the malfunctions. I further suggest form a closer cooperation with the suppliers in order to improve the basic commodity's supply. With the favour of the pipelines and the rationalization of the transport distances the shipping losses can be decreased. In order to cease the production losses the processes should be checked regularly, andon signals should be used, standards should be formed and the use of poke-yoke and visual management on the equipment. With the unionisation of the equipment the component stock can be decreased. The rationalization of the application of the liquid basis commodities can mean significant cost saving. With the application of the 5S unnecessary steps can be decreased. A In order to end waste a solution can be the standardization of the processes and the introduction of the TPM.

The unexpected malfunctions of the equipment can be decreased by the Lean management compared to the traditional one. The Lean methodology significantly decreases the existence of the malfunctions. It is proven that the response time of the problems can also be decreased with the Lean management. One of the most important factors in connection with the operation of the biogas factories is the productivity which improved with the use of the Lean methods. Another important factor during the operation of the biogas factories is the maintenance costs. The repair and maintenance costs of the biogas factories are decreasing significantly. With the help of the Lean management operated by me the work processes could be done safely within 14 days instead of 40 days, which meant 65% time savings. With this method the maintenance work processes of the biogas factories can be done within a shorted period of time, thus decreasing the factory's downtime. The Szarvas Biogas Powerhouse is not different from the other factories so the established system here with little corrections can be applied during the examination of the other factories. I suggest applying the Biogas Production System elaborated by me in the other biogas factories.

My results are presented and published in professional scientific forums and journals.

5. SUMMARY

The issue of energy resources in the continuous growth of the population is concerning people increasingly. Though fossil energy resources are running low, biomass expansion gives hope. In particular, the biogas is a versatile, renewable energy source and can be used for thermal power generation as well.

The European Union's energetic goals try to stimulate the use of renewable energy sources and envisaged a 20 % share of use of renewable energy resources by 2020. Studies show that Member States are progressing successfully in the right direction and the majority of them will reach the aim. The research presents the latest EU statistics on renewable energies. The use of these energy resources not only decreases gas emissions that cause greenhouse effect but promotes the diversification of energy supply of crude oil and natural gas dependency on market.

The National Energy Strategy 2030 program was presented, with aims to increase the share of renewable energy resources in line with EU energy policy. Its three pillars are: competitiveness, sustainability and security of energy supply. During the examination of the distribution of electricity production it can be seen that the use of fossil fuels still dominates. In the energy sector, industry is outstanding. followed by population. Hungary's potential of renewable energy is significant 2600-2700 (PJ) theoretically and 163 (PJ) in practice, however, currently 53.8 (PJ) is used only and the rest has not yet been exploited.

Biogas plants' environmental relations and its technology itself have been described and explained, being suitable for the disposal of biological waste, the majority of animal waste and the use of organic material, thus, generating green energy. Moreover, organic material is generated in the process, which is suitable for soil nutrient supply in an environmentally friendly way. It also helps the employment of the rural population, while completing the modernization of agricultural holdings. In addition to the three categories of major types of biomass, their characteristics, uses, advantages and impediments have been described.

The power feed system plays a key role on both national and international level. Unfortunately, in Hungary the purchase prices per kWh are considerably below the EU prices, so domestic plants are in a particularly disadvantaged state.

During the production of biogas, beyond the returns of various raw materials the optimal biological process and its condition-system was presented, which requires great skill and care, due to its complexity. The chopping and preparation possibilities of the raw material, including chemical, physical and biological pre-treatment were presented. It is essential to strive to achieve the most efficient exploration to gain successful operation. The raw materials affect the anaerobic gasification technology, therefore it is recommended to choose on the basis of them. Plants are compiled in the form of fermenter pipes or fermenting sewers, horizontal tanks and vertical circular container.

Hungarian natural gas supply is around 95%, which has the second largest coverage in the European Union after the Netherlands. Regarding materials, the available amount of agricultural products are: 2.3 to 3.7 million tons / year of straw, corn stalk and cob 5.0-6.5 million tons / year in our country. The amount of sunflower stem is 1.0-1.2 million tons / year. Based on these data, it can be said that much more biogas plant could be operated in Hungary.

Maintenance operations have a big impact on a substantial proportion of losses. In the case of already established plants it is very important to have a proper maintenance. We distinguish between planned, ad hoc, unplanned, preventive, periodic repair and condition-based maintenance. A key priority is to promote the reliability, error-free maintenance. The maintenance organization can be cathegorized into mathematics-, reliability-, quality- and condition-based processes. The ongoing maintenance strategies have evolved over time. The typical 1950s fire or ad hoc strategies have reached the level of TPM Total Productive Maintenance by now.

The Toyota production system, the lean-approach has been having a great success since the 1970s in car industry. It has five pillars, based on the lean philosophy are: value, value stream, flow, pull systems and continuous improvement. Two main principles of the lean-philosophy are the respect for humanity and losses, meaning the removal of non-value creating steps from each process and activity. Improper operations are divided into three major groups: Muda, Mura and Muri. The lean-management has been continuously evolving. It involves a wide range of tools which cover the earlier concepts (JIT, TQM, TPM, AMT) and is extended to labor organization. Its introduction requires careful preparation and consideration, because a lot of pitfalls and obstacles has to be faced for those who undertake this mission.

I studied the changes of renewable energy and biogas in Hungary using the system of Eurostat data collection. Linear correlation test was performed, and as a result ($r = 0.89$), I discovered a really strong positive correlation in the connection of biogas and renewable energy in Hungary.

I studied the problems and possible solutions of dealing with biogas plants, mainly the introduction of lean studying in this specific area. The lean manufacturing approach has been demonstrated in several industries, in this case a new application area will be examined. Many operators are facing problems that are largely attributable to the implementation, which derives from the technology. Since biogas plants in Hungary are not particularly supported, special consideration and attention is required, still, a sustainable, economical operation is not provided yet. Operating costs have been rising gradually, sometimes even dramatically over the years. The raw material prices go up steadily, a substantial part of the income is derived from electricity production, of which prices have decreased recently. The strict schedule, the violation of the forecast of production means a significant additional financial imposition. In the present study, exploration and potential solutions to these problems are presented through of the lean-method's implemences.

The main result of my dissertation is the lean model I have created, the Biogas production system that helps to take the system into practice. It contains many elements of engineering, but the foundation and in the tests I was carrying out my research on the basis of the scientific requirements determined by intensity at all times. I experimented on a new field to form a logical model, practical adaptation, testing its functionality. Thus, if the results confirm the expectations, the approaches and models can be adapted to similar biogas plants working with simple engineering techniques.

The introduction of the lean model was started with exploring the losses, examining the loss of seven employees. This was followed by inspection of the maintenance and operation of the processes on Szarvas biogas plant technology unit. I prepared the plant value stream map, based on the former given divisions. The problem solving method was carried out by following the TMP method, taking the 5M x PQCDSM categories into account. In all cases, fishbone diagrams were used to locate the root causes, and they are summarized in charts to keep an overview.

I allocated that changing the KÁT system or the intake of biomethane into the gas system could solve overproduction losses. In case of expectancy losses, defining of existing monitoring systems, development and error reports are necessary. Raw-material supply can be improved by closer

cooperation with suppliers. Transmission losses can be reduced by prioritizing the piping system and rationalizing transport distances. In order to eliminate production losses it is essential to carry out regular monitoring and application of surveillance and design standards. In case of inventory losses, taking the possibilities into consideration, preventive maintenance and rationalizing of dilutive raw materials can result a progress. Unnecessary movements can be reduced with the introduction of the 5S. The elimination of scrap and waste can be a solution to standardization and enforcing these standards, along with the introduction of TPM processes.

The basis of my research was the Szarvas biogas plant, as the technological structure of the biogas plant does not differ significantly. For that reason, it can be applied to other plants with smaller corrections as well. In order to examine the frequency of errors, homogeneity test (Levene-test) was performed as a pre-test for the variance test. After the test, I ran the variance analysis test, and proved that unexpected equipment failures can be reduced more by using the Lean-management in opposition to the traditional management. The investigations covered the period of failures, during which I proved that the lean methodology reduces the duration of errors.

During operation of the biogas plant productivity and efficiency is a key factor. Homogeneity test (Levene-test) was performed as a pre-test for the variance test, then I proved with variance analysis that biogas plant efficiency, productivity is significantly improved by the use of lean methods. The other major factor is the maintenance cost. Variance analysis proved that repairing and maintenance costs of the biogas plant can be significantly reduced.

Finally, I presented the efficiency of the lean-based maintenance. Using lean management without risk, managed to carry out the work in 14 days safely instead of the normal 40 days, which means a 65% rate of time saving. This can prove that biogas plants' maintenance processes managed by the lean system can be performed in shorter time, thus reducing the operating loss of near production.

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