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# PREFACE

In the name of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences we would like to welcome everyone who is interested in reading our journal. The Hungarian Agricultural Engineering (HAE) journal was published 32 years ago for the very first time with an aim to introduce the most valuable and internationally recognized Hungarian studies about mechanization in the field of agriculture and environmental protection. In the year of 2014 the drafting committee decided to spread it also in electronic (on-line and DOI) edition and make it entirely international. From this year exclusively the Szent István University's Faculty of Mechanical Engineering took the responsibility to publish the paper twice a year in cooperation with the Hungarian Academy of Sciences. Our goal is to occasionally report the most recent researches regarding mechanization in agricultural sciences (agricultural and environmental technology and chemistry, livestock, crop production, feed and food processing, agricultural and environmental economics, energy production, engineering and management) with the help of several authors. The drafting committee has been established with the involvement of outstanding Hungarian and international researchers who are recognized on international level as well. All papers are selected by our editorial board and a triple blind review process by prominent experts which process could give the highest guarantee for the best scientific quality. We hope that our journal provides accurate information for the international scientific community and serves the aim of the Hungarian agricultural and environmental engineering research.

Gödöllő, 20.12.2020.

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# IMPROVEMENT OF THE BSC MODEL WITH KPI-TREE METHOD THROUGH A DAIRY FARM CASE STUDY

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**Abstract:** In the dairy sector, the operation of the various control systems operates at the strategic level in the same way as other industries, but at the level of the task control, they operate specifically way. The Balance Scorecard is an excellent tool for measuring our strategic performance, but does not necessarily provide a clear feedback on causality and subsystems related to indicators. In our research, we highlight the deficiencies and the development possibilities of the balance scorecard through the operation process and conrol system of a dairy farm operating in Hungary. The model will be further developed using the KPI-tree method, which will be illustrated in through an example of a causal relationships with a financial KPI.

**Keywords:** agribusiness, dairy sector, balance scorecard, control system, KPI-tree

## 1. Introduction

Controlling as an important branch of management science today is undergoing extensive and widespread change. Different mathematical and IT solutions enable organizations to be able to extend their systems holistically. It is necessary to retrieve information from the information accumulated by information systems through various structures, which, by their weaponry, facilitate management decision-making and thus lead to more productive, more efficient organizational operations. Agriculture is a specialized industry, but the various management functions work the same here. Modern management tools and methods are also effective in planning, controlling and strategy making. In the case of task control and management control, different methodologies can, in many cases, create deterministic circumstances due to industry regulation and operation under these rules. In such an environment, these modern systems have the highest efficiency. In the dairy cow sector, the operation of control systems is very specialized at task control levels, but at higher levels this specialized character disappears. For organizations operating in the dairy sector, information systems are well established and sector specific. Strategic control systems (BSCs in particular) are quite common in the industry, but in most cases between measurement points and strategic control systems is lacking the level of task control.

In this study, we present a case study and model development in which the BSC model of a dairy farm is led through a causal structure of a given KPI and a variety of metrics and ratios up to different metering points. The methodology for the extension is KPI-tree, which is a well-functioning information system. With dynamic data uploads, it can provide management with continuous feedback on both organizational performance and intervention points for a given time period.

## 2. Literature processing

The term agribusiness was first introduced in American literature as a collective term for horizontal and vertical industry relationships related to agricultural production. As illustrated in the diagram of The food industry in the system of industrial relations - the concept of agribusiness, the central element of agribusiness is the production of agricultural raw materials (both of plant and animal origin) and the economic links of the product lines of the processing industries.

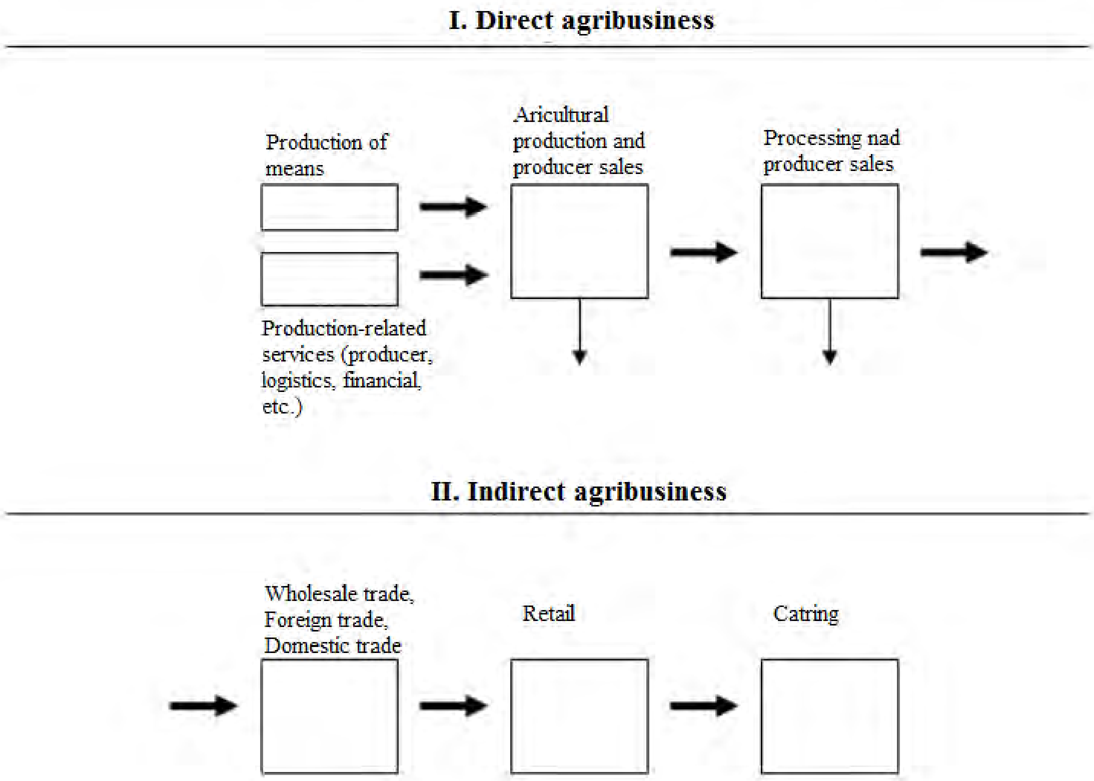


*Figure 1.* The food industry in the system of industrial relations - the concept of agribusiness, own editing, based on: (Buday & Sántha, 2011)

In the extended sense, however, the economic embeddedness of the sectoral system and its functional relations are also included in the value chain of agricultural production. Based on these, agribusiness systematizes a value chain approach to agricultural production with a focus on the agricultural production and processing sectors (Buday & Sántha, 2011). The forces of the sectoral vertical of agribusiness and the criteria of competitiveness in the sectors are determined by the characteristics of the sectoral chain structure. Its main characteristics are capital concentraton, economies of scale and the pace of technological change (Hajdu & Lakner, 2000).

Agribusiness has to take into account the so-called agricultural specificity, which influence the tools and methods of farm management. Among the agricultural specificity, the effects of natural exposures, biological cycles of reproduction, and the ongoing satisfaction of human nutritional necessities factors due constraint, risk and impact frequent in value creation (Székely, 2016).

### *Dairy cow farm management*

The cattle sector is a complex business of agricultural holdings, the main processes and their connections are shown in Figure 2. Planning, analyzing, accounting for changes in livestock for different age and utilization purposes requires process-oriented event tracking and records (Tonchia & Quagini, 2010). Although the whole business economics has already included all the economic, organizational and technical-economic knowledge, their combined application can only answer the complex business organization questions (Zéman et al, 2014).

Operational organization activities are primarily driven by the goals set by the company. Due to the complexity of the operational hierarchical target system, it is not always transparent, therefore it is necessary to specify them. Another major challenge for farm management is the production problems. In most cases, problems are recognized when the two extremes are the result for the period and the goal set different from each other. Once problems have been identified, information gathering and processing using a properly functioning controlling mechanism is required to develop action opportunities. Collecting and processing information is a very important management task. Today, the modern economy is permeated by the phenomenon of precise information management. In essence, information as such is a resource, so acquiring and managing it is just as important as other traditional corporate resources. With the help of the available information it is possible to evaluate the situation of the production with the help of analyzes and controlling activities depending on the specified goals (Castle et al., 1987).

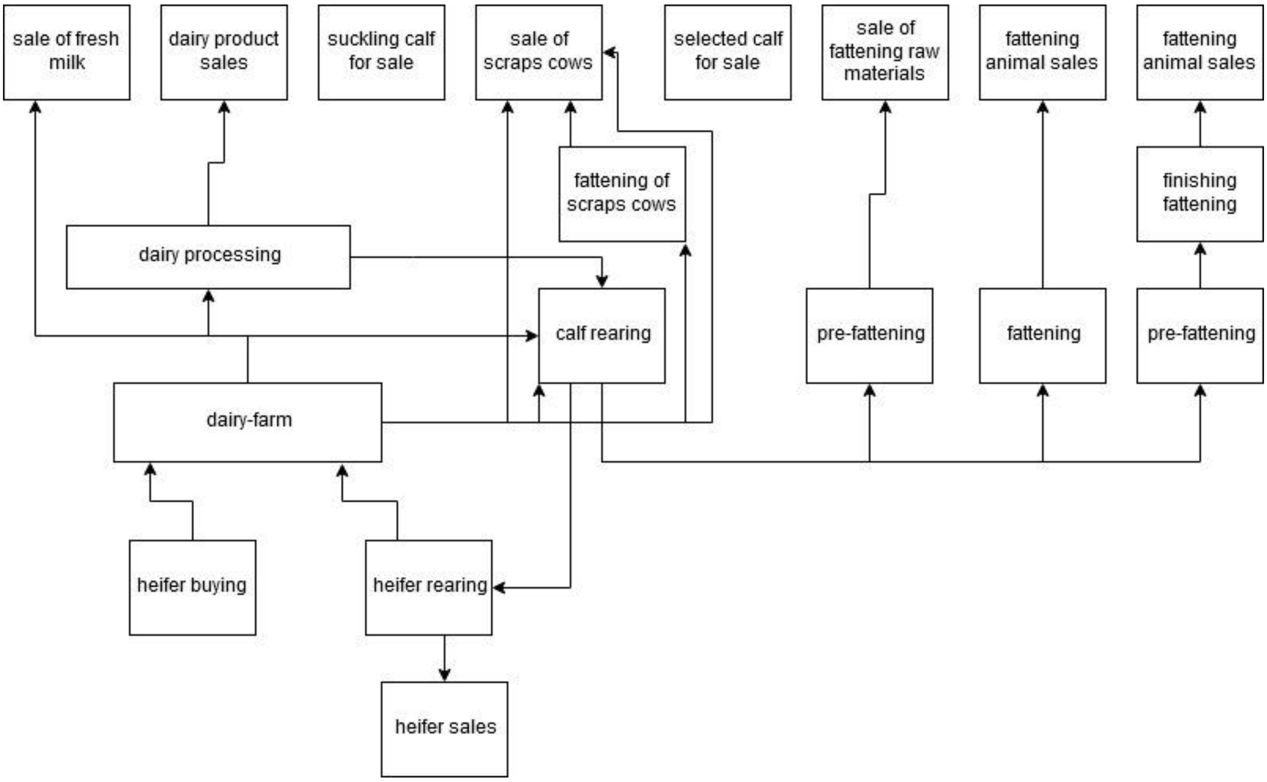


*Figure 2.* Production processes and opportunities in the dairy sector, own editing, based on: (Nábrádi et. al. 2008)

With the information available, both operation and production become more efficient. In the course of the organization of production, production processes must be regulated, the order of work processes based on each other, their placement in time, the optimal use of equipment, as well as the preparatory work and the service of animal must be organized (Beierlein, et. al., 2014). Nowadays, efficient management and organization of business cannot be achieved without the help of specialized plant management systems. In addition to recording and reporting production and breeding data, these database management programs provide online communication and collaboration with service and management agencies (Mikó & Jónás, 2006).

In Hungary, the sector is characterized by a lack of capital, technical backlog, inadequate market relations and the resulting uncompetitiveness. After the change of regime the number of animals and the production of animal products decreased by 30-40%. However, in 1997, the breed structure and genetic basis of the cattle population were at an appropriate level for the development of milk production. This was also illustrated by the production indicators. On the other hand, the domestic spread of the Holstein-Friesian breed played a significant role in the sharp increase of the specific yields of milk-producing farms at that time (Nagy, 2003). In the subsequent period, however, only the increase in specific yields resulting from the change of breed was no longer sufficient, producers had to adapt to the new requirements and to market competition (Antal et al., 2004). In order to meet these new requirements, there is a need to introduce both different management and management organization methods.

***Balanced Scorecard (BSC) application in agriculture***

The development of Kaplan and Norton (1998): Balanced Scorecard (BSC) as a model for a balanced indicator system is one of the most significant advances in controlling today. Organized around four distinct perspectives, the scorecard system is specifically linked to organizational strategy through its measurement and multidimensional approach (Otley, 1999). The four key areas of performance are financial performance, customers, operational processes, and innovation and learning (Kaplan - Norton, 2000).

BSC is a tool for executives that has a strong impact on competitiveness. Essentially, it translates the organization's vision into a comprehensive set of indicators that also define a strategic performance measurement and management system framework (Hanyecz, 2006). This is not another classic strategic planning method, but a tool to help implement the strategy, which assumes that there is a sound strategic plan with quantified elements. When applying the Balance Scorecard, it is important that organizations strive for balance. A balance needs to be struck between short and long-term indicators, financial and non-financial indicators, backward and forward indicators, external and internal performance components (Kaplan - Norton, 2000).

As a new management system, the Balance Scorecard covers clarifying vision and strategy, linking strategic goals and indicators, recording planning and expectations, strategic feedback and facilitating learning. But in today's accelerated information age, IT support and information technology have become essential in most of the areas listed. It can be said that in our increasingly globalized and digitized world, information technology has become a vital resource, both for implementing competitive strategies and for managing business processes. Thanks to the explosive development of information systems and information technology, organizations have accessed a lot of data that has not been studied before but contains useful information. Nowadays the Balance Scorecard also has access to large amounts of data, which can make the organization's process mapping and strategy definition more sophisticated and complex (Huang - Hu, 2007).

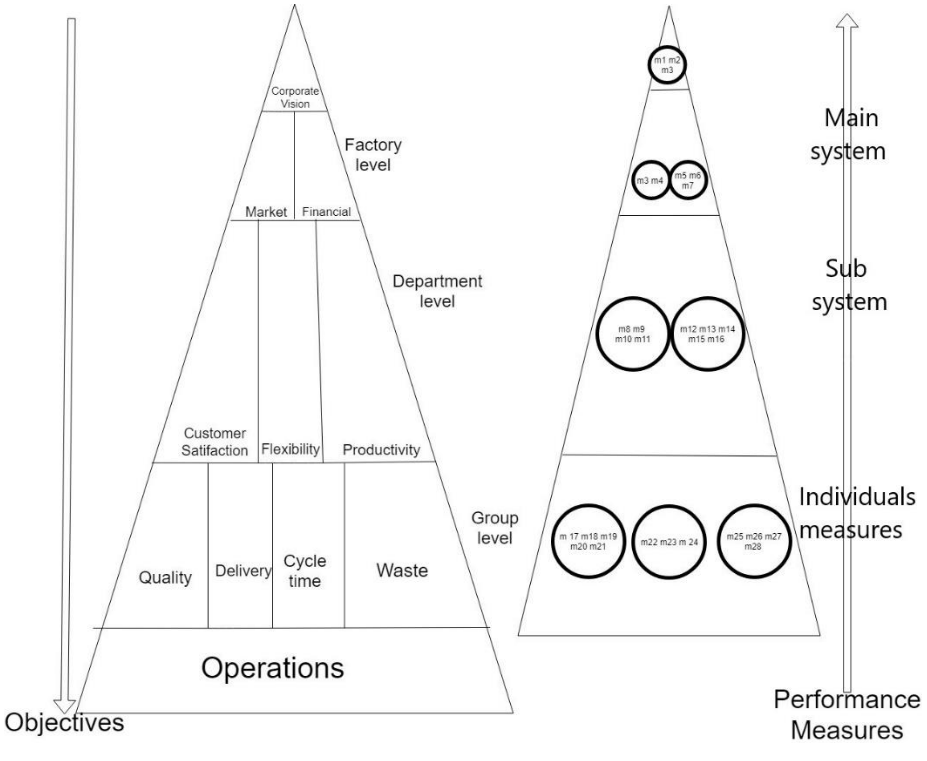


*Figure 3.* General goals and measurement points in organizational operating systems, own editing, based on: (Ante, Facchini, Mossa, & Digiesi, 2018) (Schnellbach & Reinhart, 2015)

The balance scorecard can be used in any industry, but all systems must be industry specific (Bigliardi & Bottani, 2010). Universities and research institutes can improve the economic efficiency of BSC implementation by developing models for various specialized systems and industries (Nefstead & Gillard, 2006). In the case of agriculture, the types and sizes of farms and the life cycle stages of farms can be called specialized factors. These standardized BSCs could be further refined and tailored to practical needs and made more accessible to farmers through advisory services. Compliance with the above requirements requires close cooperation between the university, research institutes and the consultant service. The specific, low level of BSC agriculture is due to the fact that existing consultants do not have the necessary competencies and methods (Noell & Lund, 2002).

***The applied KPI tree model***

KPI Tree is a controlling model used and developed in most cases by multinational organizations operating in the industry. The KPI tree organizes KPIs in different ways into groups based on specific goals and correlations (Schnellbach & Reinhart, 2015) and systematize them with a logical structure based on each other (Ante, Facchini, Mossa, & Digiesi, 2018). The various KPIs measured are determined by both the literature and the corporate practice. Big data and industry 4.0 data, on the other hand, allow for the creation of new KPIs and the collection of accurate KPIs up to the minute (Peral, Maté, & Marco, 2016). These new KPIs provide an opportunity to both compare daily plan factual and objective daily analysis based on it, as well as to measure different lean management and other organizational methods. (Schnellbach & Reinhart, 2015).
The literature does not specifically define structures for building the KPI tree model, but it is possible to implement multiple cross-structures in case studies. The Figure 3. is based on the structure used in our model development.

## 3. Material and method

During our research, we conducted an extended case study. Our case study in Hungary served as a dairy farm in the Baja district. The body under study has a Holstein-Friesian population with an annual milk production of approximately 1 800 000 liters.

We chose the extended case study method to discover the shortcomings of existing theories and the methods used in practice (Babbie, 2013), and to further develop the applied model along a model formulated in a given theoretical literature, using various parameters (Burawoy, 2002 )

In our research we looked for points that do not necessarily agree with the theory. We aimed to analyze the interrelation of different controlling models and their sequential logical structure in the dairy cow management system. We further aim to develop a complex controlling model for use in general dairy organizations. In order to illustrate the operation of the model, we set profitability as an aggregated KPI. We chose this because it is a critical and well-defined KPI in the management of dairy cows, according to both the managers of the organization under study and the literature. Because the model serves to describe reality, profitability as an aggregate target KPI is interchangeable with other aggregate target KPIs in the model, but does not affect the logical structure of the model.

## 4. Results

During our research we analyzed the controlling system of a dairy cow and its related structure. In our analysis, we illustrate in detail the logical structure of the KPI tree  through a financial KPI. During the development of the model, the data and operational processes of the examined organization were taken as the basis.

***Case Study - Dairy Cows KPI Management – BSC***

The various metrics appear as aggregates in the Balance Scorecard system of the organization under study. The organization does not measure these metrics and their content of information with the KPI- tree method, but only using various simple mathematical operations and reporting operations. The information required for these purposes is extracted from the information management system and from the accounting ledgers and processed by the finance department and integrated into the Balance Scorecard.

The figure below shows the BSC system used by the organization. It is clear from the chart that few KPIs are used, and most of them can be classified in the financial statements or in the BSC financial section.

*Table 1.* BSC model, goals and indicators

| Measures | | | |
|---|---|---|---|
| | **Strategiec objectives** | ***Key performance indicator*** | ***Calculation method*** |
| **Financial success** | Improve return of investments | ROI | Investment portfolio |
| | Increase productivity | indicatior of productivity | Profit per hour worked |
| | Increase Profitability | Indicatior of profitability | (Income/expense)X100 |
| **Customer satisfaction** | Better health status | Replacement and proportion of patients | Number of farm visit of vet |
| | Increase milk protein index | Milk protein index | milk protein%/Milk fat% |
| **Internal Processes** | Improve milk yield | Average of daily milk production/cow | Adjusted average lactation prduction per cow for 305 days |
| | increase of effiectivity Feed comsumption | Use of feed per liter of milk | use of feed/produced milk |
| | Improve utilization of buildings | Percentage of utulization of cow-shed | useful square meter per cow |
| | Reduction of the workforce | Investment in technology development | Labor cost/cow |
| | Reduce fuel consumption | fuel consumption per cow | Fuel/Cow |
| **Learning and Growth** | increase use of information system efficinity | Cost of information systems | Sharing of information efficinity |
| | Hiring of a more skilled farm manager | level of accreditation | Number of days spont in training |

### *Critical Analysis of the Model*

The balance scorecard system shown in the model above illustrates the operation of the examined organization. The KPIs defined in the system and their calculation method are based on the specified calculation methods. The information content of the various aggregated indicators is not necessarily complete, and the various fundamental interrelationships do not appear in the logical context of KPIs.

In most cases, the content of information derived from KPIs is only an aggregate unit of measurement and an analysis of this fact relative to past data. In goal definition, goal definition does not include possible optimum and deterministic data for the KPI, but rather a comparison and expectation with past data. The information content of the various KPIs defined in the model needs to be as diverse and comprehensive as possible for management to make a well-informed decision (Anthony & Govindarjan, 2006).

Further disaggregation of KPIs is not applied during organizational operations and therefore the model is not able to adequately provide causal information to management. The model lacks the level of detail and functionality required for effective decision making. Various aggregate indicators such as ROI, profitability, increase in milk yield have several and different causal factors. The goals assigned to these complex metrics and the status derived from a plan-fact analysis of the performance measured in the current period, not only illustrates the actual results, but also some level of performance.

As we associate the appropriate target formulation associated with a particular indicator in the model, the relevance of the indicator information content can be significantly increased. Similarly, if a given aggregate KPI is further analyzed in a causal relationship analysis with the indicators associated with the aggregate, then the metastatic effects of the studied complex KPI can be observed. The more detailed and further a causal analysis we analyze the main KPIs in the BSC, the more relevant and detailed information content is available to management. The objectives set for other indicators related to the aggregate indicator and their plan-fact analysis at a given point in time support the evaluation, judgment and relevance of the aggregate indicator in the decision-making process over a given time period. By defining goals to the KPIs and their further causal analysis, we obtain a complex model that, both in depth and in methodological terms, contains more extensive and relevant information than the BSC model used in the study organization.

All in all, the Balance Scorecard analysis method is an excellent management control tool in the dairy sector as well. It provides excellent assistance in planning and controlling , but the level of task control are not necessarily appropriate and are not applied by the organization. Task level of control require the further development of the BSC analysis method, the most basic foundation of which is an efficient and holistic information system. By extending the analytical method, a model is created in which relevant targets are assigned to the various points or KPIs, and dynamic actual data needs to be uploaded. This creates a structure in which aggregate KPIs and nested aggregates themselves carry performance levels, predefined categories. For this extension, the KPI tree method, as formulated in the literature, is best suited. The indicator at the top of the model is one of the aggregated KPIs from the BSC.

***Further development of the BSC model using the KPI tree methodology***

The KPI tree used to extend the BSC analysis method is a hierarchical structure that includes various metrics, KPIs, and complex metrics. The hierarchical arrangement of KPIs in a given tree is not necessarily the same as the vertical hierarchical arrangement of another tree.

The advanced model we have presented is an illustrative tool because out of the aggregate KPIs in table 1, we selected it at the peak of our profitability model. Our choice for profitability, among other things, is the aggregate peak of the illustrated model because the purchase price of milk as one of the most influential factors in profitability in the dairy sector depends on predetermined buying factors. The target defined for the aggregate peak indicator is determined by management (such as the rating at the time of acquisition). The aggregate indicator itself can be read from the various dairy cow management information systems, but due to the task controllers, and due to the lack of a relationship system, the meaning of this information in the causal context is not representative. A report from a peak KPI plan analysis shows the milk grade category projected for the period under review, thereby forecasting the expected milk purchase price. If the report does not meet expectations, then the KPIs and metrics associated with the tree's peak pointer are in themselves indicative of the achievement of the deterministic and expected goals. This clearly indicates the need for the manager to intervene in different areas.

You can assign a projected rate to most KPI-tree indicators, especially those in the lower third of the tree. Most of these ratios are not always convertible into monetary units, but currency ratios and absolute amounts must be used at the levels above where possible. This is because the company calculates profitability as a ratio of revenue to cost, and is measured in currency, therefore, the revenue shown in the model- the indicators at the horizontal level of costs must also be expressed in absolute terms. In cases where it is not possible to set a special complex ratio for the plan-fact analysis there the relative relation between the absolute value of the plan and the fact must be defined relative to one another.

The Figure 4. illustrates the structure of the measurement points required for the KPI-tree structure. These measuring points include the name of the KPI, the data of the plan-fact analysis, the name of the indicator and the calculation method of the indicator. There are exceptional cases where no indicator or calculation method can be defined for the measurement points. If the measurement points in Appendix 1 (An illustration of a KPI tree in terms of profitability aspect), then the plan fact analysis can only be expressed in currency.

The illustration above shows three large hierarchical groups. The topmost group is called **main system** group, which contains aggregate metrics. Aggregate metrics here already have complex target definitions. Information from these indicators provides management with appropriate feedback on the achievement of strategic goals and opportunities. In our model, such an indicator is profitability, which is also the top indicator of the tree under study. The profitability indicator is examined by the organization in terms of revenue per cost distribution. Another indicator in the main system group is revenue. There is no proportional ratio for this indicator, but the relative indicator from plan-fact analysis can be determined. Revenue is expressed in absolute value as follows: (revenue from milk sold plus revenue from sales of by-products plus revenue from twins plus subventions). In addition to the revenue metric, the cost indicator appears. The cost indicator must also be interpreted in absolute value, as this standardization is needed to calculate profitability. However, another metric with relevant information content is also used in the model. This metric is structured as: (cost = 1 kg milk sales price per 1 kg milk production price). This indicator adequately reflects the profitability of the milk produced by the organization in proportion to its costs. The second level in the model is called sub system group. There are already several KPIs in this group, as shown above. At this level is located the income from the subvention, which is measured both in absolute value and per cow. The milk sold indicator can only be interpreted in the model in absolute terms or as a result of a plan-fact analysis.

Calculation value of the indicator: (quantity of milk sold in kg multiplied buying-in price in currency). By-product is sold product that additionally income. In the dairy sector, this means the organic manure. In our model, the average fertilizer production per animal was measured for the by-product and expressed as kg per day. In addition, the target is defined by the average daily organic manure production as determined by the literature. The twin product can also be called a source of additional income. In the diary production sector, this means bull calves sold. The number of bull calves per calves has information for decision-makers on reproductive performance and may provide guidance for intervention options. Monitoring this is important in the model because the calf calving is an alternative loss because the heifer represents a higher value in milk production. The value of the indicator can be expressed in absolute value. The bull calf can be sold at market price, so it is income and it can be express in terms of currency. On the cost side, the direct and indirect costs are appear in the sub system grouping level. Direct costs are costs that are closely related to production.

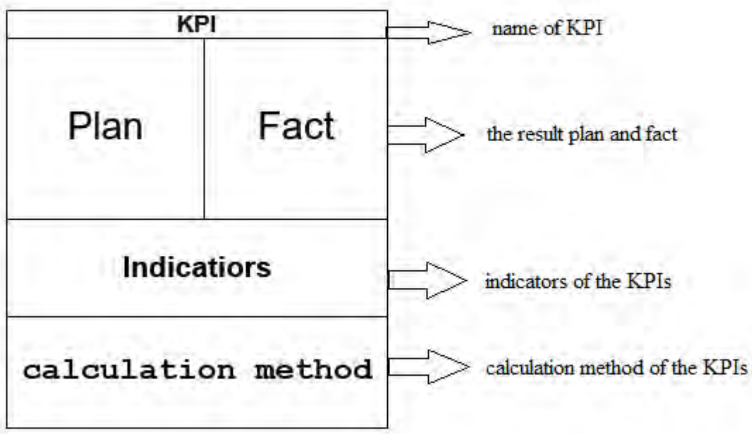


*Figure 4.* The structure of the measurement points

For this indicator, it may be possible to specify a metric other than the one in absolute currency: Direct costs over the period under review in currency per kg of milk sold for the period under consideration. For the indicator, past data is the best basis for defining a goal. As a result of the plan-fact analysis, the indicator illustrates the ratio of costs to 1 liter of milk for the period under consideration compared to past results. In the case of indirect costs, no specific ratio can be defined and is therefore an aggregate indicator in absolute terms. These are costs that are not closely related to production.

At the lowest level is the individuals measures group. Within this group, several KPIs and metric points have been formulated which are closely causally related to the various aggregate indicators at the above levels. In most cases in levels of task control, these indicators can be interpreted as reporting specific tasks and processes. The importance of milk quality in the model is pronounced as it has a major influence on entering the different class of selling. There is a significant difference in the milk buying departments purchase price per liter. The factors that determine the milk quality class are specified in the contract with the milk purchaser and thus become deterministic goals in the model. Factors determining milk quality are continuously monitored and uploaded to the farm management information system.

The volume of milk sold is also at this level in the model. The indicator can be interpreted in absolute terms, but it is not in currency terms but in kilograms. Further indicator related to the quantity of milk sold is average daily milk production. This indicator refers to lactated production per cow adjusted for 305 days, which is expressed in kg per day. Further indicator is the cost of materials, which can be expressed in absolute terms. Material cost indicators can be expressed in currency vaule, with the exception of feed utilization KPI, the information content of which is most relevant in vaule of feed consumption per 1 kg of milk. Personnel costs are all costs that include personal payments. This indicator can be expressed in absolute value. The related indicator is the wage, which can be clearly expressed in currency, but its information content can be expanded if the wage cost is compared to 1 cow. Cost of auxilary operating, as well as other costs in this class, are expressed in currency value. In connection with the auxiliary costs indicator, we have highlighted feed movement and littering in our model. For both indicators, we compare work operations to the fuel costs used. This gives the management more detailed information to assess the effectiveness of the work. Other direct costs, which include direct costs from which derivative indicators have a strong information content. One such sector-specific direct cost would be the veterinary services indicator. This indicator expresses the health status of our herd and also the absolute value cost of veterinary services. The value and status included in these indicators were also expressed in relation to 1 cow. This will illustrate the extent and proportion of the various animal health problems in the farm. Direct costs at the level of individual measures, as shown in the illustration is the, farm management, cost of depreciation and operating cost of farm. Amortization is calculated at market value. In the case of the farm operation indicator, the indicators per 1 kg of milk are an excellent illustration of the cost-effectiveness of investments in and investment subvention in the water and energy system.

## 5. Summary

It is clear from our research that although agriculture is a specialized sector, different control models can still be applied in this industry. The applicability of a balanced scorecard is excellent for strategic planning and control, but does not fully illustrate all levels of controlling. Our extended model, which is based on the cause and effect relationships of various KPIs in the balance scorecard, enables a KPI-tree with plan-fact analyzes to generate more relevant information and provides greater transparency at both hierarchical and vertical levels. In addition to more relevant and extensive information aggregation, our model has several enhancements point. The various hierarchical and vertical levels do not provide feedback on the exact reason for the good or bad performance of the aggregated KPI. By using different mathematical-statistical methods and different algorithms to determine changes and relationships, more accurate information can be provided to the management through the system.

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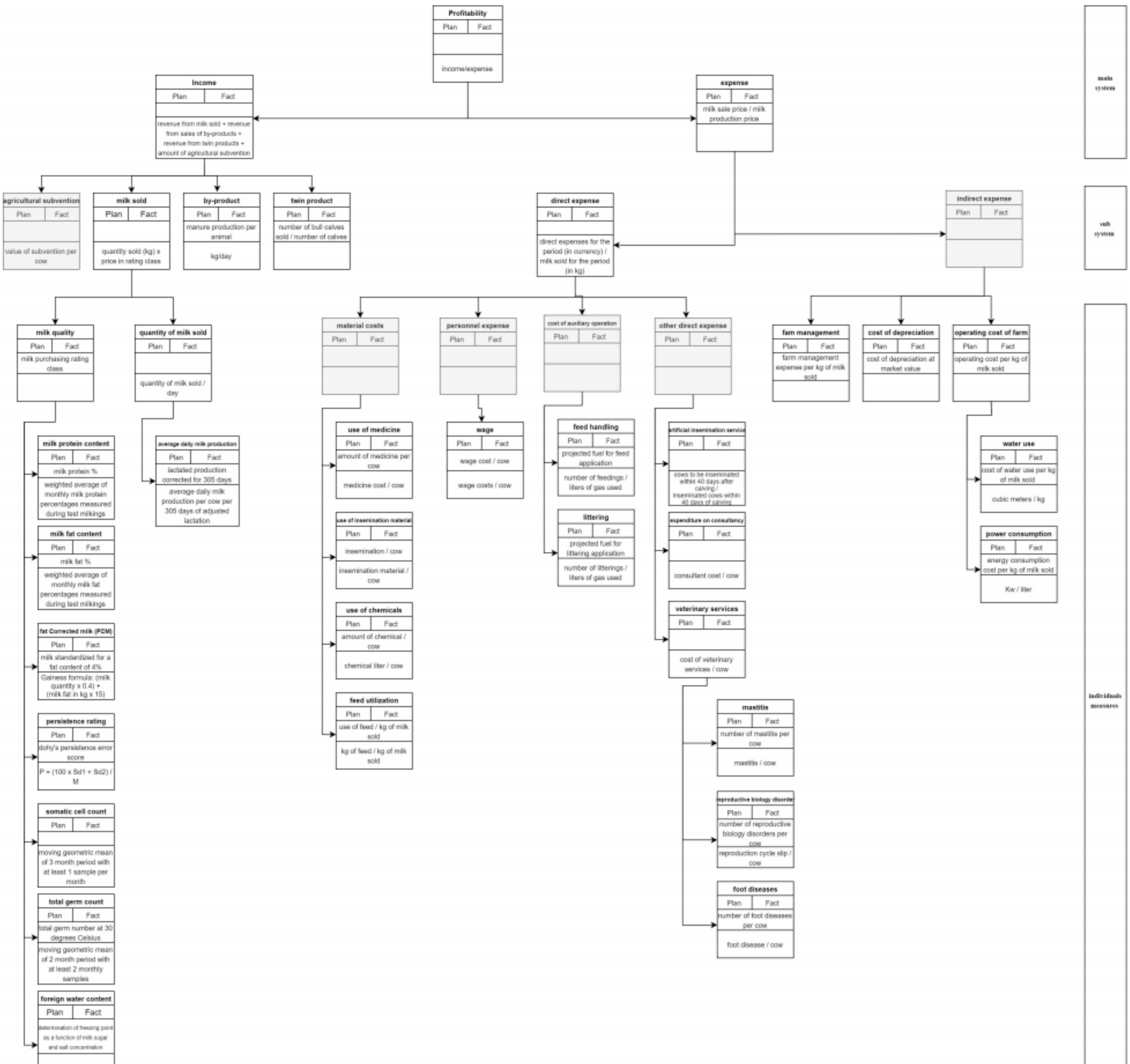
Appendix 1. Illustration of a KPI tree in terms of profitability aspect



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# THE RELATION BETWEEN ONLINE PROTECTION REGULATIONS AND THE INTENTION TO USE E-SERVICES/AGE PERSPECTIVE: A CASE STUDY FROM HUNGARY

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**Abstract:** As more regulations to protect privacy and security for online interactions is carrying out, as more complications to perform these transactions is coming forward, affecting the intention to execute these interactions online especially for old people. This study aims to reveal the relation between intention to use high secured e-services with the age of user. This study finds that there is a positive relation between the over-40 years online users' ages and their retreating from completing online transactions due the complications of security and privacy procedures. Also, the study finds that 85% of people feel more comfortable to execute their transactions online with the high secure regulation, but from another perspective, 60% of persons between 40- 55 years old don't prefer doing their transactions online due to the complication of transaction security procedures, where 92% of people over 65 are avoiding to do financial transaction online and they need another person help to perform it more than 82% of times.

**Keywords:** E- services, online security, digital gap, 40 plus people, intention

## 1. Introduction

New technology applications are extremely introducing into our daily life in an increasing basis, this high-speed change make it harder for old people to adapt at the same speed of the new generation, and that causes a digital divide between generations (Millward, 2003), for instance, in 2019, 23% European people aged between 55 and 74 are not using internet at all , where all new generation (digital-native) are using it (European Commission, 2020). This digital gap between generation deserves to be studied thoughtfully, but on the other hand, the information communication technologies offer a great opportunity to the older generation to stay connected socially with their far-distance families and friends, also it enables them to execute their activities remotely, besides to the online health care, learning and entertainment platforms, in general ICTs enhance the life quality of old generation (Schreurs et al., 2017; Bercovitz and Pagnini, 2016).

From another perspective there are people don't use ICTs, Van Dijk (1999) noticed this phenomenon and described four possible groups of factors that impede using ICTs, first one related to lack of motivation to use computers and internet, second group related to personal skills or computer literacy, third related to accessibility to internet in region the user exists, and the last groups comes from personal ability to afford costs of using technology, a little thinking about the lack of motivation to use ICTs drives the researchers to think about a group of factors such as attitude toward ICTs which in turn related to perceived security and privacy, in this context, security and privacy are considered vital barriers to use ICTs and e-services provided by e-government (Ahmad et al., 2013; Parent et al., 2005).These barriers of online security and privacy have pushed governments to develop policies and regulation to protect online interactions and encourage users to use virtual medium to execute their transaction and benefit from e-government services (Toots 2019; Osborne and Brown, 2011), but exerting online protection policies and regulation have brings a lot of complication and more steps that are not convenient to normal users especially when the age of user is bigger and drifting away of digital-natives ages (Sarah and Lock, 2016).

## 2. Literature review

In this section the study will brows literature and discuss the protection concept of online interactions from security, privacy and ease of use perspectives and their relations with the users' ages.

### *Security of online interactions and users' age*

Al-Shboul et al (2014) and Alomari et al. (2009) have defined security of online medium as a key factor affecting successful implementation of e-governments and adopting its services, and Gilbert and Balestrini (2004) has considered that the security and trust in financial activities has a vital role in users' willing to use internet in executing their transactions, in this regards, privacy and security intersect in people minds to form a behavior that tends protect an anticipated risk (Belanger and Carter, 2008), here, Kowalewski et al. (2015) and Bergstrom (2015) saw that older users are more careful in using of their credit cards in secure online space than the younger users who concentrate their attention more on privacy disclosure on Social networking Sites, from another perspective, the perceived online security from older users point of view led to a wide diversity of and fined-spread privacy preferences (Hornung et al., 2017; Garg et al., 2012).

### *Privacy of online interactions and users' age*

In spite of that the impact of online privacy on users' attitudes to use e-services has been confirmed (Waidner and Kasper, 2016; Angst and Agarwal, 2009; Parasuraman et al.,2005) there is no common consensus about the age impact on the uses' attention toward online privacy issues, as Miltgen & Peyrat-Guillard (2014) and Van den Broeck et al. (2015) found that older online users are more sensitive to the privacy issues, whereas many other studies found no relation between age of the online user and his sensitivity to the privacy issues (Taddicken, 2014; Hoofnagle et al., 2010). In the same context, younger users use internet in more protective way for their privacy (Blank et al., 2014), while the older concern more about the privacy but when they act they show less protective behavior (Van den Broeck et al., 2015). This contradiction between higher privacy concerns and less protective behavior among older user of internet may come from their perceived practical complications of privacy and security measures applied on online interactions, and this reason is what this study is trying to prove.

### *Perceived ease of use and age*

More and more of small smart devices are intervening widely in online interactions, and make it easier to interact and accomplish transactions anywhere with these smart portable devices (OECD, 2012), but these smart instruments have some limitation to be easy used such as smaller screens, many passwords to keep and relative complicated security procedures for online transactions which making it more uncomfortable for older users and more risky (Coventry and Briggs, 2016; Sarah and Lock, 2016) as they sometimes try to avoid the complication by putting more easier and predictable passwords or asking for assistance from others to read or overcome some protection measures which seem unfamiliar or complicated for them (West, 2015; Age UK , 2015; Karp and Wilson, 2011).

## 3. Conceptual framework and hypothesis development

As discussed in literature review paragraph about the contradiction between online older users' high concern in privacy and security issues and with their less careful protective behavior about them when they use internet and benefit from e-services (Blank et al., 2014; Van den Broeck et al., 2015) even when they accomplish their financial transactions and payment. The older users in general, due to Sarah and Lock (2016), need more support than younger in doing their banking transactions, as they are less flexible and have less ability to adapt quickly with continuous changing protecting requirements and procedures that may drive them to ask for personal help from others, which in turn make them more vulnerable to fraudulence and scam (Davidson, 2018). From this point, this study tries to observe the impact of complications come from protecting procedures of online transactions on the tendency to use online services from the users' ages perspective.

At the beginning, this research needs to test the relation between people' intentions to use online services on one side and privacy and security regulations and procedures on the other side, in the study environment.

H1: There is a positive relation between online protecting procedures and people's intention to use online interactions.

To be more precise this study will focus on the effects of protecting procedures of online interactions on the tendency to use online services.

H2: Complications of protecting procedures of online interactions effects people's intention to complete online interactions.

To answer the question about the contradiction between online older users' high concern in privacy and security issues with their less careful protective behavior about these issues when they use internet, this research will measure the effect of complications come from protecting procedures of online interactions on people over-40 years old intention to complete online interactions.

H3: Complications of protecting procedures of online interactions effects over-40 years people's intention to complete online interactions.

Testing these hypotheses would enhance the understanding the impacts of privacy and security online regulation and policies on users' intentions to perform their transactions and interacting online from age aspects.

***Importance of the study:***

Many researches have concerned in older age perceived privacy and security and their intention to use internet and online services, but this research provide a novelty in discussing the complications impact of online protecting procedures on online users' intentions to continue using e-services and online interactions in the light of the users' age.

## 4. Methodology

To test research hypotheses and answer the study questions this study will conduct a quantitative research based on distributing questionnaire in small cities in Hungary, not rural but not also in Budapest or large cities, to test hypotheses in moderate-developed regions in regards of ICTs advancement. The questionnaire collects demographic information about interrogators and their exact age due the importance of age for analyzing collected data for this study. Then questionnaire measures people intention to use e-government services and online application to accomplish their financial transactions.

Also, the questionnaire measures interrogated perceived privacy and security level of e-services in regard of procedure to protect online interaction. Finally, the questionnaire measures the online users' perceived complication level of regulations and procedures that intend to protect privacy and security in online environment, and measures the number of users' retreatments from completing online interactions due to mentioned complications by posing number of questions like "did you canceled an transaction or retreated to complete online interaction because of security or privacy protecting measures, choose: No at all, one time, two times, three times , more than three times…" to correlate directly the level of intention to continue using online services with the complicated protecting procedures. The questionnaire distributed in small cities in hungary, not in rural regions but not also in Budapest or large cities, to have responses from moderate-developed regions in regards of ICTs, it also directed to have more respondents who are over-40 years old.

The 135 questionnaire papers distributed in person and filled in the presence of interrogators to explain any ambiguous, taking in regard many of respondents are old, this field work took place between 15- 30 June, 2020, at the end the study has 127 valid responses.

***Sampling method***

The questionnaire distributed in small cities in hungary, not in rural regions but not also in Budapest or large cities, to have responses from moderate-developed regions in regards of ICTs, it also directed to have more respondent over 40 years old. The 135 questionnaire papers distributed in person and filled in the presence of interrogators to explain any ambiguous, taking in regard many of respondents are old, this field work took place between 15- 30 June, 2020, at the end the study has 127 valid responses.

## 5. Result and discussion

***Sample background analyzes:***

The 53% of respondents are females, and 43% males, 75% of respondents are over 40 years old, the age distribution illustrated in Figure 1.

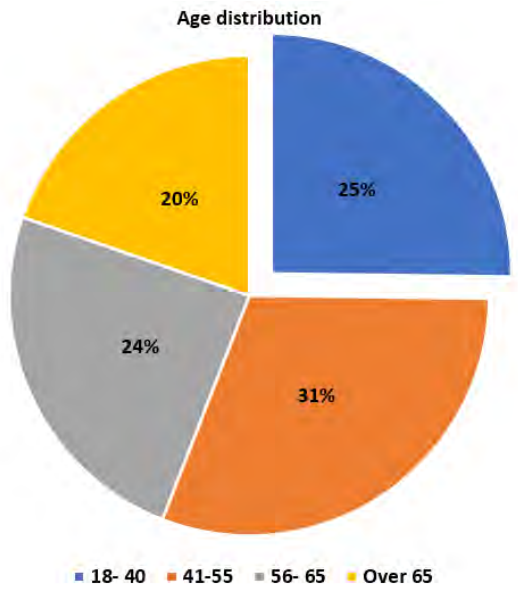


*Figure 1.* Age distribution of the sample.

Using SPSS program, this study has tested the correlation between people intention to use online services on one side and privacy and security regulations and procedures on the other side, there is a strong positive relation ($r = 0.65$, $P < 0.001$) between the people intentions to use online services on one side and privacy and security regulations and procedures on the other. In other words, increasing protecting procedures for online interactions is encouraging people to use e-government services, accomplishing their transactions online and interacting more freely on online space. But this result is not a surprising or new result, as many studies have reached the same result such as Schaupp and Belanger (2005) and Conklin and White (2006), so, this study considered this result just as a supportive outcome to be sure of the existence of mentioned relation in the study environment. A more focusing tests on the objective of this study have been done, a correlation test has been conducted between online users' age and users' retreating from accomplishing online interactions caused by perceived complications of applying protecting regulations and procedures on online interactions, the results are showed in table 1.

*Table 1.* Correlation test results between online user's age and his retreating from completing interactions caused by complications of protecting procedures

| **Correlations** | | | |
|---|---|---|---|
| | | Real Age | Retreating Numbers |
| Real Age | Pearson Correlation | 1 | 0.730** |
| | Sig. (2-tailed) | | .000 |
| | N | 127 | 127 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | |

From Table 1. there is a strong positive relation between users' retreating from accomplishing online interactions- caused by perceived complications of applying protecting privacy and security regulations and procedures- on one side and users' age on the other side ($r = 0.73$, $p < 0.01$) which means as the online user is older as the perceived complications- that comes from online protecting procedures- increases the users' retreating from completing their transactions or any kind of interactions.

For a deeper view, a regression analysis test has been conducted between the perceived complication of online protecting procedures and numbers of retreating from completing online interactions, the results are showed in the Table 2.

*Table 2.* Linear regression test results between perceived complication of online protecting procedures and users' retreating from completing av online interactions.

| **Coefficients[a]** | | | | | |
|---|---|---|---|---|---|
| | Unstandardized Coefficients | | Standardized Coefficients | | |
| Model | B | Std. Error | Beta | t | Sig. |
| (Constant) | -1.256 | .307 | | -4.088 | .000 |
| Perceived complication of online protecting procedures | .070 | .006 | .730 | 11.929 | .000 |
| a. Dependent Variable: Number of retreating from completing interaction | | | | | |

| **Model Summary** | | | |
|---|---|---|---|
| R | R Square | Adjusted R Square | Std. Error of the Estimate |
| .730 | .532 | .529 | 1.07411 |

Table 2 shows that perceived complication of online protecting procedures has a significant impact on users' retreating from completing online interactions ($B = 0.07$, $P < 0.001$) and this perceived complication explains about 53% of the change in the users' retreating from completing online interactions (Adjusted R square = 0.529), which is a considerable percentage of explaining online users' retreating from completing online interactions.

As a result retreating from completing online interactions is highly impacted by the complications of online protecting procedures, this result is very important especially if we focused on financial transaction, so these procedures on one side encourage users to do their transaction online -as they feel safe to do it (as we see in first correlation test)- but on the other side when the users feels the complications of protecting procedures during accomplishing these transactions, the possibility to behave in a reversed way to their intentions and stop completing the transaction increase too, this drives to conclude that when protecting procedures of online interactions are designed the designers should take in consideration the difficulties and complications consequences that may impede users to complete the interactions online, and designers should find a design achieves the targeted protection level, and in the same time easy to be dealt by users.

To study the effect of perceived complications of online protecting procedures on older users, correlation and regression tests has been conducted, but this time only over 40 years old responses have been taken in consideration, the results are showed in table 3 and table 4.

*Table 3.* Correlation analysis results between online over-40 years users' ages and their retreating from completing interaction caused by complications of protecting procedures

| **Correlations** | | | |
|---|---|---|---|
| | | Real Age (only over 40 users) | Retreating Numbers |
| Real Age (only over 40 users) | Pearson Correlation | 1 | .792** |
| | Sig. (2-tailed) | | .000 |
| | N | 95 | 95 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | |

Tables 3 shows a very positive strong relation ($r = 0.79$, $P< 0.01$) between over-40 years online users' ages and retreating from completing online interactions caused by complications of online protecting procedures. From table 4 it can be noticed that perceived complication of online protecting procedures has a significant impact on over-40 years users retreating from completing online interactions ($B = 097$, $P < 0.001$) and this perceived complication explains about 62% of the change in the over-40 years users' retreating from completing online interactions (Adjusted R square = 0.623), which is a considerable percentage of explaining online over-40 years users' retreating from completing online interactions.

Comparing the results which concluded from tests illustrated in table 2 and table 4,shows that over-40 years online users' sensitivity to the increase of perceived complication caused by online protecting procedures is more by 9% compared to common online users (all ages), but this statistical comparison needs more supportive analysis to give a clearer understanding. To assess the over-40 age online users' sensitivity to the perceived complication of online protecting procedures which hasn't a quite clear explanation by regression analysis alone, some additional descriptive analysis has been done

*Table 4.* Linear regression test results between perceived complication of online protecting procedures and over-40 years users' retreating from completing an online interaction.

| **Coefficients[a]** | | | | | |
|---|---|---|---|---|---|
| Model | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t | Sig. |
| (Constant) | -2.768 | .452 | | -6.129 | .000 |
| Perceived complication of online protecting procedures | .097 | .008 | .792 | 12.514 | .000 |
| a. Dependent Variable: Number of retreating from completing interaction | | | | | |

| **Model Summary** | | | |
|---|---|---|---|
| R | R Square | Adjusted R Square | Std. Error of the Estimate |
| .792 | .627 | .623 | .70652 |

Only 21.8% of under-40 years users (N = 32) have canceled at least one online interaction due to complications of protecting procedures whereas 95.7% of over-40 years users ( N = 95) have did that, 89% of users between 41- 55 years old have canceled at least one online interaction due to complications of protecting procedures with cancelation average of 1.8 time in their lives, and all respondent over 55 years old have canceled at least one time with an average exceeds 3.5 times in their lives, but these averages of cancelation are not a precise indicator as some of users didn't perform any transaction if they didn't compelled to, and others just stop trying to perform online transaction after one or two retreating.

Moreover, 60% of persons between 40- 55 years old don't prefer doing their transactions online due to the complication of transaction security procedures and 51% of them asked for another person help, 72% of persons between 56- 65 tend not to use online services if they aren't compelled and 70% of them asked for help from another person in accomplishing their transactions, where 92% of people over 65 are avoiding to do financial transaction online and they need another person help to perform it more than 82% of times. These results of high rates of asking other persons to help in accomplishing online transactions- which becomes higher with the increasing of users' age - expose online older users to the risk of deception from other persons.

Here, this study alludes that there is a responsibility of governments and financial institutions to develop special online protecting procedures concerning easy-dealing and flexibility with old users, and in the same time guarantee their privacy and data security, so, if e-services are served well to old people, it can be excellent served to all (Steele, 2016).

## Conclusion

As e-governments are replacing conventional governments and spreading their services online, more and more people increase their interactions and accomplishing transactions online, which creates the necessity to exert regulations and procedures for protecting privacy and provide a secure medium, but these procedures have a lateral consequences such as complications and difficulties in accomplishing interactions online especially for old people, this research focused on this case and concluded that as the age of online user is increasing as his sensitivity toward complication of applying more online protecting procedures is increasing, also the probability of canceling an online transaction due to these complications increases too.

Besides to that the study concluded that as older as the online user- especially over 40 years old- as the more the user asking for other persons help to overcome the difficulties of online protecting procedures, which may expose those people to deception. This research suggests that governments- if they want to keep older aged people engaged- give a priority to enhance the flexibility and easiness of online protecting measures for all user ages, and in the same time serves the targeted protection level. Also, this study suggests extending this research, or conducting a new research to observe the impacts of complications and difficulties that consequence from online privacy and security protecting procedures in lower and higher developed ICTs areas, by covering both rural areas and large cities in Hungary as an example of eastern European countries.

### *Limitation of the study*

The questionnaire was not distributed randomly, but it was distributed to have more over-40 years old respondents. Also, due to cost and time limitation, this study accepted to distribute the questionnaire in small cities in Hungary, not in rural areas but not also in the large cities, as moderate-developed regions in regards of ICTs development, leaving an extended survey that covers all Hungarian territory to a further future research.

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# THE ADOPTION OF CLOUD COMPUTING IN BUSINESS ORGANIZATIONS FOR AN IMMEDIATE TACTICAL ADVANTAGE OR MAKING IT PART OF THEIR LONG-TERM STRATEGIC I.T. PLAN

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**Abstract:** The Information Technology (IT) business ceaselessly endeavours to enhance regarding deploying products or offering services with the approach of new technology, and cloud computing is quickly moving in the promotion cycle because it will reshape the method of delivering services of data innovation. Decision-makers still have numerous worries that could drop the adoption of cloud computing. This paper will show a systematic literature review to investigate the present situation related to cloud computing adoption. This is done by analysing 25 studies published about cloud computing adoption. The results show that businesses face critical problems before they choose to adopt cloud computing.

**Keywords:** Cloud computing; Cloud adoption; Computing in developing countries; IT application; Technological innovation

## 1. Introduction

As per the market rivalry and a significantly changing business environment, firms have still provoked to embrace different best in information technologies (I.T.) to improve their business operations [1]; [2]. As of late, cloud computing concept is the lead of the information technology as its utilization is perceived as a significant area for I.T. innovation and development [3]; [4]; [5]. Cloud computing has set out through the principle territories identified with information systems (I.S.) and technologies, for instance, application, operating systems, technological solutions for firms and software, [3]. [6]characterized a style of computing where hugely versatile IT-related capacities are given as a service of external users customers by using web innovations. [7] Expressed cloud computing as a pool of exceptionally scalable abstracted infrastructure is fit for hosting end-user applications that are charged by utilization. [2] characterized I.T. capacities that are desired conducted, conveyed, and consumed in real-time over the Internet. Many computing models have vowed to convey a utility computing vision, and these incorporate cluster computing, grid computing, and, more as of late, cloud computing [3, 8]. Cloud computing application service like enterprise resource planning (ERP) where a user on the Internet can simultaneously communicate with numerous servers and trade data among themselves [9]. Besides, network technology and telecommunication have been advancing quickly; they contain 3G, FTTH, and WiMAX. Services which are provided by cloud computing provide the users the best technical support that can build up the gigantic possible interest [8]; [10]. In this manner, cloud computing gives the chance of versatility and adaptability to pull in the market on request.Companies are trying to coordinated with the processes of their business and their information systems in order to meet their needs with trading accomplices [5]. In high-tech enterprises, pervasive data transformation practices have gotten one of the essential viewpoints for improving operational effectiveness. developing cloud computing ability is very significant for developing the advantage of competition because the way of sell and buy that industries agreed with clients is not quickly changing; however, it is additionally turning into a progressively necessary piece of undertakings' business strategies [10]. Cloud computing diffusion turns into a vast research subject since it empowers firms to execute information exchanges along with value chain activities, for example (distribution, financemanufacturing, sales, customer service, data sharing and collaboration with trading accomplices [6]; [10]. Cloud computing will be adopted by organizations that are probably going to utilize a progressively hybrid procedure of on-premise, "public "cloud, and "private" cloud services when fitting [4]. The idea of private cloud computing includes organizations sending key empowering technologies, for instance, virtualization and multi-tenant applications, to make their private cloud database. At that point, individual businesses pay the I.T. department for utilizing industrialized or normalized services following concurred chargeback mechanisms. For some organizations, this methodology is less undermining than a general move to the Public Cloud. It should make it simpler to hand individual services over to trade partner providers in the future [5].

## 2. Research methods

Analysing the literature is a crucial method that produces a firm foundation for improving knowledge; it helps to uncover areas where research is required. This paper intends to systematically review the literature to describe the current situation regarding cloud computing adoption.

## 3. Cloud computing and its adoption

What is Cloud Computing as per U.S. NIST (National Institute of Standards and Technology) " Cloud computing is a model for allowing accessible, on-demand network access to a shared pool of configurable computing resources (e.g., servers, networks, storage, services, and applications) that can be quickly provisioned and delivered with minimum management effort or service provider cooperation [11]"

Adoption means the act or process of beginning to use something new or different [12]. Few studies in the past have referred to adoption as task technology fit assessment [13]. Adoption of Cloud has been discussed in various industries, including education, healthcare [14] FMCG and other business processes [15]. About Cloud Computing and for the aim of this research, the adoption of cloud computing is described as business implementing cloud computing in their organization for an immediate tactical advantage or making it part of their long-term strategic I.T. plan.

Considering how the adoption of cloud computing can revolutionize the business scenario in various technological innovations, its facilities and resources could be accessed on-demand [5]. Many previous studies in the field of cloud computing have addressed the areas of new technologies, security requirements, and future expectations in these emerging environments. From the financial point of view, [16] built two sorts of business models that can be utilized for cloud users of the companies who willing to choose cloud computing services. There are business models for firms with an actual I.T. business model and infrastructure for startup businesses. A present survey discovered that the contemporary charging pattern and different determinants of the cloud make it extremely fitting for small- and medium-sized firms [16]. However, the firm size was to influence the distinguished strategic value of cloud computing in innovative technological development. [10] has stated that firm applications typically would be in charge of their localized sets of processes, with the connection of applications to these processes.

Earlier studies have introduced a trade-off comparison that shows which technology can drive to bigger earnings. [16] examined to increase this outlook with a model that not only supports the agreement of a firm for cloud computing by simply following all the factors yet besides attempts to give a particular productivity cost of the advantages with cloud computing. [17] provides an overview of technological research studies that were performed in H.P. labs and that adopted cloud-scale smart environments, for example the smart data center and utility computing. [8] have additionally managed with market-oriented resource allocation of cloud computing by utilizing third-generation Aneka enterprise grid technology.

[18] formed a cloud-based infrastructure that had remained optimized for of the networks and maintained important data mining applications. In summary, we conclude that as mentioned earlier in cloud computing adoption research is twofold:

(1) Although various factors affect cloud computing adoption among prior researchers' findings, all these factors can be classified in technological, organizational, or environmental contexts. Therefore, it is useful to utilize the (TOE) framework to examine the cloud computing adoption matter.

(2) Most of the studies have examined the importance of the technological factors impacting Cloud computing adoption in any matter, the influences of environmental and organizational factors on cloud computing selection vary over various industry contexts. Therefore, it is needful to analyses the factors of cloud computing adoption in various industries to have a bigger perception of cloud computing adoption.

## 4. Related researches

The main objective of cloud computing is to utilize I.T. resources effectively by combining the distributed resources to gain higher throughput and be able to resolve large scale computation glitches.

Studies show that multiple firms are adopting cloud computing to gain I.T. operational and cost benefits compare to traditional I.T. systems. To reduce significant CAPEX expenditure, the total cost of ownership, and to raise the return on investment, businesses across the world appreciate the speed where the cloud can be deployed with least lead time and implementation duration. Rather than building its in-house ability and capacity to support and run in-house and on-premise I.T. infrastructure and systems, cloud-based applications and services, storage and processing can be provisioned from cloud service providers.

The need for computing facility and storage for Internet Service Providers were rising exponentially after the internet growth began in the early 90s. Technology giant Google developed its data centres to use cheap commodity hardware platforms to meet the growing demand for computing resources. Eventually, various software technologies have developed to achieve on-demand hardware elasticity, which has led three primary cloud computing style based on underlying hardware abstraction technologies, the Amazon-style based on server virtualization pioneered in infrastructure as a Service (IaaS) under the name Amazon Web Services released in 2006-2007 period. Google-style based on technique-specific sandbox provides Platform as a Service (PaaS) called Google App Engine released in 2008. Microsoft Azure works on windows Azure Hypervisor (WAH) as the fundamental cloud infrastructure and .NET application framework [19]. Software as a Service (SaaS) provides software applications to end-user, Salesforce is a leading provider of CRM software platform.

Back in 2011, organizations in the Middle East were not fully aware of the value of cloud and concern about security, data availability, and service level agreements [20]. Even though many organizations in the Middle East have exhibited their interest in cloud computing, the implementation rate is not at par with companies based out of the U.S. or European region. Most of the customers are suffering from cloud confusion as the technology stretches over a wide variety of capacities and not clear about the possibilities and the limitations of cloud computing in a well- organized way (Forrester Research, Inc.).

Most of the commercial data centres and telecom companies in the Middle East provide colocation and managed services. Service providers do advertise the availability of disaster recovery (D.R.) as a service and other infrastructure as a service (IaaS), but on closer inspection, they are not "cloud" services. Specifically, they are not multi-tenant and do not have elasticity and agility automatically built into them. Consequently, any public cloud infrastructure services would primarily be hosted outside the region (except for a few that have their global security operations centre in the region).

As per the recent IDC Energy Insights Survey 2014, 30 percent of oil and gas companies have already implemented a private cloud solution, and 15 percent are currently using public cloud services.

[21] Having a robust ecosystem for cloud computing is not enough for the company to incorporate cloud computing in its strategic roadmap and notwithstanding having a robust ecosystem for cloud computing, there are limits and difficulties in cloud computing which an organization has to defeat before it determines to adopt cloud computing, despite there is a robust ecosystem for cloud computing possible in the UAE, the matters around Legal associations, data security, and derived benefits are affecting an organization's decision on its decision of cloud computing adoption and the sort of model to adopt if it chooses to go for cloud computing.

Cloud computing emphasis its benefits for management sustainability but its impact which can be in the future for this sustainability management idea can be significant.

[22] Introduced the characteristics of business models to produce enough knowledge on the sustainability management idea. Several aspects developed for many business model design methods but their estimation proved related components behind the distinct viewpoints

[23] Cloud computing is discovered easy to learn and take minor time in accomplishing tasks of employees. It classified that the complexity of cloud computing has a negative impact on organizational expectations that lesser the complexity in utilizing cloud computing, more is the improvement in their job performance and the comfort of using it. Furthermore, the security and trust variable was determined to be an essential dimension for cloud computing adoption. Unluckily, this dimension is not well examined by Egyptian law in a form that ensures secured information on the cloud. The copywrites are not absolutely examined in the Egyptian context to be capable to adopt in a secure way to cloud services. Therefore, this is a second function of the government that has to be ideally done by adding and activating rules that limit copywrite and secure

information with the required system to support users of IT services to adopt to cloud computing.

There are many articles and research papers written on the adoption of cloud computing at a global level. There is not enough comprehensive research conducted on analysing the cloud-based ecosystem providers in Syria and its relation to the adoption of various cloud services.

Organizations in Syria are more attracted to adopt cloud computing services to reduce capital and operational expenses over traditional I.T. systems. The reliable, secure, and fast internet data services offered ISPs ensure the cloud is a practical solution for organizations of all sizes.

In today's Information Technology world, service, or product delivery based on cloud computing has become popular. Most of Tier 1 and Tier 2 players in the I.T. industry have their offerings with cloud features or functionalities. These service providers have invested in creating a cloud computing ecosystem, in terms of sales, service (deployment) and support, to enable higher penetration of cloud computing in end-user organizations, that is what some of the developed and developing countries are migrated to the cloud below are some examples:

***Cloud Computing in Australia***

[24] Australian government's perception is to engage cloud computing in order to match as much as of the government's needs in a cost-effective, secure, flexible, and reliable way. Much study has been done in order to distinctly highlight the advantages and implied risks of cloud adoption nationwide. Government businesses are prompted to make more numerous usage of cloud computing so as to save expenses while conducting more capacity and ability. Additionally, cloud computing has been adopted to improve the government's operation capability by advancing the countries IT effectiveness.

***Cloud Computing in China***

The government of China is very supportive of cloud computing. The government has introduced a cloud development strategy to launch a national cloud called the China Cloud. Hence, China attempts to finance developing many clouds that are regularly directed on advancing IaaS and PaaS. In 2012, China has begun about 100 cloud-related projects which involve building national data centers [25]Currently, cloud computing is being utilized by the telecommunication businesses to manage a huge number of data and even by the government in order to address online services. Nevertheless, the adoption of cloud computing in national private businesses is staggering behind due to concerns about data security and privacy [26].

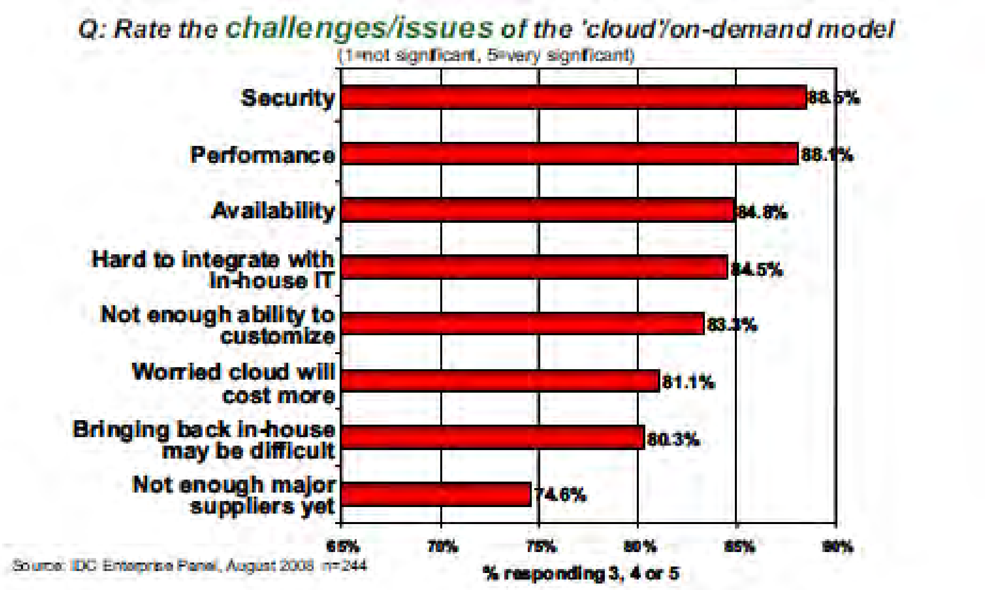


*Figure 1.* Challenges rate of the cloud on demand model [28]

***Cloud Computing in Japan***

In 2009, the Digital Japan Creation Project was begun to create new ICT markets to increase the Japanese economy. The principal focus of this plan is to progress a national cloud called Kasumigaseki Cloud by 2015. The main objective of this cloud is to build a high level of collaboration and to combine hardware and infrastructure between various ministries in order to produce platforms for shared purposes [27].

## 5. Results of cloud adoption process

As Cloud Computing is still in its beginning, current adoption is associated with numerous challenges. Based on a survey proceed by IDC in 2008, the significant challenges that prevent Cloud Computing from being adopted are recognized by organizations, as shown in Figure 1.

### *Security*

The security issue has played the most crucial role in hindering Cloud computing. Putting your data, running your software at another person's hard disk using another person's CPU seems frightening to many. Notable security issues like data loss, phishing, and cause critical threats to the organization's data and software. Besides, the pooled computing resources and multi-tenancy model in cloud computing has presented new security challenges [29] that need novel strategies to handle with. For instance, the cloud frequently gives progressively reliable infrastructure services so hackers are wanting to utilize it because it is generally lower cost for them to start an attack [29].

Two new security problems are related to the multi-tenancy model. First, shared resources (hard disk, data, V.M.) on the same physical machine invites unexpected side channels between a malicious resource and a natural resource. Second, the issue of "reputation fate-sharing" will seriously damage the reputation of many right Cloud "citizens" who unluckily share the computing resources with their individual tenant - a notorious user with a criminal mind. Since they might have sharing the same network address, any lousy conduct will be referred to all the users without differentiating real subverters from regular users.

### *Costing Model*

Cloud users need to acknowledge the trade-offs amongst communication, computation, and integration. Since moving to the cloud can particularly reduce the cost of the infrastructure, it does raise the cost of data communication, i.e., the expense of transferring an association's data to and from the public and community Cloud [30]and the expense per unit (e.g., a V.M.) of computing resource used is likely to be higher. This problem is particularly prominent if the customers use the hybrid cloud deployment model where the association's data is distributed amongst several public/private (in-house I.T. infrastructure) /community clouds. The argument made by Gray [31] that "Put the computation near the data" still applies in cloud computing Intuitively, on-demand computing makes sense only for CPU intensive jobs.

Transactional applications such as ERP/CRM may not be suitable for cloud computing from a purely economic perspective if cost-savings do not offset the extra data transfer cost. In addition, the cost of data integration can be substantial as different clouds often use proprietary protocols and interfaces.

This needs the cloud consumer to react with different clouds using cloud provider-specific APIs and to develop ad-hoc adaptors so as to spread and integrate heterogeneous resources and data assets to and from different clouds (even within a single organization).

### *Charging Model*

A started up virtual machine has become the unit of expanse analysis as opposed to the implicit physical server. A sound charging model needs to corporate all the above as well as V.M. linked items for example virtual network usage, software licenses, node and hypervisor management overhead, and so on.

For SaaS cloud providers, the expense of creating multitenancy inside their offering can be very significant. These include re-design and re-development of the software that was initially used for single-tenancy, cost of providing new features that permit for quick customization, performance and security upgrade for simultaneous user access, and dealing with complexities incited by the above changes.

Consequently, SaaS providers need to weigh up the exchange-off between the arrangement of multi-tenancy and the cost-savings yielded by multi-tenancy for example decreased overhead through amortization, decreased number of on-site software licenses, etc.

Thus, an applicable and strategic charging model for SaaS providers is critical for SaaS cloud providers' profitability and sustainability.

### *Service Level Agreement*

Despite the fact cloud customers do not have observation over the implicit computing resources, they must make sure the availability, quality, reliability, and performance of these resources when consumers have moved their core business functions onto their contingent cloud. Meaning that, customers need to gain guarantees from providers on service delivery. Typically, these are offered through Service Level Agreements (SLAs) treated between the providers and consumers. The absolute first problem is the definition of SLA particulars so that has an suitable level of granularity, namely the trade-offs between expressiveness and complicatedness, so that they can cover up most of the customer expectations and is generally easy to be weighted, confirmed, assessed, and authorized by the resource allocation mechanism on the cloud.

Besides, different cloud offerings (IaaS, PaaS, SaaS, and DaaS) will need to define different SLA meta-specifications.

This also raises several implementation problems for cloud providers. For example, resource managers need to possess precise and updated information on resource usage at any particular time within the cloud. By updating information, we mean any changes in the cloud environment would fire an event subscribed to by the resource manager to make real-time evaluation and adjustment for SLA fulfillment. Resource managers need to utilize fast and effective decision models and optimization algorithms to do this. It may need to reject specific resource requests when SLAs cannot be met. All these should be done in a nearly automatic fashion due to the promise of "self-service" in cloud computing. Besides, advanced SLA mechanisms need to persistently corporate customization features and user feedback into the SLA evaluation framework.

### *What to migrate*

The result based on a questionnaire that progressed by IDC in 2008 reveals that organizations still have security/privacy concerns in moving their data on to the cloud. Currently, peripheral functions such as I.T. management and personal applications are the easiest I.T. systems to move. Organizations are conservative in employing IaaS compared to SaaS. This is partially as a result of marginal functions are typically outsourced to the cloud, and core activities are kept in-house. The survey also presents that in three years, 31.5% of the organization can move their Storage capability to the cloud. However, range continues to be comparatively low compared to cooperative Applications (46.3%).

## Conclusion

This research attempted to manage a systematic review of the present literature on cloud computing adoption by businesses. This entailed distinguishing the present participation of information systems research concerning the Phenom and defining the under investigated problems and the participation of information systems research regarding the Phenom. However, there is still a gap in the available research papers that focus on the relationship between the adoption of cloud computing and how various factors like security concerns, perceived benefits, legal regulation, and functionalities impact the decision making.

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# VALUE-CREATING PROCESSES OF CIRCULAR BUSINESS MODELS IN THE DEVELOPMENT OF IT SYSTEMS

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**Abstract:** The profitability of "mainstream" economic systems lies in outsourced external factors, which make it cheaper to waste resources than to track and eventually recover them. However, non-circular economic models, that is, without feedback, carry many risks. These include deficiencies in primary resources, including resource price volatility, declining supply chain efficiency, increasing bans on waste trading, declining costs of renewable energy sources, etc., and these unfavorable patterns can also be termed "linear risks". Through the analysis of open and closed business models and the presentation of the value-creating processes of the ReSolve matrix, we want to demonstrate how modern IT systems and digital solutions can increase the efficient use of resources and reduce production risks.

**Keywords:** business model; circular economy; value-creation; IT application; linear risk; circular value chain

## 1. Introduction

The use of new IT tools has opened up new channels on the front of working with partners and reaching customers. According to Amit and Zott (2012), the importance of business transformation has received increased attention due to the development of information technology (IT). Chesbrough (2010) clearly states that an excellent business model around an ordinary product offers much better opportunities than a great product used in a medium business model. What and Massa (2011) confirm this statement is that products should always be complemented by appropriate business models. Although this area of research has received special attention in recent years, the basic concept still lacks comprehensive elaboration. The most accurate description so far comes from Teece (2010), who sees the concept of business models in bringing the mechanisms of value creation, value transfer, and value preservation to a common nomination. In his view, the business needs to clearly identify the needs of customers and find ways to respond to them. Customers' investments turn into profits if certain elements of the value chain are tuned accordingly, ie these processes come together in the value chain (form a value chain). The growing role of business planning is explained by Schaltegger et al. (2012) on corporate sustainability, identifying business model innovation as one of the key elements of corporate sustainability. In recent years, several authors (Gauthier and Gilomen, 2016; Breitbarth et al., 2018) have reported on the practical experiences of successful businesses, in which entrepreneurs create outstanding social and environmental values while also generating significant financial revenues. Armas-Cruz, Gil-Soto, and Oreja-Rodríguez (2017) focused their studies on the potential for green business proliferation and concluded that the low profitability of such initiatives does not motivate corporate decision makers to move away from conventional business models. The same idea is supported by Fogarassy et al. (2017), who argue that traditional firms respond only to emerging market demands. Therefore, the transformation of mainstream economic thinking should offer higher financial value than in previous systems (Schaltegger et al., 2012). Otherwise, sustainability businesses will remain just case studies, rather than becoming trends. The position is in line with Ramkumar et al. (2018) who see environmental solutions as market expectations rather than complementary functions. The authors argue that the current benefits of BAU (Business As Usual) processes will soon pose a threat to companies in many ways. These include deficiencies in primary resources, including resource price volatility, declining supply chain efficiency, increasing bans on waste trading, declining costs of renewables, etc., and these unfavorable patterns can also be termed "linear risks". Recent studies (Brooks et al., 2018; Horvath et al., 2018) support the above when they argue that the profitability of "mainstream" economic systems lies in outsourced external factors, i.e., it is cheaper to waste resources than to monitor and eventually regain them. However, this situation seems to be changing soon as dominant global players (e.g. China, Kenya, Bangladesh) have exited the waste markets. It can therefore be assumed that the transition from a "take-make-waste" approach, the creation of closed resource loops, will be a basic requirement for companies and economic actors in general. This is one of the reasons why the European Commission (2015) has announced its "Closing the Loops" Action Plan, which is already in the introduction, urging the transition to a circular economy. The Circular Economy Action Plan, or 'CE' for short, rejects the traditional characteristics of economic growth (e.g. mass production, use of non-renewable resources, production of preserved goods, etc.) but offers innovative solutions to preserve natural capital and enhance social well-being. Achieving the best possible circular flow of materials and energy through economic processes and avoiding resource leaks is a top priority (Ellen MacArthur Foundation, 2015). Contrary to previous sustainability efforts, these circular initiatives are receiving increased attention from the business sector.

According to a recent study by the World Business Council for Sustainable Development (WBCSD), 80% of companies surveyed say that accelerating growth and increasing competitiveness depend on the use of circular strategies. The remaining 20% identified risk reduction as the main motivation for developing business models (WBCSD, 2017). These results suggest that the application of circular strategies has reached the realm of business model research. In interpreting the concept of circular business models, Scott (2013) argues that circular initiatives should use recyclable biological materials or use their technical raw materials continuously. Both activities are expected to be harmless to ecosystems and can be operated without waste. According to Mentink (2014), circular businesses need to create value and capture material flows in a closed material cycle. However, he points out that a business model alone cannot be a circular system. Loop closure can be achieved more through a network of businesses. Bocken et al (2017) classify circular businesses based on their environmental strategies. It was found that companies can influence resource loops in three different ways. The first option is to slow down the flow of resources by expanding product use. This option requires the design of durable goods. Another method is to close the loops through recycled materials. The last solution is to narrow the loops, which means reducing resource use, increasing material and energy efficiency. Lewandowski (2016) considers enterprises to be sustainable in a circular way if their model includes basic 'CE' properties (e.g., resource optimization, loop closure, etc.). In summary, circular strategies and business models are evolving together in current business practices. According to Kraaijenhagen et al. (2016), their mutual application is inevitable for two reasons. On the one hand, a country-wide circular transformation cannot be carried out without bottom-up initiatives, and on the other hand, business models can only work effectively today if they incorporate circular and constantly evolving system features. Manninen et al. (2017) also share this view, but add that scientific research shows a growing interest in developing a circular business model, which is of paramount importance because if the business models to be introduced are preceded by thorough scientific research, their introduction , their application stands on safer foot. Previous studies do not examine the business-level changes of circular progress, ie what circular elements and solutions the currently used business models use, and what phase of the linear-circular transformation they are in. Therefore, the main goal of our studies was to evaluate current business models in terms of their fit to circular solutions. Some studies (Bocken et al., 2015; EMF, 2015; Aminoff et al., 2017; Fogarassy, 2017) hypothesize that linear-circular transformations start most in the knowledge-intensive and innovative industries, and therefore as a research area. we can mark outstandingly active changes in biotechnology. The sector is expected to be the most important area of the economic era following the financial crisis, in 2015 the second highest amount of global investment was invested in this sector (Ernst & Young, 2017). By examining the new generation of biotechnology business models, we want to answer at what stage the application of circular strategies is at the business level. In addition to recognizing the circular elements of biotechnology enterprises, research results can contribute to the evaluation of models used in practice to determine how the process of linear-circular transition can be accelerated for knowledge-intensive enterprises that prefer digitalization.

## 2. Examining some features of business models

Exploring the business models used in digital technology and exploring their operational background is mostly possible through the analysis and review of Belgian biotechnology companies (Doranova, 2016). Belgium has small biotechnology companies with a market capitalization of € 286 million (2016), the second highest value in Europe. Seven of Europe's top ten biotech companies are in the country, and the world's 10 most influential pharmaceutical companies are doing some research in Belgium. This excellent biotechnology ecosystem has a strong scientific background and an efficient, innovative SME community. In addition, national regulations and financial incentives provide strong support to sector actors. Belgian law allows companies to shorten and complete Phase I biotechnology trials, clinical trials within 15 days, resulting in the highest position in Europe in terms of the number of clinical trials (Essenscia, 2017). In his work published in recent years, Segers (2017) identified 22 different business models in the field of biotechnology. According to his observations, companies use a combination of certain models. He recognized that joining collaborative networks was a trigger for the evolutionary breakthrough of biotechnology businesses. Therefore, during the evaluation and classification, the main grouping aspect was the innovation sharing practice of the companies, on the basis of which closed and open business models can be distinguished. In the case of closed models, the company relies significantly on internal resources, but mostly on the efficient use of its own knowledge, licenses and know-how, which basically also means the usual form of business models. However, current trends show that large companies are outsourcing certain activities to smaller companies to better focus on their core business. This phenomenon leads to the sharing of innovation and the development of open business models. In the case of open business models, the presence of affiliated small businesses that contribute to the creation of a real, viable or sustainable business ecosystem is prominent (Sagers, 2017). The methodological background for the evaluation of sustainable business models was developed in 2013 by the staff of the Ellen MacArthur Foundation (2013), which examines the system properties of business models based on circular evaluation criteria. This method was given the name 'ReSolve', which Lewandowski further specified and developed in 2016.

*Table 1*: The ReSOLVE framework

| Activity | Descriptions |
|---|---|
| Regenerate | use of renewable materials and energies |
| | preserving and restoring the healthy functioning of ecosystems |
| | the return of recovered biological resources to the biosphere |
| Share | increase the usefulness of products by sharing use, access, or ownership |
| | prolonging the life of products by reusing, maintaining (eg repairing, renovating) or designing durable products |
| Optimize | optimizing the use of resources by increasing performance or outsourcing certain activities |
| | waste avoidance in production and supply chains |
| Loop | closure of material flows by remanufacturing, re-use, recycling or recovery |
| Virtualize | dematerialization of products or services by digital systems |
| Exchange | use of new technologies, materials or processes |

Source: based on Lewandowski, 2016

Table 1 provides a detailed description of the defining components of Ellen MacArthur's framework. It can be seen from the table that the acronym ReSOLVE consists of the initials of the English names of the activities supported by the circular economy.

## 3. Open and closed business models in practice

Based on the circular criteria introduced, Table 2 provides an overview of the first generation of pharmaceutical companies (closed models) and highlights key patterns that meet the requirements for circular operation.

*Table 2*: Closed business models of the Belgian pharmaceutical biotechnology industry

| Business model | Features |
|---|---|
| **Product based** | • Vertical integration;<br>• full control over the value chain;<br>• high capital requirements;<br>• large enterprise model. |
| **Platform based** | • Carries out early-stage research;<br>• develops research tools and platform technologies and then sells their licenses to other companies;<br>• less risk;<br>• low capital requirements. |
| **Hybrid version** | • A mix of Product and Platform Based Models;<br>• offers services and deals with the later stage of product development;<br>• there is the possibility of short-term revenues. |
| **Based on royalties** | • It is popular with those with few financial resources;<br>• conducts early-stage research;<br>• sells royalties on its results<br>• to large companies who complete research work and bring the product to market. |
| **No research - only development** | • It buys "discarded" products from large corporations;<br>• complete the research period;<br>• brings the product to market. |
| **Based on licensing** | • It operates in the initial stages of the value chain;<br>• issues but does not sell licenses for its results to other companies. |
| **Based on research service** | • It offers a research service;<br>• specifically fills market gaps in the value chain;<br>• it can move in two directions: pre-clinical and clinical trials; biological and chemical products and medicines. |
| **Initial public distribution** | • Non-income start-ups;<br>• they are evaluated on the basis of their research and publicly announced results;<br>• in the absence of revenue, the exit strategy is not available. |

(Source: based on Horvath- Khazami – Ymeri - Fogarassy, 2019)

The first three models show the traditional forms of biotechnology enterprises (Table 2). A common feature of the other models is that they are suitable for starting businesses with a capital shortage. They operate at an early stage in the value chain and try to grow further by selling their intellectual property or special services. Their only circular feature is the service provided to large corporations, which is one of the principles of sharing or sharing. A sympathetic exception is the "*No Research - Only Development*" model, which deliberately positions itself at the end of the value chain. This business solution offers a biotechnology module for one of the top priorities of the circular economy: 'to extend life with reuse'. If a large company "throws out" a product at a later stage of development, we can lose all the energy and materials previously invested. This model is able to save these products and the energy invested in them by buying expired drugs and performing the innovation associated with them. The model prevents the generation of unnecessary material and energy flows that would be required for research and development of new active ingredients. In the case of the business model in question, we can see that its profile not only contains circular elements, but is built specifically on it. The emergence of open business models shows that knowledge sharing has become a key factor - even in an industry where intellectual property protection plays a prominent role (Table 3). Businesses can become each other's service partners if their roles will be changing.

*Table 3*: General open business models of the Belgian pharmaceutical biotechnology industry

| Business model | Features |
|---|---|
| **R & D based on open innovation** | • Companies outsource R&D to operate more efficiently in their own profile. |
| **Networking** | • The open form of the traditional, vertically integrated model;<br>• partnerships of varying intensity and form tailored to current needs;<br>• more efficient resource management using the assets of other companies. |
| **EFQM[1] excellence** | • Self-assessment according to the following criteria of the European Foundation for Quality Assurance: implementation of key activities, achieved results. |
| **Fully diversified** | • Large enterprise model;<br>• expanding the company profile to produce related products;<br>• tools used: licensing, collaboration, corporate merger, acquisition. |
| **Based on intellectual property** | • It is based on property rights and patents;<br>• the protection of intellectual property is key;<br>• sells or leases all items in your portfolio. |
| **Re-utilization and technology intermediary** | • Reuser: Utilizes molecules under development or existing for other purposes than their intended use (e.g., use of old drugs to treat new diseases);<br>• patent management is key.<br>• Technology Intermediaries: The discovery of a molecule in a company's portfolio and then its transmission to another company. |
| **Shared partnership** | • Discovering products that look promising;<br>• purchasing the product at an early stage of product development and finding its applicability interface;<br>• selling the product to other pharmaceutical companies; which complete product development. |
| **Result-driven** | • It is based on the principle of performance-based pay;<br>• uses various methods to evaluate performance;<br>• it has a great influence on pricing when patenting accepted drugs. |

Source: based on Horvath- Khazami – Ymeri - Fogarassy, 2019

The common features of open models can be summarized based on three aspects. First and foremost, sharing innovation (e.g. between a large company and an SME) and the presence of collaboration are essential in open innovation. Second, the use of informatics becomes paramount due to the rapid and efficient exchange of information. Eventually, the rapid flow of information has led to higher customer awareness, which also results in the emergence of a need for personalization. These new considerations indicate that the digital revolution is also strongly influencing pharmaceutical biotechnology. The above assessment therefore distinguishes between standard open business models and those whose operation is highly dependent on the use and management of data.

## 4. Discussion and conclusions

As a result of digitalization, the paradigm shift that has taken place in the biotechnology industry with open business models. This has allowed companies to focus broadly on their core competencies by outsourcing some of their R&D activities. The use of external resources by large companies has allowed small businesses and start-ups to enter the biotech market by targeting certain gaps in the value chain. Today, the presence of these biotech SMEs is extremely important not only in practice but also in terms of innovation for the whole sector and even for the economy as a whole. The digitalisation of technological development processes of biological systems have contributed to the creation of business ecosystems where innovation is carried out through a collaborative, platform based network of companies of different sizes and disciplines. This mechanism reduces operating costs and value chain dependency. Based on the analysis, it can be concluded that models of digital based circular business solutions in biotechnology have contributed to the creation of a real values of business ecosystem. This mechanism reduces operating costs and dependence on value chains. In addition, it opens up new revenue channels by connecting its players to the local market. The proliferation of open business models shows that knowledge sharing is becoming a key factor even in industries where intellectual property protection plays a prominent role.

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Faculty of Mechanical Engineering

# EFFECT OF SELF-CLEANING COATINGS ON SOLAR MODULE REFLECTANCE AND POWER

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**Abstract:** The pollution caused power loss of solar modules can be reduced by using self-cleaning coatings. When applying these coatings, the basic question is how the coating itself effects on the power of the solar module. The recent paper deal with this. It examines power, reflection capability and power changes due to contamination and self-cleaning of 5 different coated solar modules and compares them with the measured values of an uncoated solar module. Based on the results of laboratory measurements, it can be stated that the effects of photocatalytic thin layer and lotus effect based coatings increase the power of the solar modules by average 2%. The effects of the same contamination reduced the power of all modules, but the power of the coated modules is higher. After spraying with rainwater, the examined coated solar modules operated at nearly 4% more power than the reference, uncoated solar module.

**Keywords:** photovoltaic, photocatalytic thin layer, lotus effect, reflection, contamination, power

## 1. Introduction

The use of solar modules is an increasingly important electricity generation option. It can be found in all segments of our lives, including agriculture. The power of a PV module is influenced by numerous factors. The most basic ones are the types of PV module, the orientation, the angle of inclination, geographical and meteorological conditions of the location. Among the meteorological factors, apart from the fundamental role of radiation, the temperature (Skoplaki and Palyvos, 2009; Snaith et al., 2006) and the humidity of the air (Hosseini et al., 2019), but the wind speed (Chandra et al., 2018) also has influence. It is also important to consider the role of shadings (Ishaque, 2011) in the installation. The reflectance and the pollution of the solar modules are also significantly influence the performance of PV systems. The reflectance is reduced by anti-reflective coatings (Prevo et al., 2007; Kumar et al., 2011; Luo et al., 2018), in nowadays the usage of organic possibilities spread (Forberic et al., 2008). The contamination caused power loss and efficiency decrease is quite high, up to 40% (Mani and Pillai, 2010; Adinoyi and Said, 2013). To keep the modules clean is important to achieve the maximum power of the system.

The PV technology is not yet fully matured technology, the latest results of modern physics, materials sciences and nanotechnology generated the continuous development of this area. The application of nanotechnology coatings in various fields is more and more popular (Faustiny et al., 2010; Ganesh et al., 2018). For self-cleaning effect, the photocatalytic thin layers and coatings with lotus effect are the most important at solar modules (Parkin and Palgrave, 2005; Oelhafen and Schüler, 2005; Piliougine et al., 2013; Arabatzis et al., 2018) but CPV modules (Jesus et al., 2018) also has to be taken into the account.

Photocatalytic thin layers absorb photons and create a number of chemical reactions. Chemical redox reactions and reduction of organic materials are catalysed by electron-hole pairs generated in the layer by photons. The anatase crystalline phase of $TiO_2$ is the primary material used for catalytic applications. Photocatalytic thin layers are used for the decomposition of organic contaminants and energy applications include dye-sensitized solar cells and artificial photosynthesis (Hwang et al., 2008; Snaith, 2013; Malinkiewitz et al., 2014; Jeon et al., 2014). The base of the lotus effect is the hydrophobicity, which helps self-cleaning process (Koch and Barthlott, 2009). Dirt particles are picked up by water droplets due to the micro- and nanoscopic architecture on the surface, which minimizes the droplet's adhesion to that surface. In this study the effects of several Hungarian-developed layers on the solar module reflectance and power are studied and compared. The powers of the modules are compared in clean, contaminated and after self-cleaning states.

## 2. Module and coatings

A 4 W power polycrystalline solar module with 156x156 mm$^2$ area without cover, as uncoated and 5 modules of the same type, 1 with photocatalytic thin layer and 4 with lotus effect coated were compared. In some measurements the uncoated module covered with rainwater and with glass layer also were examined. The coatings were applied on the surface of solar modules by the developer companies. The main features of the studied thin layers are as follows:

- The **Nanopro** is a photocatalytic self-cleaning coating, developed by NanoPro Ltd for solar modules. The main materials of the coating are 0.5% $TiO_2$, 0.5% $WO_3$ and 2% $SiO_2$. The coating was prepared by spraying.
- The **Nanobase**, is a lotus effect nanotechnology coating, which was developed by Nanobase Ltd., this hydrophobic layer has been rolled onto the solar module surface.
- **Hardbody**, **Bodyguard** and **Misteryjuice** are the fantasy names of coatings which are the self-developed coatings for self-cleaning of different surfaces of cars, made by Wolf Chemistry Ltd., working base is the lotus effect. The $SiO_2$ based nano ceramic coatings are super hydrophobic. The dry matter content and the distribution of the solid and liquid components are the differences between the 3 coatings. The coatings were applied to the solar modules by rubbing with sponge.

Images taken from the surface of uncoated (natural) and the exposed coatings by microscope (BIM135M-LED microscope 3,0 MPMicroQ microscope camera, 100x magnification) are shown in Fig. 1.

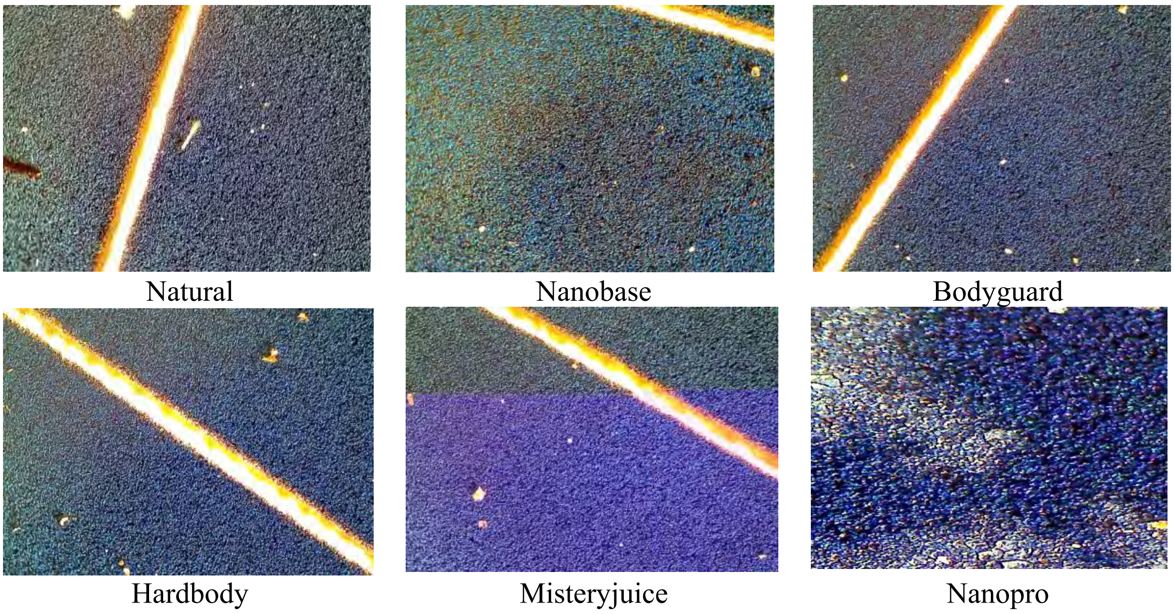



*Fig. 1.* Images of uncoated and coated solar panels made by microscope

During the measurements the properties of the natural module, the solar modules with the presented coatings and some cases the properties of a natural solar module covered with water and with a 2 mm thick normal glass were compared.

## 3. Measurements and results

### 3.1. Maximum power

For the comparability of power, the same boundary conditions were applied in each case. The relatively small solar modules were under the same uniform artificial illumination. The continuous spectrum light of a normal, 40 W bulb reached the different solar modules from the same, 22 cm distance at the same position, perpendicularly to the center of the modules. For to determination the power, values of voltage and current are required at different load resistors. For the current measurement the internal resistance of the ammeter was too large due to the small inner resistance of the solar modules. The problem was solved by inserting a shunt. A small, but finely variable resistor was a metal wire. During the data gathering a NI USB 6009 AD converter unit was used and a computer with LabVIEW program collected the data. The schematic diagram and photograph of the measuring system are shown in Fig. 2. and Fig. 3.

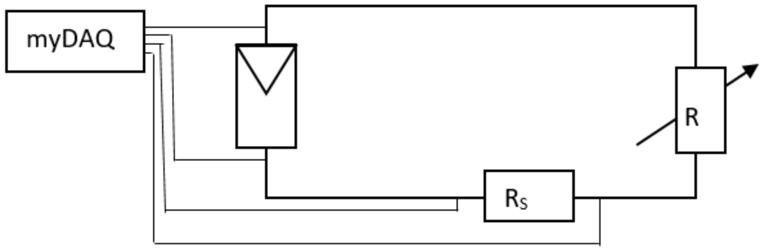



*Fig. 2.* Sketch of the power measurement

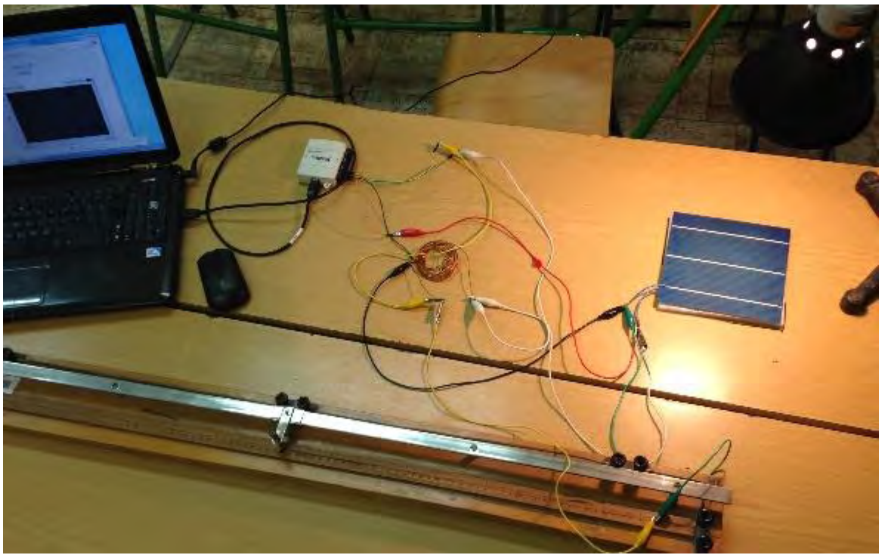


*Fig. 3.* Photo about the measurement system

For each solar module, 3-3 I-V characteristics were recorded. The maximum powers were determined based on these characteristics. The maximum power determined by the measurement data, taking into account the law of error propagation, contains less than 5% error. As a sample, the uncoated (natural), the water and glass layer covered natural solar modules I-V and P-V characteristics are shown in the Fig 4. and Fig. 5.

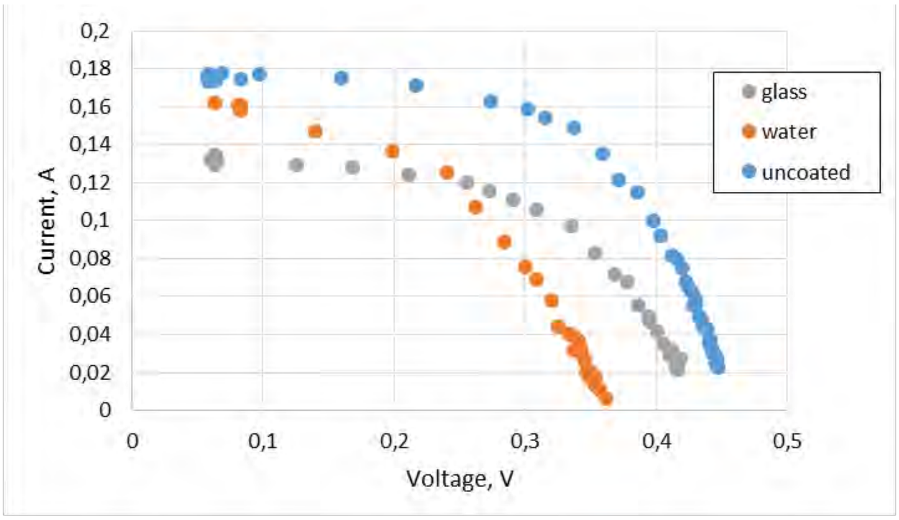



*Fig. 4.* I-V characteristics

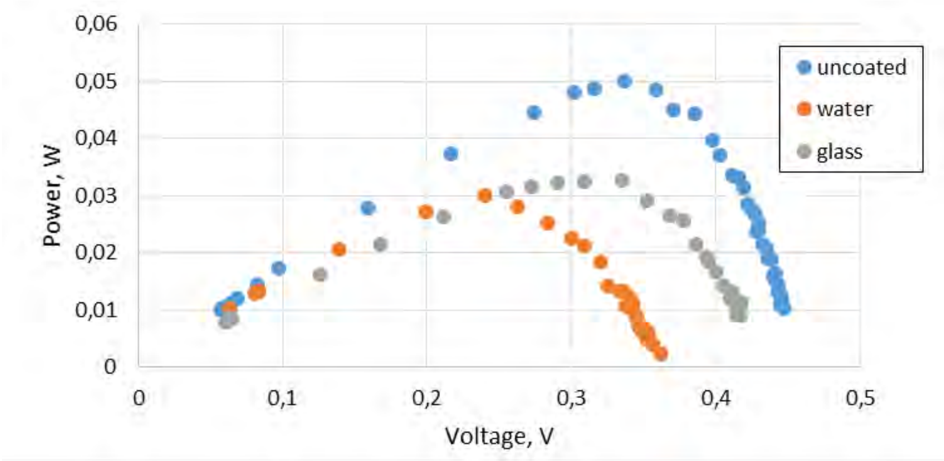



*Fig. 5.* P-V characteristics

Based on the results, it can be stated that both the water and the glass layer reduced the power. The maximum power of PV modules coated with various self-cleaning nanotechnology coatings were determined by the above described measurements. In case of the uncoated solar module, at the applied illumination the maximum power was 0.05 W. Compared to this the maximum power of the coated modules (based on the average of 3 readings, too) can be seen in Fig.6.

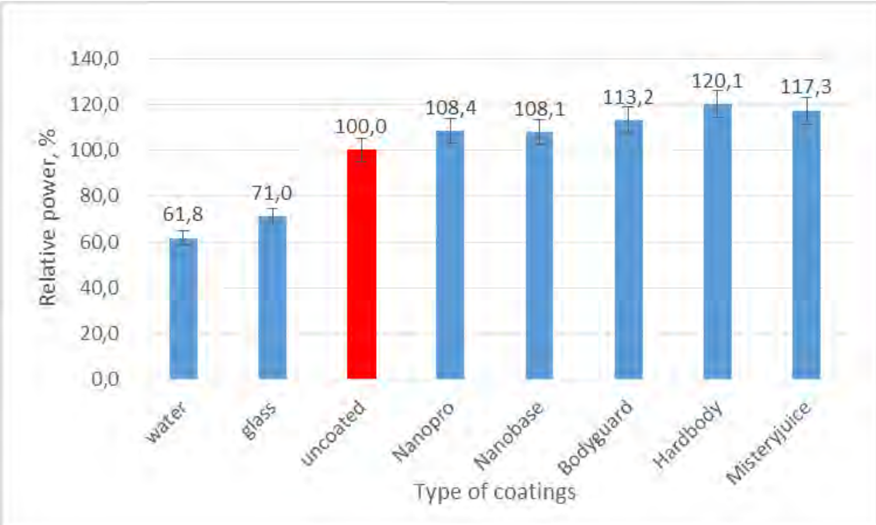



*Fig.6.* Relative effect of the coatings

The diagram shows that the nanotechnology coatings slightly increased the maximum power of the solar modules. The examined modules are not enclosed, so the coatings are directly on the solar module surfaces. The surface of the solar module is rough. The different coatings are constructed from different binders and are otherwise related to the surface which results the difference between the light entering the surface of the solar module and thus resulted the difference in the powers.

### 3.2. Optical effects

The difference in the energy utilization of the solar modules is caused by coatings which modified the optical properties of the modules. The optical effects how the solar radiation passing through a layer are summarized in Fig. 7.

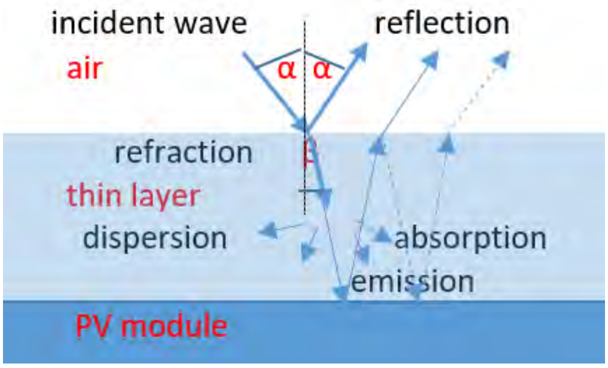



*Fig. 7.* Optical effects

The appearance of thin layers on the module surfaces may change over the light transmission and the reflections and these changing resulted in the change of the power. Reflection and transmission of the light beam through the boundaries of two mediums is determined by the Fresnel equations (Hecht, 2002), which can be used to determine the amplitudes of reflection and transmission on the several frequencies, based on the refractive indexes and the incidence angle, considering the interferences of multiple reflection too. If the layer is already on the solar module, than the reflection may be well-researched from the optical properties. The reflection is direction and wavelength dependent quantity. During the illumination a standard bulb with 100 W electric power was used. The module's reflected light spectrum was determined by the Ocean Optics spectrometer. Based on the signal coming into the spectrometer via the optical cable, the spectrometer gives intensity every 0.36 nm between 340 and 1026 nm, which can be measured and recorded using the Overture program which run on the connected computer. The experimental layout is shown in Fig. 8.

*Fig. 8.* Experimental layout for measuring the reflected spectrum

The measurements were performed under the same boundary conditions (same continuous spectrum light source; location and direction of the illumination, solar modules and sensor of the spectrometer). Examples of spectra made in the different reflection directions are shown in Fig. 9. and Fig. 11. The Fig. 10. and 12. show the intensity differences of natural and coated solar modules reflected lights as a function of wavelength at 41° and 52° incidence angles. Based on the experimental data, it can be stated that at the wavelengths below 550 nm each coating reflectance is lower than that measured on the uncoated solar module. In areas with more than 550 nm wavelength, Nanobase and Nanopro coatings reflect better than the uncoated solar modules. The characteristic of the curves is the same, the major difference is found only at the Nanopro coating, which can be explained by the fact that this coating is working with another principle. The direction sensibility of spectrum intensity is very high.

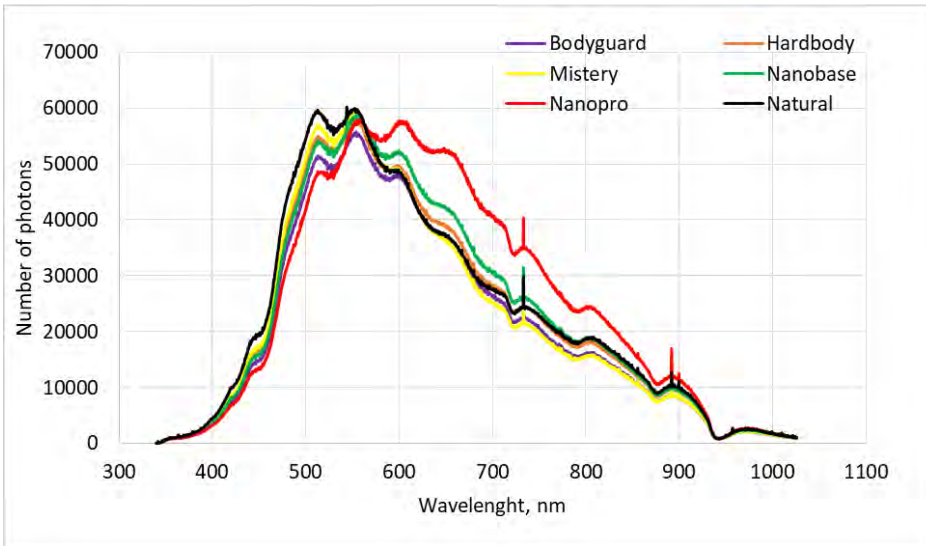



*Fig. 9.* Solar modules reflected spectra, at 41° incidence angle

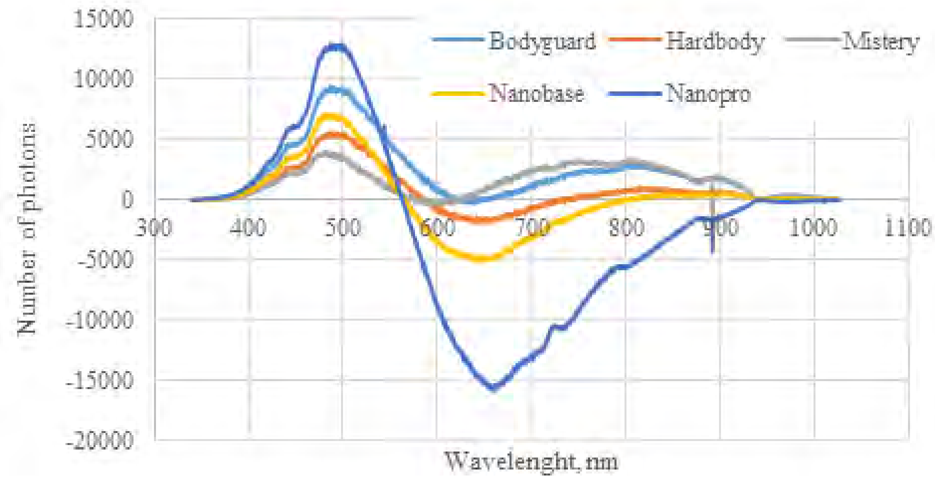



*Fig. 10.* Intensity difference between the coated and natural spectrums, at 41° incidence angle

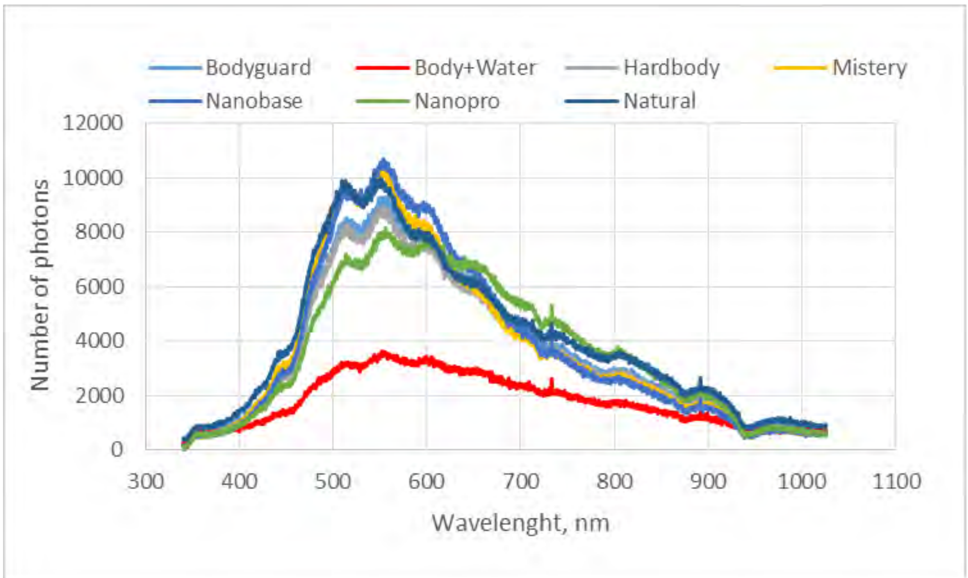



*Fig. 11.* Solar modules reflected spectra, at 52° incidence angle

Fig. 11. shows the reflection of the aqueous Bodyguard coating (Body+Water) also. It is well observed the reflectance reduction, but the characteristics of the spectrum do not change. The reason of reflectance reduction is that the water droplets in the form of small spheres on the hydrophobic surface significantly reduce the reflection.

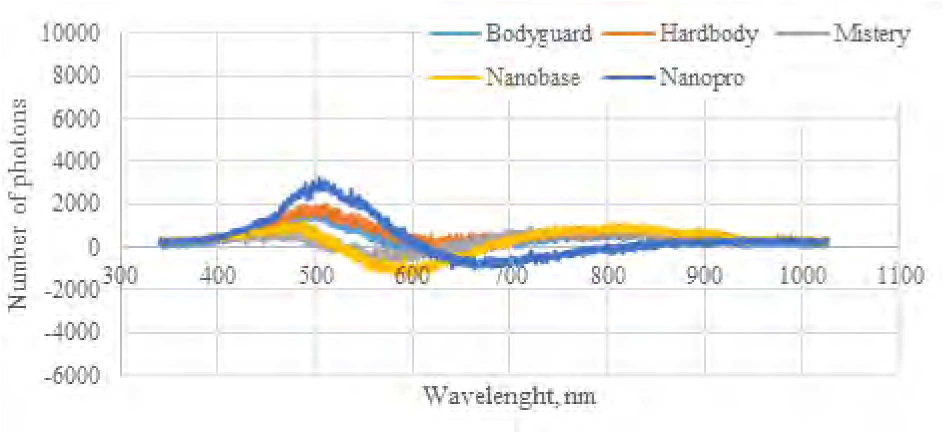



*Fig. 12.* Intensity difference between the coated and natural spectrums at 52° incidence angle

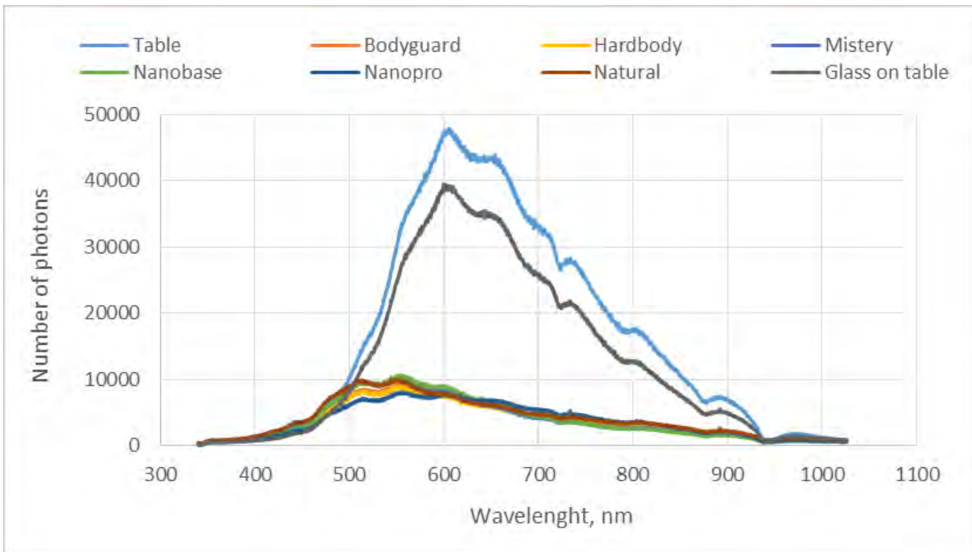



*Fig. 13.* Spectra, 52° incidence angle

Under the same conditions than was in the Fig. 11, Fig. 13. shows the measured reflected spectra from the table, the glass on the table and the covered solar modules also. From Fig. 13. it can be seen, that the reflection from the table and glass plate is definitely higher than from the natural and coated solar modules. The 550 nm characteristic peak of the solar modules is transmitted to 600 nm in case of the table and the glass on the table.

The energy of the photon is (eq.1):

$$\varepsilon = h \cdot f = \frac{h \cdot c}{\lambda} \qquad (1)$$

where h=6.62$\cdot$10$^{-34}$ Js, the Planck constant and c=3$\cdot$10$^{8}$ m/s is the speed of light in vacuum (air).
In case of N(λ) pieces photon, the total incoming energy at the wavelength λ is (eq.2):

$$E = N \cdot \varepsilon = \frac{N \cdot h \cdot c}{\lambda} \qquad (2)$$

The total reflected energy is given from the sum of energies for the whole spectrum (eq.3).

$$E_{total}=\int \frac{N(\lambda)hc}{\lambda} d\lambda = hc\sum \frac{N_i}{\lambda_i} \quad (3)$$

and similarly in case of natural module (eq.4):

$$E_{natural,total}=\int \frac{N_n(\lambda)hc}{\lambda} d\lambda = hc\sum \frac{N_{ni}}{\lambda_i} \quad (4)$$

The values of the relative reflectance energies are resulting from the ratio of the two energies. These values are shown at 41° and 52° incidence angles in Fig. 14.

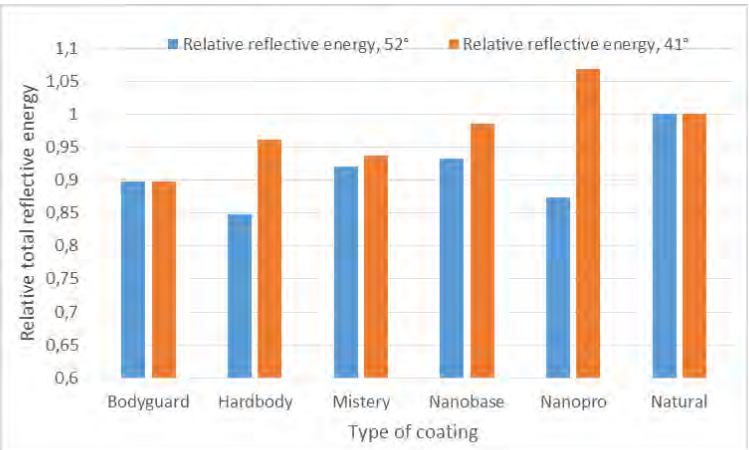



*Fig. 14.* Relative total reflective energy

The coatings generally reduce the reflection for the entire studied spectrum, the only exception was the photocatalytic Nanopro coating, although the reflectance is sensitively dependent on the angle of incidence as shows the Fig. 14. Fig. 15 compares the relative reflected energy and relative maximum power in case of the different coated solar modules. The references are the values of uncoated module.

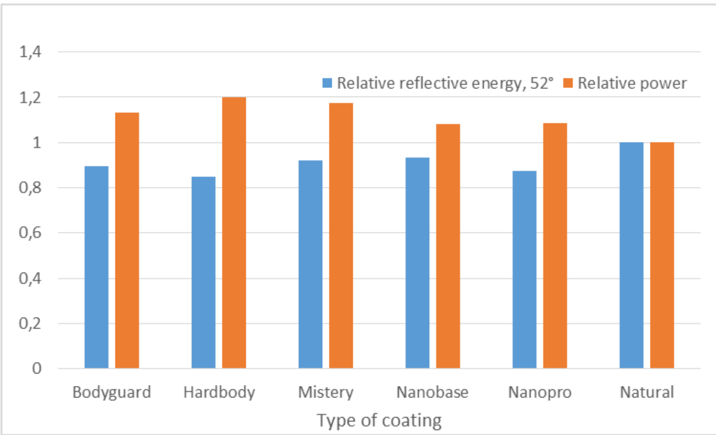



*Fig. 15.* Relative reflective energies and relative powers

In the Fig. 15. it can be observed, that the relative total reflection and the relative maximum power change in the opposite way, the maximum power increases in case of the reflection increases. Thus, the coatings alone have anti-reflection effects. In addition to the change in reflection capability, other optical factors (e.g. absorption in the coating, dispersion) may also effect the power, and investigation of these effects is another task of the research.

### 3.3. Effectiveness of self-cleaning

The coatings alone are power enhancers, which is an important result, but with their application the real aim was the self-cleaning of the modules. Coatings are intended to reduce the loss of power due to the contamination on the surface of solar modules. For the investigation the effect quantitatively, the solar modules were made dirty first. The uncoated and coated solar modules were evenly contaminated with a fine meshed (0.02 mm) house dust. Then, the solar module was turned upside down, while most of the dust was fallen down, so as much dirt remained on the surface as it had adhered to the surface properties. All solar module was contaminated with this contamination. Fig. 16. shows the difference of the uncoated solar module in contaminated and clean states.

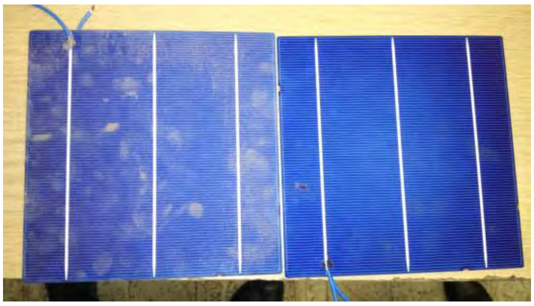
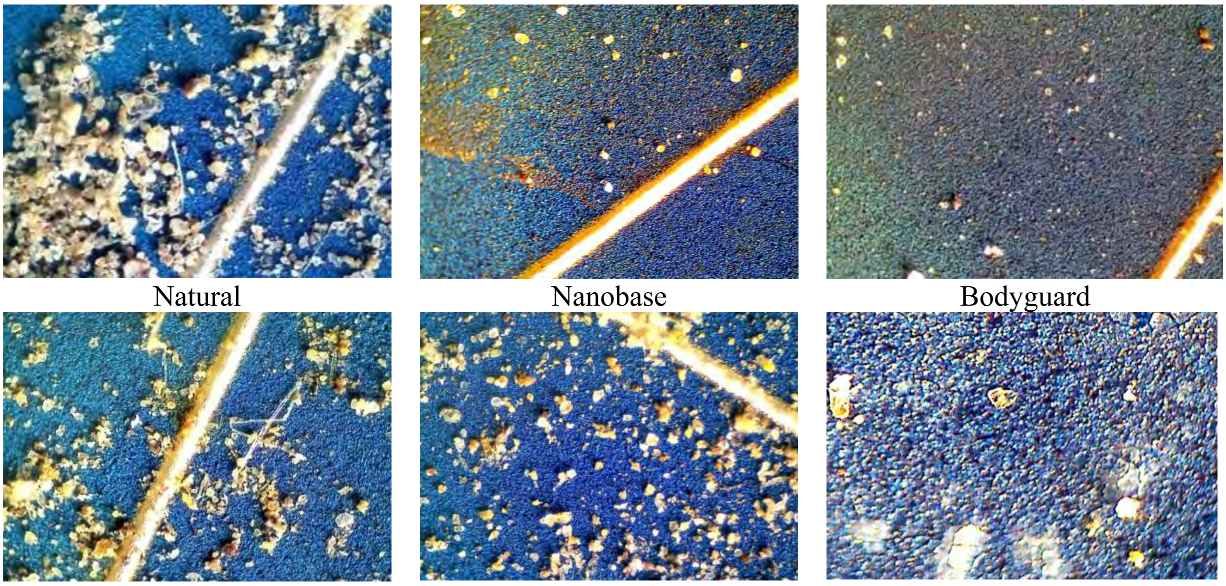


*Fig. 16.* The contaminated and clean uncoated solar module

On the pictures of the Fig. 17. the surface of the contaminated solar modules can be seen through a microscope, under the same conditions, as in Fig.1.



| | | |
|---|---|---|
| Natural | Nanobase | Bodyguard |
| Hardbody | Misteryjuice | Nanopro |

*Fig. 17.* The contaminated modules

After determining the power of contaminated solar modules, the next step is to examine the effect of self-cleaning. Under real conditions, the photocatalytic layer is activated by light, while the lotus-effect self-cleaning surface becomes effective when it gets wet. In the laboratory, the rain was simulated with 6.55 $cm^3$ rainwater which was sprayed evenly, perpendicular to the surface. It is corresponding to 0.29 mm rainfall. From the point of view of water depletion, the angle of inclination is important. In this case it was 41.6 degrees, because the optimal inclination angle in Hungary for all year usage is 40-42 degrees. After cleaning, the cleaned state power of the solar modules was determined. Fig. 18. shows solar modules in different states of the investigation: the dusty and cleaned uncoated, and coated (Bodyguard) during the cleaning.

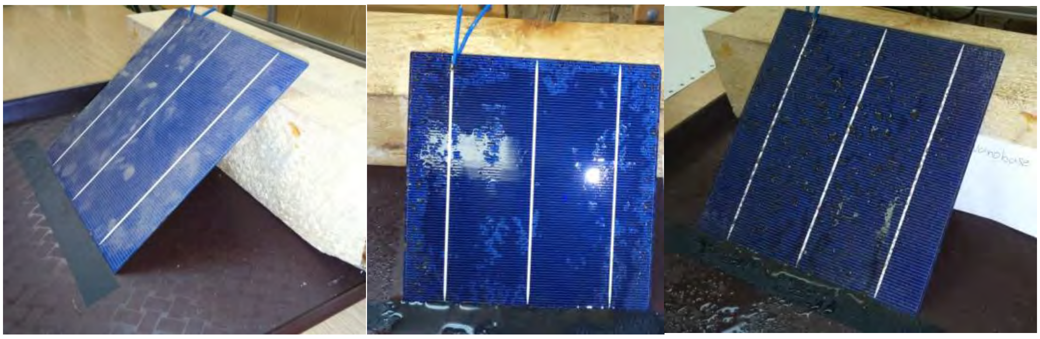


*Fig. 18*. Solar modules before, after and during the cleaning

It could be observed that in case of the uncoated module the water droplets rather spread on the surface, while for the coated cases regular droplets appeared on the surfaces of the solar modules and the larger droplets rolled down, carrying the dirt with themselves. In Table 1 the relative power-changes of the solar modules in contaminated state relative to the clean one and the relative effect of the cleaning are presented.

*Table 1.* The Impact of contamination and cleaning on power

| Type of coating | Relative power-change due to contamination, % | Relative power-change due to cleaning, % |
|---|---|---|
| uncoated | -16.4% | 1.3 |
| Nanopro | -7.3% | 2.2 |
| Nanobase | -22.2% | 19.4 |
| Bodyguard | -23.2% | 22.3 |
| Hardbody | -26.1% | 25.7 |
| Mistery | -22.3% | 21.4 |

The Fig. 19. illustrate graphically the values of measured relative powers in clear, contaminated and after cleaning states.

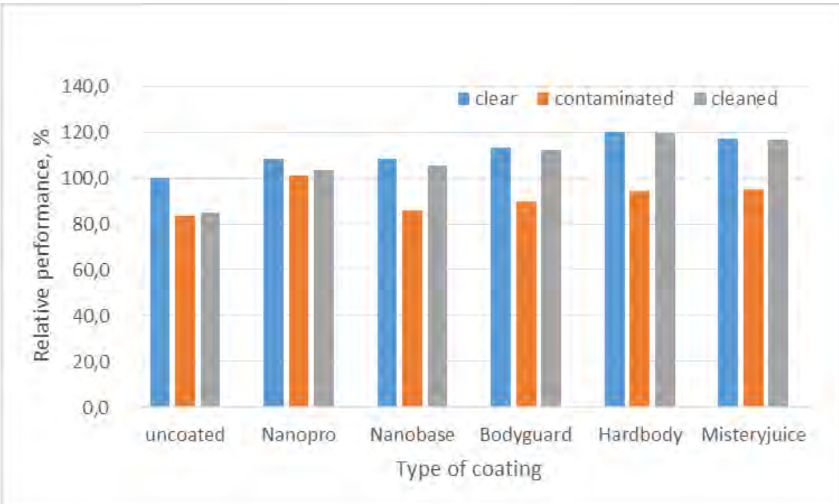



*Fig. 19.* Clean, dirty and after-cleaning powers compared to uncoated clean solar module power

Based on the data, it can be stated that the power of Nanopro photocatalytic photovoltaic layer decreased the least, which can be explained by the fact that self-cleaning works with the necessary illumination. At lotus effect coatings, the power reduction due to contamination is greater compared to the uncoated solar module, but even in contaminated state, each coated solar module operates at a higher power than the uncoated. The results show the behavior of solar modules in dry, non-precipitation period. Misteryjuice worked the best in contaminated state from coatings using lotus effect, the maximum power was 13.6%

higher than uncoated contaminated solar module. The Hardbody coating was the most sensitive to contamination, the power reduction was 26.1% compared to its clean state. The average power reduction due to contamination in the tested coatings was 20.2%, while the average power growth with the coatings was 13.4%, so the coated solar cells operated on an average of 93.4%, which is 10.2% higher compared to the uncoated reference. After the cleaning with rainwater, the powers were increased. While the power growth of the uncoated and photocatalytic-coated solar modules was only small, 1-2%, for the lotus effect coated modules the simulated rain resulted over 20% average performance growth. The values show that, in the case of uncoated solar modules, the fine dust deposited from the air results in a significant reduction in power and for the removal of this dust the rainwater itself is not enough efficient. As for the contaminating, for the cleaning also the Hardbody coating was the most sensitive. The average power of the coated solar modules after cleaning is 26.5% higher than the reference solar module, which gives almost 4% power surplus by using a self-cleaning coatings, assuming 15% solar module operating efficiency. The result is consistent with the result of Verma et al (2011), who tested 5% efficiency growth by using their anti-reflexive self-cleaning coatings compared to uncoated solar cells. The base of the data, the lotus effect coatings compared to the examined photocatalytic layer are more effective in the case of such precipitation, because after the cleaning they almost returned the initially higher performances. Among the coatings the Hardbody coating was the most effective. Based on power data, the recommended coatings would be the Hardbody for the area where rain often falls, while Nanopro for the areas, poor in the rain. Of course, before application of the coatings beside the power, other factors (e.g. unit price, coating aging, re-applicability) must be taken into the account.

## 4. Conclusions and proposals

The nanotechnology coatings alone increase the power of the solar modules compared with uncoated one. The surplus was 2%. The reflection spectrum of the examined coated solar modules has similar characteristic curve, the maximum value of the function was found at 550 nm. The coatings reduced the reflection, which depends on wavelengths and angle of incidence. The pollutant has been deposited in different ways and quantities on each solar module, because the coating composition, the application technology and the surface roughness are different. The artificial pollution caused in average 20% decrease in the power. During the cleaning the same amount of water were used under the same conditions. The cleaning caused an average power growth of 18.2%. Among the coatings, lotus-based ones are more sensible for the contaminant, but their self-cleaning is also more effective when exposed to rainwater. Additional tasks: for clarification of coating results coated solar modules under natural conditions should be tested. In addition to the performance growths the testing for durability and economic analysis is another step. As the anti-reflexivity and self-cleaning is also important for the solar collectors and PV/T collectors the examination of coatings can be extended to these devices, too.

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Faculty of Mechanical Engineering

# DIGITIZATION AND BIG DATA SYSTEM OF INTELLIGENCE MANAGEMENT IN SMART DAIRY FARMING

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**Abstract:** The transformation of agricultural production systems is one of the pillars of today's modern production structure. The use of digitized and big data systems and the integration of smart solutions are important for efficient business structures and environmental efficiency. This will make it possible to adapt production systems based on sustainability and economic efficiency criterias. All this can also be seen in the optimization of milk production systems, as the development of data collection systems, the systematization and analysis of the big data obtained are an important part of new business solutions. Technological development has made it possible to transform business systems using modern data collection and analysis methods. Efficient business solutions invest in technology-driven tracking of production parameters and enable flexible, immediate system development. This article provides an overview of the data collection and analysis options available through the digitization of dairy production systems, which can thus be used as a reference in subsequent system transformation and business transformation processes.

**Keywords:** dairy farming, circular business transformation, smart technologies, digitization, big data, intelligence system

## 1. Introduction

Smart systems that can be implemented with digitalization are an essential part of modern circular business models. In addition to value creation, which is a key part of any new business model, emphasis must be placed on operating intelligent solutions and big data systems. If we examine the economic components of value creation, the data analysis systems that can be obtained through digitization also mean the predictability and economic predictability of milk production systems. As with any agricultural production system, it is important in dairy farming how the circular business nature can be realized. Digitization and the use of smart data collection and processing systems can provide the "virtualize" side of circular business models presetnted by the ReSOLVE framework, which is often used in business transformations (Lewandowski, 2016).

Smart farming covers developments that can improve the technological background of an agricultural production system, track the economic parameters of each production cycle, and shed light on development points through big data analyse (Bronson, 2019; Wolfert et al., 2017). In modern production-economic systems, the big data obtained with intelligent solutions and remote data collection devices means a large amount of data, which accurately describes the parameters of the production system, can be easily and continuously collected, analyzed and assisted at each decision-making level to take control of production-economic factors (Lytos et al., 2020). Using the big data, the parameters of each production cycle can be predicted, real-time decisions can be made and business processes can be transformed in order to place each circular system element in the production system (Wolfert et al., 2017).

## 2. Conceptual frameworks of smart farming technologies

In modern smart production systems, system transformation tools based on the analysis of production data are becoming increasingly important. With the help of big data systems, production structures are becoming more and more data-centric, which is also facilitated by the development of computer systems and the growth of data analysis solutions. All this points towards intelligent farming (Sundmaeker et al., 2016). In intelligent production systems, not only the specific characteristics of production are taken into account, but also the traceability of real-time system events based on the collected data is considered important.

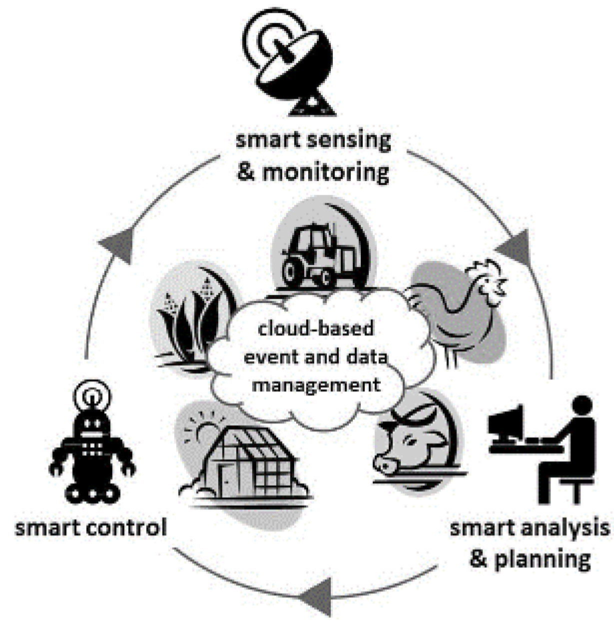


*Figure 1.* General overview of smart farming technologies (Wolfert et al., 2017)

In special production systems, such as dairy production systems, it is particularly important that we have the ability to act immediately with real-time data analysis solutions in the event of an unexpected accident (e.g. illness) (Wolfert et al., 2014). Figure 1 gives a general overview of the structure of intelligent production systems. The Figure also shows how a full intelligent transformation of production control systems will be possible in the future. Operating systems, data collection and analysis methods available through digitization can be effectively integrated into system transformation processes.

Big data has an important role in intelligent management systems. Different sensors are connected to each system element and to the actors involved in production (for example, farm animals in dairy production systems), which provide continuous data on pre-set and required parameters. Up-to-date and continuous data collection systems produce large amounts of data (big data), which provide feedback on the production efficiency of each system component (Wolfert et al., 2017).

There are several conceptual frameworks for the design and transformation of intelligent managment production systems. Most of these frameworks apply to value chain management as well as data-driven production strategies. All members of the production chain need to work together both vertically and horizontally to create added value, thus facilitating not only the development of intelligent production systems but also the implementation of an efficient business model (Christopher, 2005). In production systems working with a large amount of data, up-to-date continuous data provision creates a value chain connection that provides useful information during production system transformations, from data collection to decision-making. A frequently cited network management model of Lambert and Cooper (2000) builds an efficient production system structure on three interrelated pillars: network structure, business models, and management components.

In most cases, the network structure defines the participants in the production system, basically according to the special requirements of the production system. In dairy production systems, this mostly ranges from farm animals, employees to the production of the finished product. The issue of business models nowadays means the possibility of integrating circular system components, as the features of intelligent production systems available through digitalization must also be reflected in the business concept. In this case, in addition to value creation, it also means the efficient adaptation of the business model to the changing production parameters (Miller and Mork, 2013). Management components mean the tracking of the elements of the entire production system, in which big data systems are of paramount importance nowadays. As described earlier, up-to-date data collection and analysis, as well as making the necessary changes in the light of the results, are all part of an intelligent management system. It is important to emphasize that big data makes it possible to monitor accurate production parameters, for example in the case of dairy production systems vital parameters related to farm animals, continuous analysis of biological, chemical and microbiological parameters of milk as a product, evaluation of measured values and non-compliant parameters (Lambert and Cooper, 2000; Miller and Mork, 2013).

Figure 2 shows an adapted framework. Big data play a role in business process planning, as can be seen in the lower layers of the Figure. Business processes are divided into three parts, these are production processes, production management, and data collection and analysis chains. Another element of the framework is provided by big data applications, which actually give the essence of intelligent production structures. The data chain and production parameters affect the network of stakeholders both individually and collectively. This framework is suitable for transforming intelligent production processes and building an efficient production business model (Lambert and Cooper, 2000; Wolfert et al., 2017).

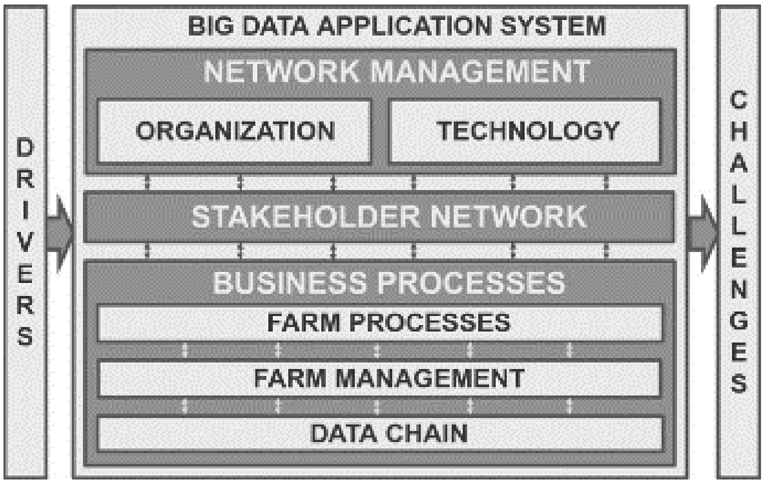


*Figure 2.* Conceptual framework for intelligence management of production
(Based on Lambert and Cooper, 2000; adapted by Wolfert et al., 2017)

## 3. Transformation of business models in focus of digitization and big data

Current economic approaches generally follow the linear principle, the extract-product discard structure. This system does not support the environmental and sustainability aspects of our natural resources and does not visualize the material cycle (Di Maio et al., 2017). The linear economic system favors high mass production and low production costs, with the goal of obtaining the raw materials needed for production at the lowest possible cost (Blades et al., 2017; Di Maio et al., 2017). In contrast, by examining and applying the basic pillars of sustainability, i.e. the social, environmental and economic dimensions, it is possible to create the circular system that forms the basis of modern 21st century economic processes. (Michelini et al., 2017). Sustainability is a system of criteria maintained jointly by the three dimensions, ie if there is a change in one, it affects the other two. Linear economic models are not suitable for analyzing social and economic impacts in the context of consumption because they do not seek to ignore the negative impacts of production systems (Fogarassy-Kovács, 2016).

The business model adaptation of circular economic concepts typically focuses on value creation and the display of related circular system elements. Value creation basically relies on three segments: the analysis of social, economic and environmental impact factors (Blades et al., 2017). In our case, the digitization and the related efficient data collection and analysis solutions basically appear at the level of economic value creation. Figure 3 shows the three value creation segments which appear in the Business Model Canvas. This division is presented by the Triple Layer Canvas (TLC) models, which show new approaches to circular business modeling. It is important to emphasize that the three value creation segments also interact closely with each other. As shown by the Figure 3, the economic value creation is at the top, which has an impact on environmental and social value creation opportunities also. If we develop a production system from an economic (business) point of view, in this case with digitization and a big data management system, then the environmental and social factors of the total production structure also adapted to this (Joyce and Paquin, 2016). Although the Triple Layer Canvas Model is usually compared at the levels of value creation, it should also be discussed that based on these three layers. The three layers of the Triple Layer Canvas Model are: economic layer, environmental layer and social layer. As shown on the Figure 3, these three layers are also closely (vertically) interconnected through each value creation segments. In order to carry out an effective business model transformation, it is worthwhile to prepare the layers related to the three value creation segments separately, that the detailed value creation opportunities associated with the digitization of the milk production system can be emphasized (Joyce and Paquin, 2016).

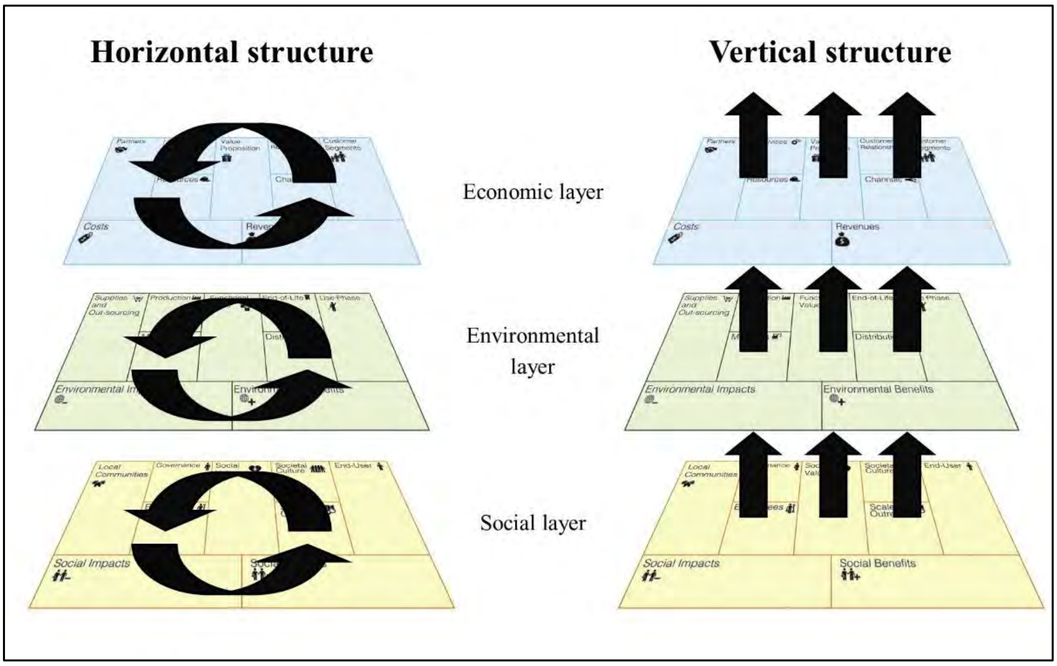


*Figure 3.* Value Creation by the Triple Layer Canvas Business Model
(based on Joyce and Paquin, 2016)

The Triple Layer Canvas Model is an innovative solution for sustainable business models. It adds three layers to the traditional circular business model creation strategy, which are the environmental layer (typically based on the results of life cycle analysis of raw materials used in production systems and the material produced) and the social layer traditionally based on the capabilities of interested business partners (Pigneur et al., 2015). Related to these is the step of economic value creation, which vertically brings these two layers together. This enables a holistic approach to business model innovation that fosters the sustainability attitude of the Canvas Model.

The Triple Layer Canvas business model offers an opportunity to explore the horizontal and vertical relationships of production systems through value creation potential. Together with digitization and big data management systems, the value creation can be demonstrated through both the horizontal and vertical chains through the economic value creation layer (Pigneur et al., 2015).

## 4. Study of transformation and digitization in a milk production system

Recognizing economic efficiency in dairy production systems is important in several ways. On the one hand, producer systems want to achieve more income with more milk, but at the same time, providing the necessary feed for this already has an impact on cost-effectiveness. As in all production systems, it is important in milk production systems to properly assess the quality and quantity of the product. Measuring production efficiency is a particularly important segment of efficient production systems (Horvath et al., 2019). An important element of this is the efficient use of resources in both small-scale and large-scale conditions. It is important to be aware of which cows on the farm are showing how efficient they are in terms of milk production, with the most efficient feeding and health maintenance. We need to have an accurate cost assessment in order to set up an efficient milk production system. The operation of milk production systems with software data collection and analysis is definitely suitable for this, where we can work with practically artificial intelligence and computer evaluation with constantly updated data sets (Ana-Lisa, 2018). We can monitor the health status of the cows, their vital data, and the qualitative and quantitative parameters of the product. Biometric sensors are used to monitor the vital parameters of cows, which can be used to collect continuously measured data per cow, and by analyzing them we can save time and, above all, costs. Clinical symptoms measured on individual cows can be detected, evaluated, and immediate action is possible.

It must be seen that artificial intelligence, big data analysis systems and computer-controlled solutions improve the capital efficiency of the economy. Each cow (breeding animal) should be interpreted as a unit capital. As a result, the efficiency of the dairy farm can also be interpreted as the continuous monitoring and provision of available capital. Smart systems, by constantly monitoring the physical and vital parameters of animals (capital stock), allow for rapid and effective intervention, thus avoiding the economic disadvantage resulting from the deterioration of capital stock.

The application of savage intelligence and the necessary technological (computer) solutions is also reflected in the labor demand. It can be seen that in the case of smart milk production systems there is a lower need for labor, however, in our opinion, the need for handicrafts cannot be triggered entirely by artificial and intelligent solutions. The business success of U.S. farm systems depends heavily on approximately 3 million registered farm workers who are not seasonal but permanent players in production systems. Here, too, it can be seen that the human resource needs of the system cannot be neglected.

### *A short overview from the Netherlands*

The following short overview presented the cooperation between the Wageningen University and the TNO Company from the Netherlands.

For many years, the dairy sector has been collecting detailed information on dairy production systems from both small and large-scale operators, and on the processes of production systems (Fogarassy et al., 2016). With this data, we can gain insight into the dairy production process, animal health, and business efficiency of the entire system along appropriate collection and analysis strategies. Each solution moves you towards optimizing business processes. The TNO Company works with Wageningen University and a number of dairy farms, such as CRV, Agrifirm or Friesland Campina (Smart, 2020). As a result, an intelligent dairy project has been built where business efficiency, scientific background and practical production side meet. TNO Company assists in the efficiency of actors in each sector, in the analysis and evaluation of big data systems, with technological solutions such as bokchain and artificial intelligence. The data (big data) of the milk production system and the results of the analysis are treated encrypted and can only be disclosed to the parties involved. This is important because it can reduce the linear elements in business models that hinder efficiency and maximize value creation. Managing big data systems in this way is important for both business partners and farmers, as it makes milk production processes more coordinated and improves the sustainability of the production system (e.g. useful life of animals, dairy ability, vital parameters) (Smart, 2020).

## 5. Conclusions

Based on the description of the study, it can be stated that artificial intelligence, intelligent system-controlled milk production systems, big data collection and analysis possibilities represent the future of modern agricultural production systems and processes. With digitalisation, a continuously and up-to-date production system can be developed, which enables immediate and effective interventions. The efficiency of business models can be increased if we successfully adapt smart systems to dairy solutions, as many European and overseas examples show that all this can be done successfully. In the dairy industry, both discrete and continuous processes can benefit from digitization. Digitization is based on a holistic approach that integrates the traditional value chain of a product, into a product and production lifecycle, from product design to manufacturing design, engineering, execution, and services. Only a fully digitized, consistent business model has the power and flexibility to accelerate processes and optimize production operations. After design and planning, the digital twins allow for virtual deployment so that all previous development steps can be effectively validated. Both the manufacturing process and packaging benefit from simulation and optimization with digital systems. Machines and production lines connected to open, cloud-based IoT operating systems provide a whole new dimension of transparency, offering additional opportunities to optimize value-added processes for customers: shorter market entry, more flexible engineering design, optimal product quality, and better plant availability and efficiency.

The aim of the study was also to shed light on these contexts as well as to show the business development opportunities obtained during the review of dairy production systems as modern agricultural production structures. Integrating circular system components into the production structure can be an effective solution towards creating economic value and increasing environmental and social factors as positive externalities.

In summary, the framework of the study does not allow for a detailed analysis of the smart systems associated with full digitization, but it can be stated that this is definitely the way for future milk production systems.

**Acknowledgement**

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and
**SZENT ISTVÁN UNIVERSITY**
Faculty of Mechanical Engineering

# EXPERIMENTAL SCR SYSTEM FOR ENGINE DYNAMOMETER APPLICATIONS

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**Abstract:** In order to meet increasingly stringent emission reduction standards [18], diesel engine producers are under constant pressure of evolving R&D. For this reason, development responsibilities also appear on the supplier side. This paper describes the design, development, and testing process of an SCR dispenser, which suitable for testing internal combustion engine's exhaust gas treatment system. The created equipment opens up modelling opportunities for exhaust gas management system development engineers in order to design tractors and vehicles with less pollutant emission.

**Keywords:**

## 1. Introduction

Emission technology is one of the most developing sectors of the engine and automotive industry since the millennium. Tightening emission standards and restrictions, both at European and global level, provide the basis for the development of newer and more modern exhaust gas management systems. The "skillfulness" of the manufacturers has also attracted the attention of the public to keep emissions to an appropriate level.

Among internal combustion engines, diesel engines with the best thermodynamic efficiencies produce a number of pollutants during operation, which modern diesel exhaust treatment systems contain an oxidation catalyst (DOC), a particulate filter (DPF) [20] and a NOx reducing catalyst (SCR) to neutralize [15]. These are treated as one system, scaled and designed as they have a direct impact on each other's operation [1].

An SCR (eg. AdBlue) system is effective in neutralizing nitrogen oxides, but its use can degrade certain engine performance under certain load conditions and adversely affect the operating parameters of the exhaust gas management system. For example, it can cause higher soot formation during combustion, which puts an additional load on the DPF. Furthermore, the SCR catalyst has a direct effect on the passive regeneration efficiency of the diesel particulate filter. During passive regeneration, the catalytic material on the DPF surface removes oxygen from the $NO_2$ content of the exhaust gas while oxidizing soot particles at low temperatures ($t = 250\text{-}300$ °C) [6]. When SCR is used, the exhaust gas $NO_2$ ratio decreases, thus reducing the amount of oxygen released on the DPF surface, thus reducing the amount of soot burned. Avoiding such phenomena requires further research and development effort on the part of automakers and related automotive suppliers.

In order to explore the deeper connections between the development goals and the system, it is necessary to create a widely programmable SCR (in this case: AdBlue) injection equipment suitable for test purposes, as an injection test system with such properties is not available on the market. It can be used to simulate events such as AdBlue additive overdose or deficiency, leakage, and other system failures or operating conditions that result in measurable emission values.

## 2. Method and equipments

The exhaust gas management system is tested under engine bench dynamometer with laboratory conditions, the main units located in the room (Figure 1):

- the exhaust gas treatment system to be tested with the associated diesel engine,
- soot particle number counter,
- exhaust gas concentration measuring equipment,
- the AdBlue injection unit ,
- and other sensors (eg. temperature sensor).

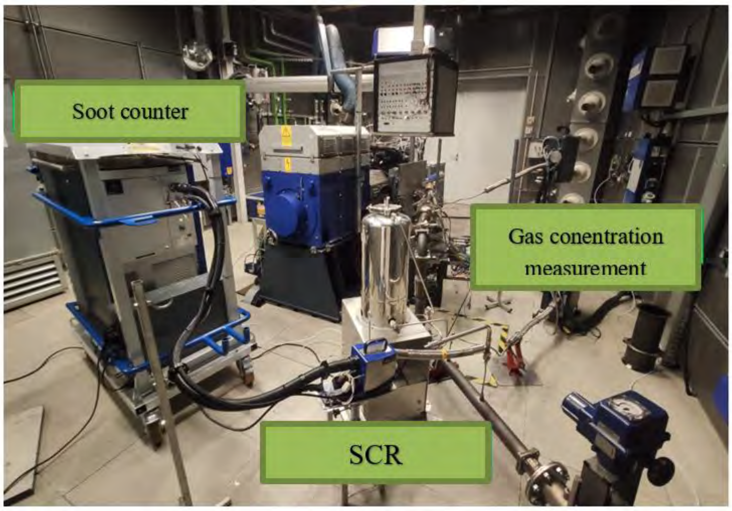


*Figure 1:* Location of exhaust gas treatment system test equipment; Source: Norbert Bíró

The AVL LD (Light Duty) 220 kW dynamometer is equipped with a PSA DW10c , EURO 5 compliant diesel engine, the exhaust side of which is equipped with an exhaust gas management system widely used by the PSA Group for passenger car engines (Fig. 2.). The AdBlue additive injector is located in front of the SCR catalyst and is connected to the exhaust pipe through a 1/8 inch connector. The injection takes place perpendicular to the inlet surface of the SCR catalyst, so that mixing and chemical transformations can be performed optimally.

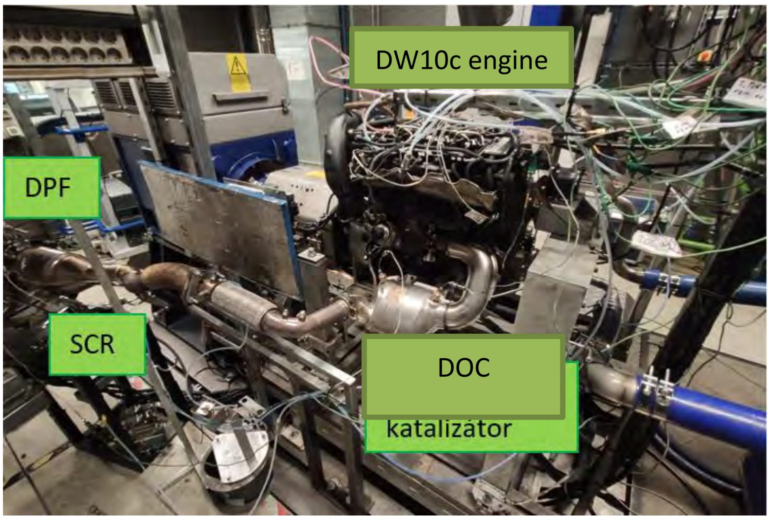


*Figure 2:* Engine and exhaust system under test; Source: Norbert Bíró

The gas concentration is measured with an AVL AMA i60 wide-range analyzer, which is suitable for the detection of THC, $CH_4$, NO / $NO_2$ / NOX, CO, $CO_2$, $N_2O$, $O_2$ and $SO_2$ gases, as well as for the analysis of both diluted and raw exhaust gases. The meter has official measurement cycles certified by EPA and ECE authorities [12].

When the test equipment is used in automatic mode, the gas concentration analyzer measures the concentration of the gases in the exhaust gas in real time and transmits them in real time to the dynamometer control computer. From the measured $NO_x$ (NO, $NO_2$) concentration, the amount of AdBlue additive required for neutralization is determined, as well as the electrical signal for the valve opening time, which is sent to the AdBlue additive injector at an analog output.

The schematic diagram illustrates the structure of the exhaust gas treatment system, together with the measurement and intervention points.

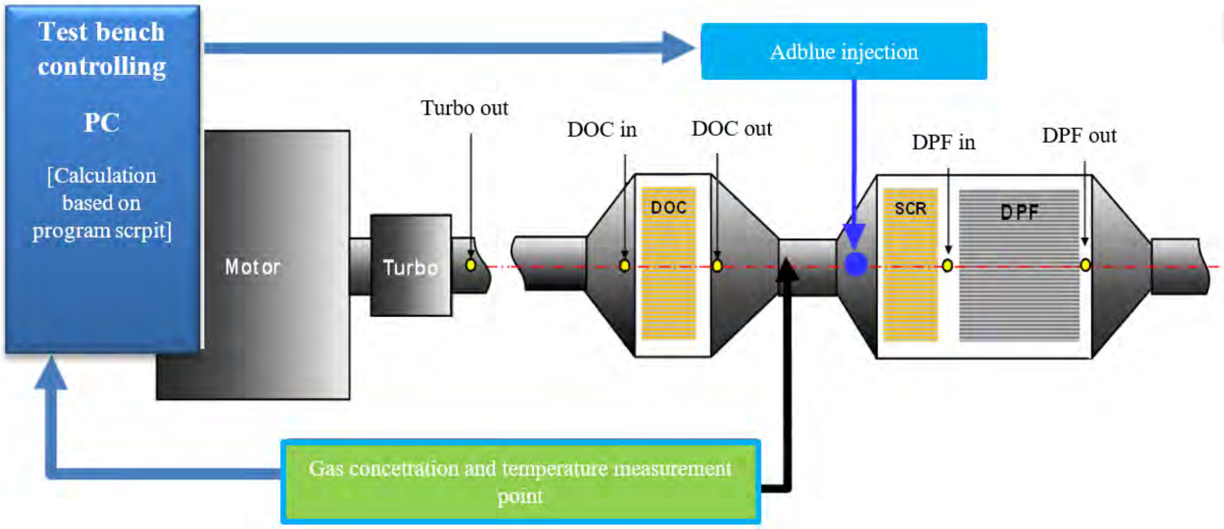


*Figure 3:* Schematic diagram of a test system; Source: Norbert Bíró

## *AdBlue dosing unit design*

The main component of the dosing unit is a stainless steel tank (X3CrNiMo17-13-3). The tank has a mean diameter of 300 mm, a height of 500 mm and a wall thickness of 3 mm (Figure 4). With these dimensions, store the liquid at a nominal pressure of 2 bar with a double safety factor. The possibility of filling and refilling the tank can be solved through the roof plate on the top, which can be locked / unlocked with a threaded clamp, thus allowing quick and easy use. After the mains air supply has been shut off, the tank pressure can also be reduced by means of a pressure relief valve on the roof plate for refilling, storage or overpressure. The pressure gauge was also located on the roof plate. To check the level of AdBlue liquid in the tank, a vertical transparent plastic tube has been installed, which is connected to the tank via a 1/8 inch connector [19].

The flow of the various media is controlled by electrically controlled solenoid , normally closed valves. The connectors are made of ¼-inch brass and are resistant to dissolved ammonia. Figure 5. clearly shows the flow direction of air and Adblue, the traversed path. The reducer-controlled compressed air is split in one “T” passage and provides the supply pressure to the tank on the one hand, and supplies compressed air to the venturi pump of the injection nozzle on the other.

Through flexible Teflon tubes that are resistant to dissolved ammonia, both air and AdBlue fluid enter a three-port Nippon control TFA-R4 type solenoid valve. The valve works on the Venturi principle. The compressed air flowing through the upper line creates a negative pressure, so it carries the AdBlue fluid coupled to the lower line. Injection can be stopped by closing the valve, while the injection volume can be controlled by changing the opening time of the valve.

*Figure 4.*: AdBlue dosing unit; Source: Norbert Bíró

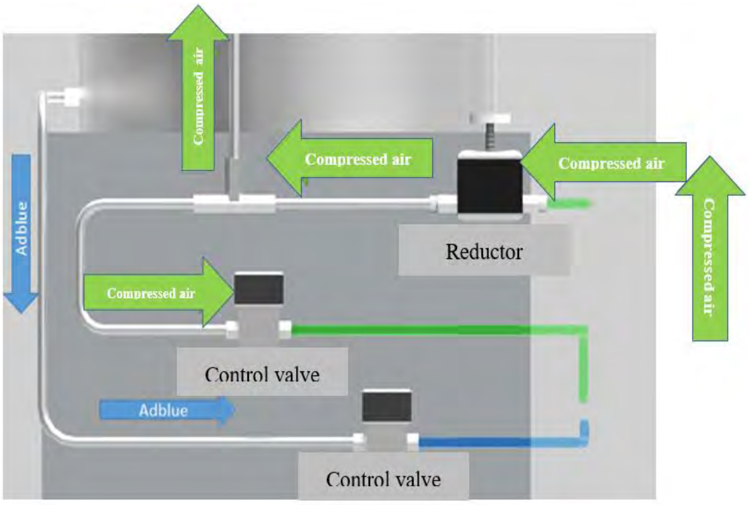


*Figure 5.*: Compressed air and AdBlue pipe lines; Source: Norbert Bíró

### *Injection control principles*

The three 24-volt solenoid valves are powered by a 230V to 24V DC adapter. For commissioning, the toggle switch labeled “POWER” [1.] must be toggled to power the controller (Figure 6). The injector opening frequency can be set with knob [2.] After setting, the injector can be started with the rocker switch [3.] marked "START / STOP". In the start position, the cyclic opening and closing of the injector starts at the set frequency. The process continues until the toggle switch is turned to the "STOP" position. Toggle switch [4.] "EXT / INT" can be used to toggle between internal, ie control as described, and control based on an external analog signal source (AUTOMATIC). When the equipment is used in automatic mode, the gas concentration analyzer measures the concentrations of the gases in the exhaust gas in real time and transmits them to the dynamometer control computer. Based on the control program, the computer determines the amount of AdBlue additive to be injected and the required valve opening frequency.

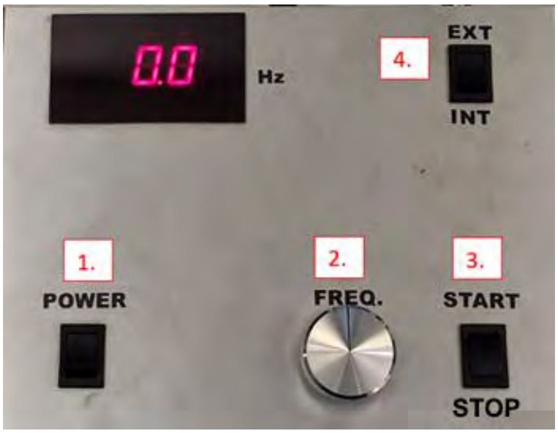


*Figure 6.* Control Panel; Source:Norbert Bíró

### *Control program script*

The control program determines the 24V output frequency of the appropriate frequency to operate the injector based on the gas concentration analyzer data, intake air mass flow rate, hourly fuel consumption, and exhaust gas temperature.

The program had to ensure that no injection was performed below the minimum gas temperature of 180 °C required to convert AdBlue to ammonia. Prohibiting injection is especially important at low temperatures, as AdBlue does not contain pure ammonia. When ammonia is injected, it is formed from AdBlue by a hydrolysis / thermolysis reaction. Because both pure ammonia and AdBlue pollutants cannot escape to the ambient air from the exhaust system.

## 3. Measurement process and results

To test the AdBlue dosing device, the engine placed on the dynamometer implemented the driving cycle shown in Figure 7, so that the operation of the dosing device could be tested at several operating points. The engine and exhaust system are warmed up in two stages. In the first step, run for 10 minutes at 1500 rpm with a load of 50 Nm. This was followed by the second stage with a 12-minute run at 3000 rpm and a load of 180 Nm. The warm-up phase was followed by three load phases with flight times of 2.5, 1.7, and 1.3 minutes. The speed values varied negligibly for the load sections, and the torque values were 220 Nm, 260 Nm, and 295 Nm, respectively. The last load phase was followed by a 10-minute cooling phase running at 1500 rpm and a load of 50 Nm.

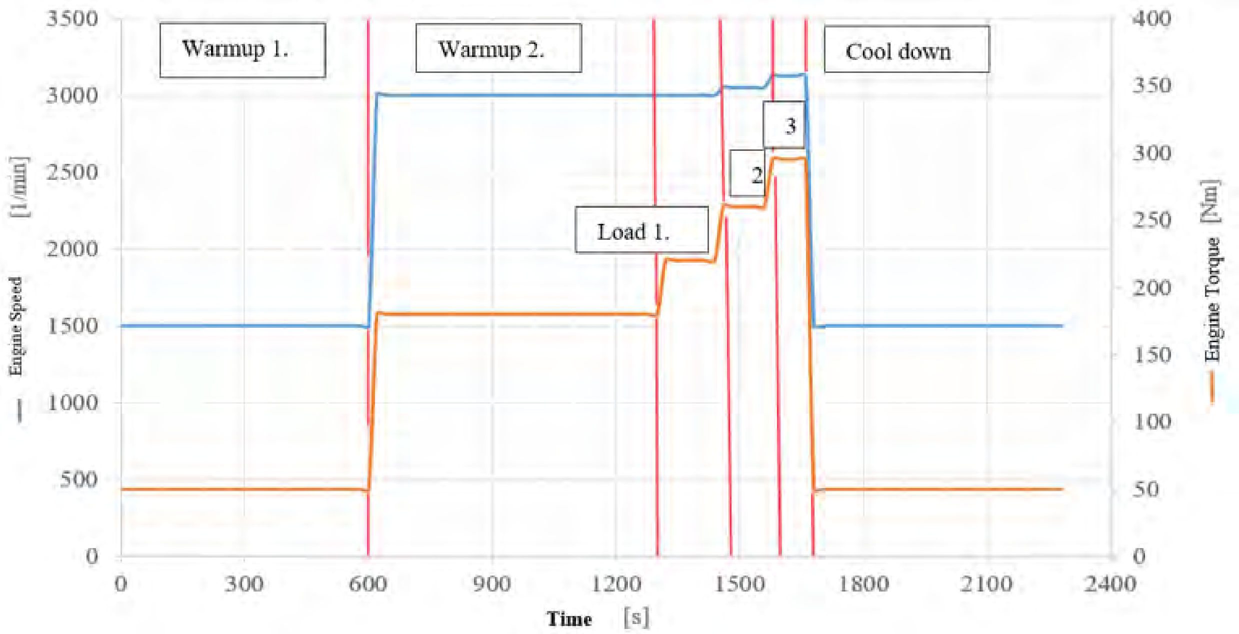


*Figure 7.:* Dosing test cycle; Source: Norbert Bíró

Figure 8 shows the gas concentration before and after the SCR catalyst. It can be stated that $NO_x$ reduction is the most efficient in the low and medium load stages, here it neutralizes up to 99% of the harmful gas.
At high loads, the efficiency drops to 75%, which results in nominal values (max: ~ 370 ppm) under the current regulations of EURO VI. At high loads, fuel consumption increases, proportionally to the amount of intake air, and thus the exhaust gas mass flow.
It can be seen that in the case of long-term use at high loads, the amount of AdBlue injected can be increased by increasing the supply pressure of the container and by using a larger diameter injection nozzle.

## 4. Conclusions, suggestions

During the preliminary and final tests, the device functioned properly, fulfilled the set goals, and performed the planned functions:

- ✓ $NO_x$ neutralization, min. 80% efficiency over the entire test cycle.
- ✓ Manual injection setting option, which allows simulating malfunctions in static tests and ExFm (extreme failure mode) tests, thus preventing them.
- ✓ Automatic use with ANR (Ammonia Nitrogen Oxide Ratio) 1: 1 settings, which fully corresponds to the operation of NOx reduction systems (SCR) in standard passenger cars, making it easy to simulate

all diesel particulate filters manufactured in accordance with the EURO 6d-temp directives after 09.09.2017.

- ✓ No error has occurred since the device was used.

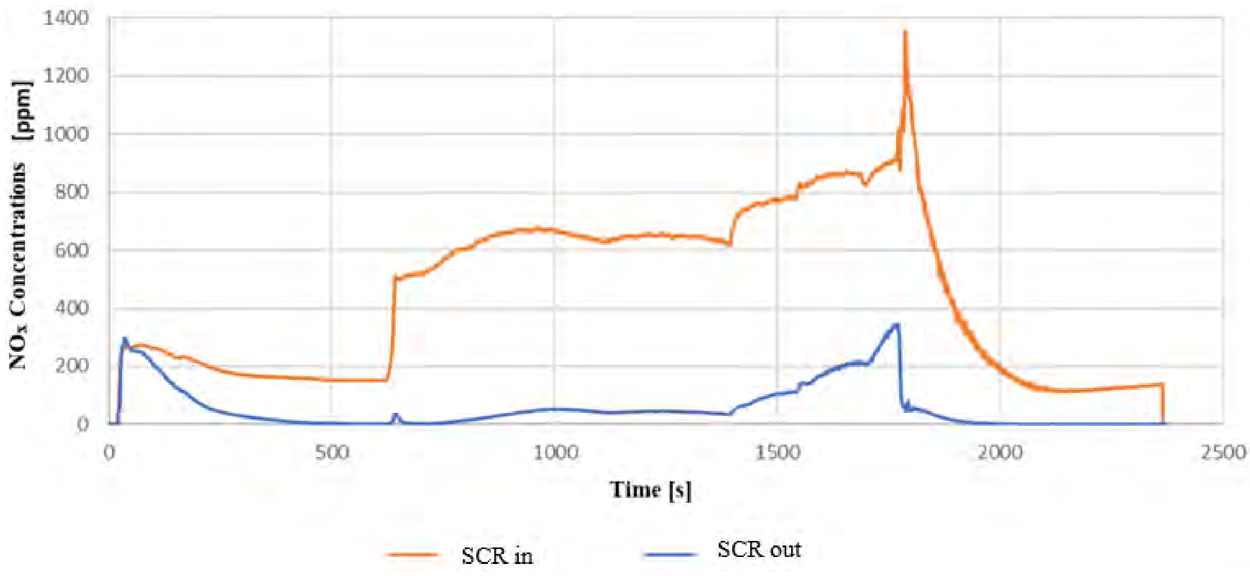


*Figure 8:* Dosing test cycle; Source: Norbert Bíró

Further development opportunities

Examining the $NO_x$ reduction diagram clearly, it can be seen that in the lower load regions the reduction reaches 99% while in the parts with maximum load the reduction efficiency decreases up to 75%. The output voltage is maximum at these stages, i.e. the solenoid valve operates at the maximum opening frequency, in order to increase the amount of AdBlue injected and thereby increase the reduction efficiency, the following improvements must be made:

- ➢ Increase the inside diameter of the injection nozzle or use another nozzle with a larger inside diameter for higher load tests.
- ➢ Increase the maximum tank supply pressure from 2 bar to 4 bar, which would not endanger the operation of the appliance. This would increase the amount of Adblue injected, which would increase the reduction efficiency.

These development opportunities would require new tests, but a correspondingly increased AdBlue injection could also open up the possibility of testing more powerful car and truck engines.

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# A BRIEF LITERATURE INVESTIGATIONS ON FOLIAR PLANT NUTRITION AND ITS FUNCTION IN THE PROTECTION OF HORTICULTURAL CROPS

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**Abstract:** Over the most recent couple of years, human health disintegration and ecological contamination because of unnecessary utilization of engineered agrochemicals have become a developing concern. The objective of this review essay was to shed the light on the foliar plant nutrition practice, especially in tomato and pepper production. The article depended on research articles and extension reports. The article covered significant issues arising in foliar plant application incorporate integrated pest management strategies, plant nutrition complex connection with biotic and abiotic stresses, merits and challenges of foliar application method, and close literature review for tomato and pepper foliar application. In summary, the use of foliar application techniques in horticultural plant production is a crucial strategy for integrated pest control, sustainable environmental practices, and balanced food production. It is recommended that agricultural science research be extended to enhance integrated management practices and integrated plant protection.

**Keywords:** foliar plant; horticulture; IPM; organic production

## 1. Introduction

There have been many questions recently raised about the foliar application technique. Some researchers include it within the methods of integrated pest control, and others as part of organic farming procedures. Besides, there is an implicit relationship between the health of horticultural plant crops and nutrients deficiency. For example, modern science seeks to uncover the hidden relationship between drought stress and the infection of tomatoes and peppers with powdery mildew disease and the use of foliar fertilizers as a precautionary procedure to maintain growth and production.

The goal of this review essay was to shed light on the foliar application practice, particularly in the production of tomatoes and peppers. The article discussed major issues related to a foliar application, including integrated pest control methods, complex plant nutritional status, and linkages with biotic and abiotic stresses. Advantages and challenges of foliar application technique, and a close analysis of the literature on tomatoes and peppers.

## 2 Integrated pests management strategies and tactics

Integrated Pest Management (IPM) is an accessible and environmentally sensitive approach to pest management. It uses natural predators, pest-resistant plants, and other means of maintaining a healthy environment to minimize dependency on chemical pesticides.

The concept of integrated pest management (IPM) was first suggested in 1957 as a concept that promoted the use of biological control and effective agricultural practices before the use of chemical pesticides for pest control. Integrated pest management (IPM) or integrated plant protection (IPP) relies on the main principles: growing a healthy crop, managing natural enemies, constantly monitoring fields, and turning farmers into experts (FAO, 2005). In 1959 a published paper entitled "The Integration of Chemical and Biological Control of the Spotted Alfalfa Aphid". Stern et al., (1959) gave the first statement of theory concerning the integrated control term or definition. The philosophy says that "whatever the reasons for our increased pest problems, it is becoming more and more evident that an integrated approach, utilizing both biological and chemical control, must be developed in many of our pest problems if we are to rectify the mistakes of the past and avoid similar ones in the future".

Agri-technical, mechanical, biological, chemical, and economic threshold levels are all part of the concept of integrated pest management. Stern et al., (1959) described integrated control as applied pest control, which incorporates and integrates biological and chemical control and use economic thresholds to decide when chemical control should be used to prevent pests from reaching economic injury levels.

Integrated pest control has grown into a modern scientific term that involves insects, plant pathogens, weeds, and vertebrate pests. For example, Massimi (2017) concluded that integrated weed management (IWM) plans usually consist of several methods that are divided into biological, cultural, and physical (mechanical) and chemical. Physical approaches include the use of mulches, manual weeding, tillage, flame, soil steam sterilization, and soil solarization. Cultural techniques, primarily crop rotation, are used to rotate crops with crops that kill weeds by choking them out. This is a way to avoid the use of toxic chemical herbicides and to reap the advantages of crop rotation. Biological weed control regiments may consist of biological control agents, biological herbicides, the use of grazing animals, and the protection of natural predators.

Integrated pest management has several approaches to protect horticultural crops, such as choice of disease-tolerant varieties, solar solarization, ventilation of the greenhouse, reduction of the plant density, irrigation to minimize drought severity, removal of old and large infected leaves, collect and removal of infected fruits, avoid growing more than one variety in the same greenhouse, long crop rotations, hand weeding, safely sterilized seeds, use of sterilized manure, biological control, tillage, trap crops, optimal plant nutrition, and irrigation scheduling, and drainage management.

## 3. Plant nutrition relation with biotic and abiotic stresses

Other fundamental principles for integrated pest control are soil fertility management and irrigation and drainage management. In 2005, the FAO (Near East IPM Project) proposed that decision-making in integrated pest management would require an overview of the agricultural environment with all its components, including plants, insects, diseases, natural enemies, weeds, soil, and climate.

It is well established that there is a close relationship between the nutrient supply of the plant nutrients and the resistance to diseases. In other words, disease control, the value of supply of the nutrients are becoming an increasingly important part of sustainable plant defense. For example, it is well recognized that the plant protection mechanism against pathogens with optimal phosphorus and potassium nutrient supplies is much stronger than plants with inadequate nutrient supplies. Huber and Haneklaus (2007) concluded that nutrient management by amendment, improved genetic quality, and environmental modification is a significant cultural control of plant diseases and an integral component of successful production agriculture. Disease resistance is genetically regulated but mediated by physiological and biochemical processes linked to the nutritional status of the plant or pathogen. It has been stated that resistance of wheat and flax to rust, and corn to Stewart’s wilt, maybe have been lost under potassium deficiency (Huber and Arny, 1985). Fusarium wilt of tomatoes and cabbage yellows, Stewart’s wilt of corn, and downy mildew of tobacco are increased by potassium when there is an imbalance of other nutrients (Huber and Arny, 1985). The association of tissue nutrients in diseased compared to healthy, plants have also provided insight into the interactions between nutrients and diseases, and detailed examples are recorded for most important nutrients. The resistance of rice to blast, sheath blight, brown spot, and stem rot is associated with high levels of silicon in plant tissues (Savant et al., 1997(.

Iowa State University extension and outreach reported a recent experiment published a recent experiment performed by Wright and Lenssen (2013) with evidence of many pros effects on plant growth of substances such as humic and fulvic acids. At low concentrations, humic acid increased the vegetative growth of soybean and corn. Stimulation of root growth can therefore increase plant resistance to disease, plant response to herbivores and nematodes, and water stress caused by drought. Massimi et al., (2019) performed an extension analysis on green bean (the name of the variety is *Valentino*) and a variety of green cowpea (*California Black Eye*). An organic liquid fertilizer product containing 12 percent humic acid and 3 percent fulvic acid should be applied with irrigation water after two weeks of planting and repeated every two weeks during the growing season. The latter research recommended that farmers use one of the most essential organic products manufactured in Jordan, a liquid compound containing the active ingredient organically coated copper-phosphate. It has 10 percent copper and 10 percent phosphorus. The comparative advantage of this commodity is that it is used as a fertilizer for plant nutrition where pulses such as calcium require phosphorus.

It can also be applied with foliar spray at a rate of 100-125 mm per 200 liters of water or with irrigation water at a rate of 500-1000 mm per 0.1 hectares. The active ingredient is an organically coated copper-phosphate that is persistent in plant leaves and soil and has a systematic effect that stimulates the development of phytoalexins and strengthens the walls of plant cells and plant tissues that stimulate plant growth and prevent plant dwarfing. Prevents the penetration of fungus hyphae and bacteria, encircles infected spots with halo and covers the aerial and ground sections of the plant. It is used to protect plants from diseases such as anthracnoses, molds, rots, mildews, and blights. It may also be used to combat fungal wilts (*Fusarium spp*. and *Verticillium spp.*), and fungal damping off (*Fusarium spp*, and *Pythium spp.*).

The addition of nutrients to the soil is generally defined by the negative availability of the nutrients. Each crop requires an adequate soil pH for growth and development. The supply of nutrients for the crop is also linked to the optimum pH of the soil. Cornell University Cooperative Extension released a fact sheet in the agronomy fact sheets series in 2005. The recommended soil pH range for optimal corn growth has been reported (5.8-6.2), and soybean has been reported (6.6-7). Neutral soil pH (around 7) is ideal for the availability of nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium availability. However, iron, manganese, copper, zinc, and boron are more readily available in acidic soils.

Lack of calcium combined with less sap movement in the xylem of tomato plants resulting from a water deficit can affect the production of xylem tissue during the development of the fruit. This hinders the movement of calcium into the fruit by the xylem and as a result, the blossom-end rot may occur and may affect the distribution of calcium inside the damaged fruit, with healthy fruits providing more soluble calcium than the fruits presenting this physiological disorder (Flores, 2018). Also, calcium administered to the plant via foliar application has been to be essential for resistance to bacterial wilt and fusarium crown rot resistance in tomatoes (Woltz et al., 1992) cited in (Singh et al., 2013). Calcium-containing sprays containing calcium can also be used to avoid blossom end rot in tomatoes (Singh et al., 2013).

Powdery mildew (*Leveillula taurica*) is a severe fungal disease, although it is a fungus that can grow very naturally in dry conditions. It lives at temperatures between 10-12 ºC, but the optimum conditions are located at a 30 ºC. It is considered a significant disease of tomatoes in the vegetative, flowering and fruiting stages. As in the case of sweet corn (Plantix App 3.3.0, PEAT, 2020) reported by (Strey, 2020). However, pepper is affected both in the vegetative and in the flowering phases. Powdery mildew affects soybeans in the seedlings, in the vegetative, flowering, and fruiting stages. Amacher et al., (2000) of Utah State University reported that as the soil dries, salts become concentrated in the soil solution, increasing salt stress. Salt problems are therefore more serious under hot dry conditions than under cool, humid conditions. It is reasonable to conclude that drought and salinization increase the chance of plants becoming infected with powdery mildew.

However, contradictory reports have shown that (*Oidium neolycopersici*) induces extreme powdery mildew on all aerial parts of tomato, except fruit. The latter research findings indicate that the combination of high temperatures and low relative humidity can help to reduce *O. neolycopersici* powdery mildew in greenhouse tomatoes (Jcob et al., 2008). Kafle et al., (2017) experimented with tomato as a model plant to improve its resistance to powdery mildew disease (*Oidium spp*. and *Leveillula spp*.) by stimulating its innate immune system at an early seedling stage due to poor drought shocks. Plants have been treated with three degrees of drought stress: low, medium, and high (75 percent, 50 percent, and 25 percent field capacities respectively). Drought treated plants displayed an elevated level of hydrogen peroxide (H2O2) and after disease inoculation, these plants had a higher total phenol content and less area under the disease progression curve with higher biomass compared to the control plants; improved resistance to the powdery mildew. It was concluded that immune provided by hydrogen peroxide and phenolic compounds may be responsible for developing the resistance of powdery mildew in tomatoes.

As a result, foliar sprays are increasingly used in horticulture to increase crop yield and quality, as well as to improve plant production under possible abiotic and/ or biotic stresses (Rengel, 2020).

## 4. Merits and challenges of foliar application technique

On the other hand, in comparison to supplying nutrients to crops via the soil, a new technique called a foliar application or foliar fertilization has emerged. The soil application of fertilizers is mainly based on soil tests, whereas the application of foliar nutrients is largely based on visual foliar symptoms or plant tissue checks. The correct diagnosis of nutrient deficiency is therefore necessary for effective foliar fertilization (Fageria et al., 2009).

Patil and Chetan (2018) noted that foliar feeding has been widely used and accepted as an important part of crop production, especially in horticultural crops. While not as widespread in agronomic field crops, The object of foliar feeding is not to substitute soil fertilization. Supplying the key nutrient needs of a plant (nitrogen, phosphorus, and potassium) is the most efficient and cost-effective by soil application. The foliar application has, however, proven to be an excellent method of supplying plant requirements for secondary nutrients (calcium, magnesium, and sulfur) and micronutrients (zinc, manganese, iron, copper, boron, and molybdenum).

Patil and Chetan (2018) reported the advantages of foliar application in some areas that aid in the rapid correction of nutrient deficiency:

1. It helps to fix nutrient deficiency quickly.
2. Foliar spraying may be mixed with other sprayings such as insecticides.
3. When the soil is low in nutrients, the application of foliar application is advantageous.
4. When a rapid growth response is needed, the foliar application can be sprayed.
5. It will aid during the high phosphorus and potassium fixation.
6. A foliar spray may be applied when adverse conditions such as root rot disease, dryness, *etc*… have been in the field.
7. A foliar spray can also be used if there is insufficient moisture in the topsoil to absorb the nutrients from the roots of the plant.
8. Just use small amounts of fertilizer.
9. Improved parameters of yield and quality efficiency.

Haytova (2013) recorded the merits of foliar application. The technique promotes rapid absorption of mineral nutrients, preventing the occurrence of soil interactions that minimize root uptake due to soil immobilization. It can correct physiological disorders caused by nutrient deficiencies. Foliar application can be used as an integrated pest control practice for the cultivation of many types of vegetables (Haytova, 2013). It can increase crop yields, reduce plant protection costs, and reduces soil and water contamination.

Several studies have reported that the foliar use of nitrogen, phosphorus, and potassium has improved the nutrient uptake of sweet corn. Diver et al., (2001) stated that foliar feeding, used in conjunction with a chlorophyll meter, is a yield-enhancing production technique for corn. This method can be seen as a sophisticated organic farming practice. Another research conducted by (Muktamar et al., 2016) concluded that there is a rise in rates of foliar application of liquid organic fertilizer and nitrogen uptake by sweet corn, but not phosphorus and potassium, in the closed agricultural system. One of the most prominent researchers in this field observed through laboratory analysis of leaves, in the case of magnesium and zinc supply, foliar fertilizers have been able to prevent the production of nutrient deficiency in sweet corn (Racz and Radocz, 2020).

Theoretically, foliar fertilization is more environmentally sustainable, and targeted than soil nutrients fertilization, since nutrients can be transmitted to plant tissues during critical stages of plant growth. However, while the need to remedy a deficiency may be well defined, the effectiveness may be far more unpredictable. Since all aerial plant parts are protected by a hydrophobic cuticle that restricts the bi-directional exchange of water, solutes, and gases between the plant and the atmosphere. However, the nutrient solutions can be absorbed by cracks, stomata, and lenticels (Fernandez et al., 2013).

Stomata can play a major role in the absorption of nutrient solutions applied to leaves and foliages. Mineral element carriers may be added on their own or in a combination mixture with a variety of adjuvants that may boost contact characteristics, absorption rate, and surface distribution of the active ingredient(s) when applied to the leaves. Surfactants are an important, widely used group of adjuvants that reduce the surface tension of nutrient solutions and generally increase their wetting and spreading to the plant surface. Some adjuvants, such as surfactants, penetration synergists, stickers, and humectants, can increase and improve the rate of uptake, retention, and retardation of foliar nutrient sprays drying (Fernandez et al., 2013).

Fernandez et al., (2013) reported that light, humidity, and temperature could affect foliar absorption by affecting plant metabolic status and could therefore cause alteration of photosynthesis, stomatal opening, respiration, leaf expansion, and sink activity, thereby altering the energy and metabolic activity involved in the uptake, assimilation and subsequent transport of foliar-applied nutrients. In conclusion, short-term and long-term environmental interactions have long-term effects on the physical and chemical characteristics of leaves and plants.

From this point on, it can be seen that long-term interactions of abiotic influences, such as relative humidity, light, and temperature, with the biotic stresses such as pests, can alter the efficacy of the foliar application. It has effects on plant nutrient status that changes the structure of the leaf, the physiology of the leaf, and can alter leaf assimilation of foliar applied-nutrients (Fernandez et al., 2013).The process of absorption and biological assimilation of leaf-applied substances is so complex, and many anatomical, physiological, environmental, and physicochemical factors may have a positive or negative effect on plant response to the treatment (Rengel, 2020).

## 5. A close review of foliar application in tomato and pepper

Tomato (*Lycopersicum esculentum* Mill.) and pepper (*Capsicum annuum* L.) are important summer warm-season horticultural crops. Németh and Ehret-Berczi (2014) reported that the production of greenhouse vegetables is a key horticultural field, accounting for a substantial proportion of the production value of horticultural products and contributing to the minimization of imports in Hungary. Greenhouse vegetables account for 5-6 percent of the total area of vegetable production in Hungary, where tomatoes are the most important vegetable crop for greenhouse vegetables after paprika. In addition, the agricultural survey conducted in Jordan by the Department of Statistics (2017) confirmed that tomatoes in Jordan are a major vegetable crop. Of the total area (37695.6 ha) cultivated with all other vegetables, the total area grown for tomato cultivation in 2017 is (12194.5 ha). A similar pattern was recorded in the oldest agricultural survey in Jordan in 1995, with the tomato region representing a greater area of (11104.6 ha) than the total area of vegetables (42930.9 ha). Massimi and Al-Bdour (2018) reported that according to statistics from the Jordan Government's (2016) Statistics Department, the total area of vegetables in Jordan was approximately 50579 hectares including open and covered crops, most of which included tomatoes, squash, eggplant, cucumbers, potatoes, cabbage, cauliflower, pepper, and faba-beans. In 2017, tomatoes, squash, eggplant, cucumber, potatoes, paprika, and cauliflower were the highest in Jordan (Department of Statistics, 2017). The statistics on Hungary and Jordan show the importance of tomatoes and pepper plants.

On the opposite side, the absorption of nutrients from water solutions and foliar applications on the leaves and their physiological impacts on the plant have been the focus of study for many decades. The first reports for foliar applications are available in France during the 1844 year (Haytova, 2013). After these first publications, several other studies have given rise to the popularity of the foliar application.

Yildirim (2007) studied the impact of foliar and soil fertilization with humic acid (HA) on the growth and yield of tomatoes under greenhouse conditions in 2004 and 2005. Tomato plants have been treated with soil and foliar humic acid applications at various concentration levels of (0 ml $l^{-1}$, 10 ml $l^{-1}$, and 20 ml $l^{-1}$). During the vegetation season, humic acid was sprayed four times at 10-day intervals after three weeks of planting. In addition, 0, 10, and 20 ml $l^{-1}$ humic acid solutions were applied to the root region of the plant four times during the vegetation cycle at 10-day intervals three weeks after planting. Foliar applications have led to a higher content of leaf and stem dry matter than control. Fruit characteristics, including fruit diameter, fruit height, mean fruit weight, and fruit number per plant, were positively influenced by both foliar and soil treatments. In the same way, treatments increased the early yield of tomatoes compared to control. The yield of tomatoes was significantly affected by soil and foliar applications. The highest yield was observed occurred in the foliar treatment of 20 ml $l^{-1}$. The study concluded that the concentration of 20 ml $l^{-1}$ of humic acid sprays could be successfully used to achieve better growth and yield in the tomato plant. Premsekhar and Rajashree (2009) found that foliar feed application of 5 N-P-K sprays (19:19:19) recorded the tallest tomato plant (the hybrid name is *COTH 2*), highest fruit weight, the highest fruit number per one plant, fruit yield, and the highest cost-benefit ratio (BC). This may be due to the higher fruit yields obtained in the foliar application treatment.

Further in-depth studies demonstrated the effectiveness of the foliar application technique. It has previously been mentioned that zinc deficiency is considered to be one of the nutritional constraints for the development of vegetable crops, in particular tomato plants. Ejaz (2012) tried and tested tomato cultivar (*Sahil*). Seedlings were planted on raised beds under polytunnel with a uniform spacing of 45-cm plant-to-plant distance and 75-cm as bed–to-bed distance. ZnSO4 was used as a source of Zn (10 percent or 12 percent) and Urea as a source of nitrogen (N) (1 percent and 2 percent). The results showed that the foliar application of either Zn or N separately at both concentrations increased, growth, yield, and quality of tomato cultivar. However, the most prominent result showed that the combined use of both Zn (12 percent) and N (2 percent) increased the growth, yield, and quality of tomato plants. This research concluded that the combined use of Zn and N in foliar applications can be a viable practice in the production of tomato plants. Li et al., (2018) published an article in the Journal of Experimental Botany comparing the absorption of Zn when supplied as either ZnSO4, nano-ZnO, or bulk-ZnO and found that the absorption of ZnSO4 was around 10-fold higher than that of nano-and bulk-ZnO, indicating that it was mainly absorbed as soluble Zn. The latter study investigated the role of trichomes in the absorption of foliar-applied zinc fertilizers in tomatoes and soybeans.

Other findings indicated that the foliar application of Zn on two tomato cultivars (*Blizzard*), and (*Liberto*) may overcome the negative effects of zinc deficiency on plant growth when applied to the optimum range (Kaya and Higgs, 2002). However, several other contradictory studies have shown other findings. The research carried out in Turkey was to investigate the effects of copper application on calcareous soil and leaves on the yield and growth of tomato plants. Copper was first applied to soil as CuSO4.5H2O in three different levels (0, 1000, and 2000 mg of copper $kg^{-1}$) and then to leaves at three different frequencies (no application, biweekly, and weekly application) in pot experiments performed in a computer-controlled greenhouse. Total yield, the number of fruits, dry root weight, and plant height decreased with increasing application of copper (Cu) to the soil. Increased levels of copper added to the soil and leaves resulted in decreased final fruit count, dry root weight, and plant height at $4^{th}$, $5^{th}$, and $6^{th}$ weeks. The combined applications of copper to soil and leaves may be more deleterious to plants than when copper is applied only to soil or leaves (Sonmez et al., 2006).

Wittwer et al., (1963) cited in Singh et al., (2013) reported that plant foliage resistance to foliar application varies from plant to plant. However, the resistance of tomato and pepper foliage resistance was close (0.48-0.72 Kg of Urea sprays 100 $l^{-1}$ of water). Singh et al., (2013) also compared the timing and application rates of sulfur foliar in different crops. The researchers concluded that the tomato plant can be sprayed 3 times at the stage of the first sign of bloom, 21 days after the first spray, and 14-21 days after the second spray. The foliar sulfur spray was at a rate of (0.18 – 0.36 Kg $Acre^{-1}$) for each tomato spray. However the pepper plant recommended to be sprayed at the bud formation stage, 10-14 days after the first spray, and 10-14 days after the second spray at a rate of (0.11-0.23 Kg $Acre^{-1}$) per each sulfur spray time.

Plants such as tomatoes and peppers need high levels of magnesium for optimum growth. However, the effects of magnesium deficiency cannot be seen by plants until it is serious. The foliar application of a 2 percent solution of MgSO4 to tomatoes also relieved magnesium deficiency and improved crop yields (Singh et al., 2013). Nannette (2011) recommended foliar spraying of magnesium sulfate hydrate (epsomite) in tomatoes and peppers for maximum product growth, yield, and quality.

There is a complex relationship between abiotic stresses such as drought and salinity and plants' susceptibility to diseases. It highlights the importance of foliar application as one of the integrated pest management methods for the treatment of diseases in conditions of heat stress, drought stress, and salinization of soil such as Jordan. It is important to note the indirect relationship between drought stress and other forms of stress, i.e. high temperatures may trigger drought stress, and thus salinity stress. It can be understood that drought stress is the most significant abiotic stress in horticultural crops. Utah State University Amacher et al., (2000) stated that as the soil dries, salts are accumulated in the soil solution, increasing salt stress. Therefore in hot dry conditions, salt problems are more extreme than in cool, humid conditions. Vegetables are succulent, most of the plants are sensitive to drought stress, particularly from flowering to stage of seed growth. It has been stated that corn, soybeans, beans, and peas are considered to be moderately sensitive to water stress, while tomatoes are part of a community group sensitive to severe drought (Nemeskeri and Helyes 2019). A greenhouse experiment was performed to investigate the effects of potassium (K) foliar application on pepper plants grown with various irrigation salinity waters (3000 and 6000 ppm as compared to tap water with a salinity level of 300 ppm). In contrast to those of plants irrigated by tap water, irrigation with high salinity water decreased plant height, biomass production, and fruit yield. For the plants under the maximum salinity irrigation (6000 ppm), the most serious impact was compared to plants under moderate salinity irrigation (3000 ppm). Foliar application of potassium monophosphate (KMP) at 200 ppm concentration increased plant growth, biomass production, and fruit yield. This showed that to some degree, foliar application of KM mitigated the adverse effects of high salinity water irrigation on the growth of pepper plants and fruit yield (Hussein et al., 2012).

## 6. Conclusions and recommendations

In short, the use of foliar application techniques in the development of horticultural plants is a critical strategy for integrated management of pests, sustainable practices in the environment, and healthy food production. To improve integrated management practices and integrated plant protection, it is proposed that agricultural science research be expanded. This requires specialized research to discover the ability of a foliar application to treat pests that spread in certain environmental conditions. It is recommended to investigate the relationship between the development of powdery mildew fungal disease, and drought stress on tomatoes and peppers in Hungary and Jordan.

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Faculty of Mechanical Engineering

# ARCHITECTING FARMER-CENTRIC INTERNET OF THINGS FOR PRECISION CROP PRODUCTION

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**Abstract:** The aim of this study is to develop a decision support system using sensors and IoT (Internet of Things)-based application in precision agriculture, first of all, in Hungary. These new technologies have the potential to transform decision-making in agriculture and to reduce environmental impact. In this paper, the advantages are demonstrated of two types of sensor sets that were installed to collect data from soil, plant, and the environment. Data are processed in a decision-making system. The proposed system allows users to monitor the fields in real-time and gives recommendations for production using wireless and internet communication.

**Keywords:** sensors, wireless network, LoRaWAN, precision agriculture, IoT

## 1. Introduction

Major IoT technologies include radio frequency identification technology, sensor technology, sensor network technology and internetwork communication, all of which have been involved in the four links of IoT industrial chain, namely, identification, sensing, processing and information delivery **(TongFe, 2017)**. In this way, IoT can operate certain programs and realize remote control (**Kovács and Husti, 2018)**. The Internet of Thinsg (IoT) provides lots of sensor data. However, the data by themselves do not provide value unless it is converted into some action. Real-time sensor data analysis and decision-making is often done manually but to make it scalable, it is preferably automated (**Bandi et al., 2017**). Smart farming era has already begun and its social and environmental impacts are expected to be major. Thought IoT technologies have became the large-scale path towards practices (**Glaroudis et al., 2020**). IoT has the potential to become the key enabler for realizing the vision of smart agriculture (**Sinha et al., 2019**). IoT are associated thorough Internet via Wireless Sensor Networks (WSN), Radio-frequency Identification (RFID), Bluetooth, Near-field communication (NFC), Long Term Evolution (LTE) and various other smart communication technologies (**Khanna and Kaur, 2019**).

IoT in this way some sensors connect the internet, so as to operate certain programs and realize remote control. The central computer can Smart Agriculture Based on Cloud Computing and IoT realize concentrated management and control of machine, equipment and personnel based on the internet and improve production and life through more detailed and dynamic means. This is useful for integration and harmony between human society and the physical world and is regarded as the third wave of information industry development following computer and internet. Major IoT technologies include radio frequency identification technology, sensor technology, sensor network technology and internetwork communication, all of which have been involved in the four links of IoT industrial chain, namely, identification,

SmartFarmNet IoT based platform is capable of automating the process of data collection from various parameters related to agriculture e.g. environmental, fertilization, soil, irrigation, etc. It is also capable of correlating data and filtering out invalid variable from the perspective of assessing crop performance and computation crop forecasts (**Jayaraman et al., 2016**).

The long-term aim is the continuous automatic validation of data provided by the on-the-go measuring systems that occurs while passing by the installed stations and making wireless corrections in the measurement of mobile devices. Based on previous background collected by research, the IoT system will be expanded and operated (**Nyéki et al., 2020**). The information, automatically gathered by the sensors, is analyzed and different techniques (e.g. decision support system and artificial intelligence) are compared. Artificial Intelligence (AI) provides the framework and tools to go beyond trivial real-time decision and automation use cases for IoT (**Bandi et al., 2017**). Until now, parameters were measured manually in a hard, long and expensive process. This new sensors network offers "Big Data" and clearer results.

### *Internet of Things hardware, platforms and sensors in crop production*

The structure of IoT is based on three layers: namely, the perception layer (sensing), the network layer (data transfer) and the application layer (data storage and manipulation) (**Tzounis et al., 2017**).

The first expectation is a fault tolerant and energy efficient WSN architecture for real time monitoring of the field conditions. Several IoT based commercial platform have been developed with the vision of modernizing and enhancing the effectiveness of farming process (**Sinha et al., 2019**). Due to the distributed nature of IoT, in cases of battery-operated nodes, placed in crop fields or other agricultural facilities, replacing the power source can be a very difficult task, if not impossible. Other factors making a low-power, embedded device selectable for a deployment are its long-term stability, the number of digital and analogue inputs/outputs which determines the number of peripheral sensors (**Tzounis et al., 2017).**

The quality of field crops depends mainly the soil and the meteorological – seasonal- conditions they are growing. The soil type, chemical and physical conditions, moisture content and some other factors are responsible for the quality of crop yield. Information can be obtained using sensors, with low power devices that collect data from soil, crop and the surroundings by growing season. Sensing has led to adoption of technology in the precision agriculture and it also enables improved efficiency of agricultural production and practices (**Vuran et al., 2018**). To observe the growth of the crop under varying real-time conditions (e.g., soil quality, environmental conditions, etc.), typical crop studies involve phenotyping to understand the key factors (e.g., the soil pH level, the rate of nitrification) affecting crop growth (**Jayaraman et al., 2016**). The application of technology in the field are used to improve crop yield or quality and to reduce costs. The use of WSN in precision agriculture assists the farmers in a statistical number, helping them make better and well informed decisions (**Fang et al., 2014; Kodali et al., 2014**). Sensors are used for irrigation scheduling to measure humidity, solar radiation, temperature (**Fourati et al., 2014**).

Due to limited prosessing power and energy considerations, data processing, storage and decision making are not generally conducted locally. Field information can be stored in a private database (**Yan et al., 2017**). Sensor data is transmitted to a local gateway, which transit the database to data center for storage and analysis. Data center is mainly cloud or server storage. Real time monitoring by implementation of WSNs contributes to minization of potential production risks, emerging mainly from environmental influences and human actions (**Wu et al., 2013**). Furthermore, real time data from fields may be used by farmers to help adjust the crop production strategies at any time, without the need to use of a tractor to get to each sampling point. Therefore, the implementation of WSNs contributes to some extent to the decrease of energy consumption in agriculture (**Srbinovska et al., 2015**).

*Table 1.* Summary of the most popular IoT wireless technologies
(Source: Tzounis et al., 2017)

| Wireless technology | Wireless standard | Network type | Operating frequency | Max. range | Max data rate & power | Security |
|---|---|---|---|---|---|---|
| WiFi | IEEE 802.11a, 11b, 11g, 11n, 11ac, 11ad | WLAN | 2.4, 3.6, 5 GHz 60 GHz | 100 m, | 6–780 Mbps 6.75 Gbps at 60 GHz 1 Watt | WEP, WPA, WPA2 |
| Z-wave | Z-wave | Mesh | 908.42 MHz | 30 m | 100 Kbps, 1 mW | Triple DES |
| Bluetooth | Bluetooth (Formerly IEEE 802.15.1) | WPAN | 2400–2483.5 MHz | 100 m | 1–3 Mbps, 1 W | 56/128 bit |
| 6LowPAN | IEEE 802.15.4 | WPAN | 908.42 MHz or 2400–2483.5 MHz | 100 m | 250 Kbps, 1 mW | 128 bit |
| Thread | IEEE 802.15.4 | WPAN | 2400–2483.5 MHz | N/A | N/A | N/A |
| Sigfox | Sigfox | WPAN | 908.42 MHz | 30–50 km | 10–1000 bps | N/A |
| LoRaWAN | LoRaWAN | WPAN | Various | 2–15 km | 0.3–50 kbps | N/A |
| BluetoothSmart (BLE) | IoT Inter-connect | WPAN | 2400–2483.5 MHz | 100 m | 1 Mbps, 10–500 mW | 128 bit AES |
| Zigbee | IEEE 802.15.4 | Mesh | 2400–2483.5 MHz | 10 m | 250 Kbps, 1 mW | 128 bit |
| THREAD | IEEE 802.15.4, 6LoWPAN | Mesh | 2400–2483.5 MHz | 11 m | 251 Kbps, 2 mW | 128 bit AES |
| RFID | Many standards | Point to Point | 13.56 MHz | 1 m | 423 Kbps, about 1 mW | Possible |
| NFC | ISO/IEC 13157 | Point to Point | 13.56 MHz | 0.1m | 424 Kbps, 1–2 mW | Possible |
| GPRS | 3GPP | GERAN | GSM 850, 1900 MHz | 25 km/10 km | 171 Kbps 2 W/1 W | GEA2/GEA3/GEA4 |
| EDGE | 3GPP | GERAN | GSM 850/1900 MHz | 26 km/10 km | 384 Kbps, 3 W/1 W | A5/4, A5/3 |
| HSDPA/HSUPA | 3GPP | UTRAN | 850/1700/1900 MHz | 27 km/10 km | 0.73–56 Mbps, 4 W/1 W | USIM |
| LTE | 3GPP | GERAN/UTRAN | 700–2600 MHz | 28 km/10 km | 0.1–1 Gbps, 5 W/1 W | SNOW 3G Stream Cipher |
| ANT+ | ANT + Alliance | WSN | 2.4 GHz | 100 m | 1 Mbps, 1 mW | AES-128 |
| Cognitive Radio | IEEE 802.22 WG | WRAN | 54–862 MHz | 100 km | 24 Mbps, 1 W | AES-GCM |
| Weightless-N/W | Weightless SIG | LPWAN | 700/900 MHz | 5 km | 0.001–10 Mbps, 40 mW/4 W | 128 bit |

Numerous wireless devices have been developed upon the various wireless standards. As can be seen in Table 1, IoT wireless communications provide a wide variety of bandwidth, power consumption, network type and communication range. So, the number of sensor sets (or nodes), the distance between them, the operating frequency based on the size of messages (size of required data) are pivotal factors to be taken into consideration, when choosing a wireless transceiver for open-field operation.

LoRa (LongRange) is a digital wireless data communication technology used long-range connectivity for various IoT devices. The LoRaWAN network ensures the messages between end-devices (sensors) and a central network server. The major benefits of this system are low power, low range and low cost connectivity. LoRa has brought in a lot of interesting application such as utilities, precision agriculture and smart city (**Singh et al., 2020**).

## 2. Materials and methods

### *Agro-IoT system in Mosonmagyaróvár (M-AIoT)*

The systems main purpose is to collect data from crop fields and from the surrounding natural (or quasi-natural) areas. Thereby, the relationship between natural ecology and agro-ecology can be profoundly studied. One of the tools of processing Big Data is using artificial intelligence.

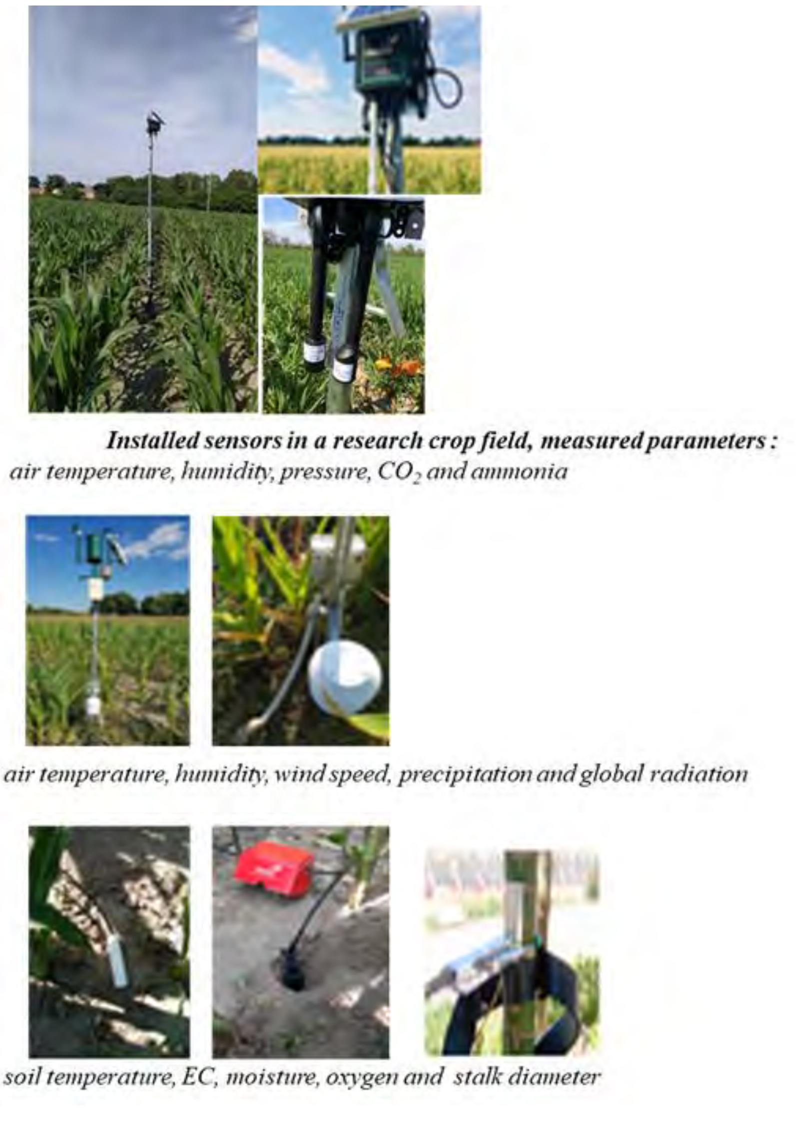


*Figure 1.* Sensor components of M-AIoT system in Mosonmagyaróvár
Source: based on Nyéki et al., 2020

***Components of M-AIoT system***

The system consists of soil, crop, environment and atmospherics sensors (Figure 1). This system is based on solar energy power. In this project Raspberry Pi, Arduino and Libelium (http://www.libelium.com/) platforms.

## 3. Results

This paper presents an IoT web-based platform for agriculture farming system with the use of Raspberry Pi, Arduino and Libelium platforms. The results focuses on online monitoring of fields with LoRaWan communication protocol.

By interconnecting all the sensors shown above, we proposed a system for a commercial use for monitoring agricultural fields.

***Server structure***

In this project was designed a system structure which can integrate the database from different sensors (from different producer) using different communication protocols. The server development was implemented in .NET language. MS SQL database was used to store the sensor data. The system consists Raspberry Pi, Arduino platforms using different sensors with GSM communication, which were developed by research team (Figure 2). Arduino and Raspberry Pi platforms with GSM communication were developed in this project, which have different purpose and sensors. We also use Libelium's sensors and Lorawan's data communication device through purchases.

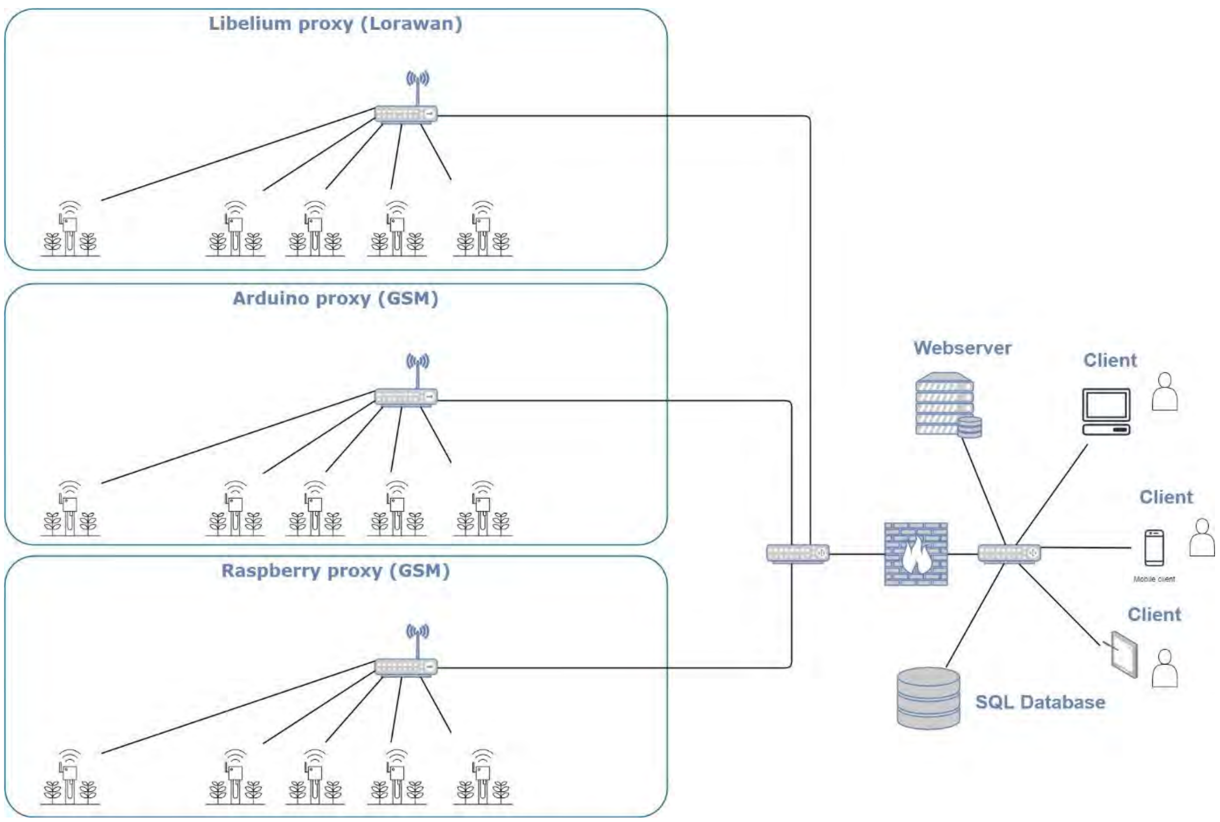


*Figure 2.* Diagram of IoT server structure

The aim of the IoT-based web interface development was a farmer-centric system that allows (displays) for end-users the clear database enhanced useful information for farming. Therefore, a web application (site) was development that already supports useful tools what was development in Angular platform. The web interface is designed to handle the different GPS-based measuring stations from crop fields uniformly. This web-based system can provide a comparative and valuable analysis with the experiences and conclusions. The analysis can help the farmers and makes them better decisions related to field management (e.g. optimal time for sowing, optimum nitrogen fertilizer amount, irrigation recommendation). The improvement was constructed in Angular framework. The development of system applications and tools are continuous.

*The achieved tools and features of system are the following.*

As web administrator:

- adding a new sensor types to the system,
- application of new sensors with IDs, units, measuring ranges,
- register a new sensor station with GPS coordinates,
- register a new repeaters in the system.

As user:

- viewing measurement data,
- tabular view,
- chart view,
- handling alerts,
- overviewing of sensor (measuring) stations on a map.

Figure 3 shows the dashboard with graphical display of values from field sensor. The user can choose the time interval and the sensor type from given GPS-based measuring station.

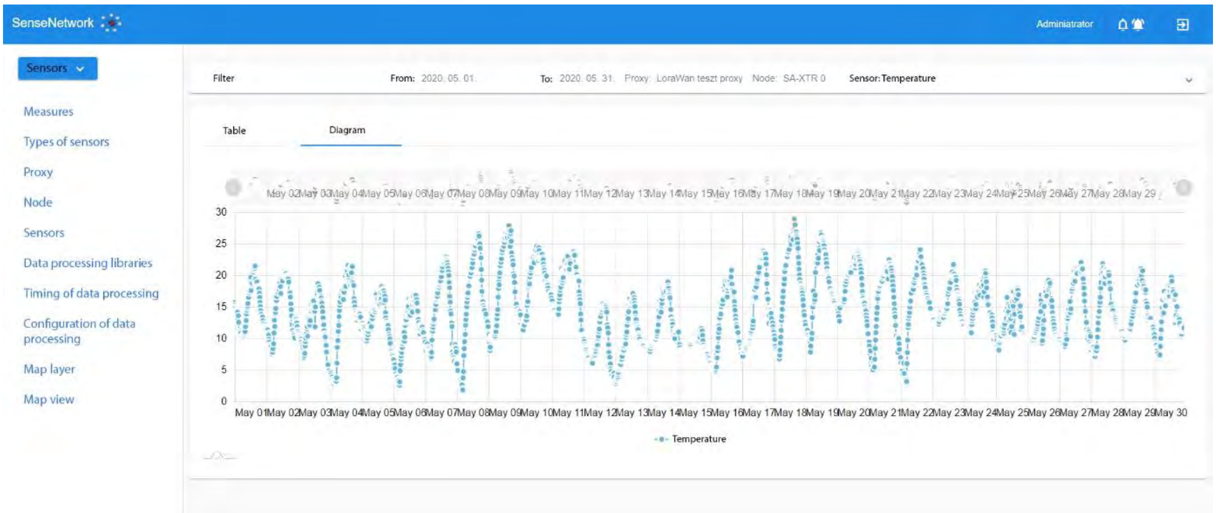


*Figure 3.* Graphical display of temperature values from the sensor

Figure 4 shows the alarm view of the user interface where the user can configure email and sms alerts. The complexity and intricacy of alarms can be adjusted to the specific microclimatic environment, crop or sensor. It is possible to examine the absolute value of a given sensor value. For example, if the soil temperature has reached 7 degrees Celsius. It is possible to examine the average of a given time interval, for example, the average air humidity over the past 12 hours was higher than 80%. Furthermore, there is an opportunity for combining the conditions of different sensor data, e.g. if the air temperature in the last 24 hours has been higher than 15 degrees Celsius and the air humidity has been higher than 75% in the last 18 hours.

The specific alarms can be saved by the farmer. In the case of a certain condition or conditions system is confirmed, the farmer will be notified by e-mail and / or sms.

Additionally, through the platform, we can collect data from field sensors, such as temperature, dielectrical permittivity and soil electrical conductivity (Figure 5). These values are suitable, for example, for irrigation support.

The application has a high usable visual functionality on the basis of the variables acquired by the sensors. In this way, intelligent programming can be achieved for farmers, too, with simple programming settings. The field information come from soil, weather, environment and plant conditions. The essential web platform requirement in our project is to be able to store, scale, process of several hundreds of agricultural IoT sensors.

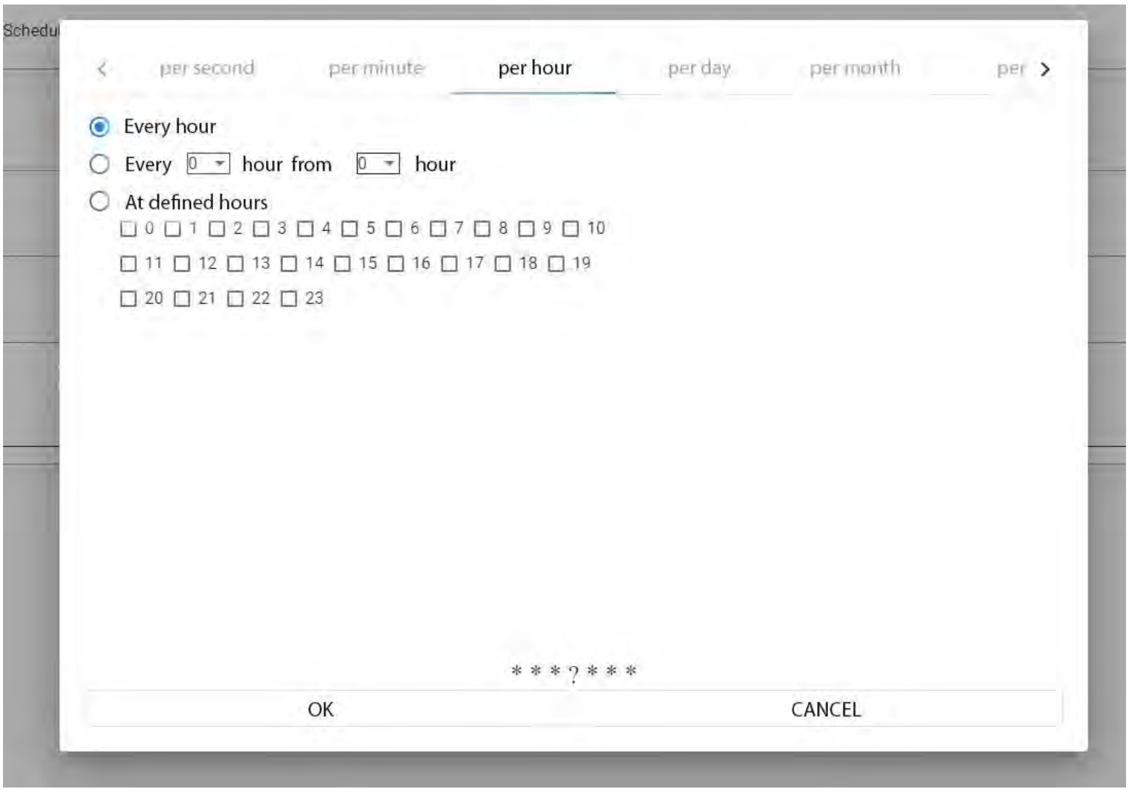


*Figure 4.* Specific alarms setup on IoT platform

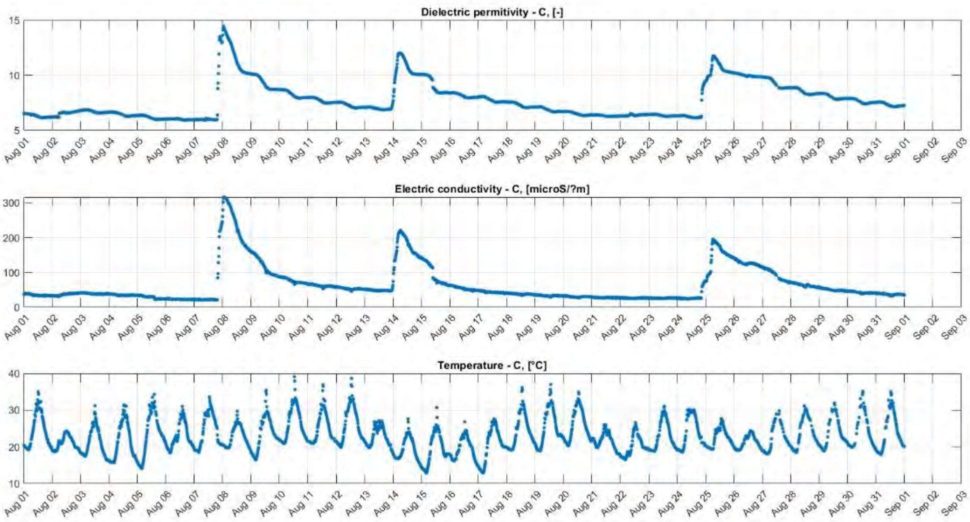


*Figure 5.* Dielectric permittivity, electrical conductivity and temperature measured from August 1 to September 3

## 4. Conclusions

In this paper, we proposed an IoT-based farmer-centric system, which provide automated control of crop production. The proposed system is beneficial for farmers as well as decision makers. The web-based system provides interconnections between different sensors using wireless and web technologies to monitor field conditions. In this paper have presented a new decision support system for agriculture using different sensors and connection types. This system comprises automatic sensors with wireless networks and web application.

The database system will be implemented as a web-based system. The collected and stored data will be used for decision making to monitor and control the automatic management of crops. The system can send notifications about water demand of crop, temperature and moisture content of soil in order to suggest the irrigation, planting or other application. The user can also be used to determine the optimum time to crop protection. Moreover, this database allow data mining to analyze the data for predicting environmental variables for optimal future crop production management. Furthermore, we would like to implement effective prediction of sensors database using artificial intelligence. Therefore, the farmer will be able to manage more efficiently the site-specific, precision farming.

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Faculty of Mechanical Engineering

# BUSINESS MODEL INNOVATION WITH PRECISION FARMING TECHNOLOGY FROM THE FARMERS POINT OF VIEW

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**Abstract:** Agricultural holdings try to survive in the fast-changing word. The agricultural production goes throw several revolutions. These revolutions motivated companies to change their business models. The digital revolution going on nowadays. Digital agriculture has emerged as a way of feeding the world sustainably using technologies and data science to optimise on-farm production and supply chains that are responsive to real-time consumer demand. The aim of this paper to identify the changes in business model by precision farming technology. The new production methods give a chance to the agricultural holdings to make ability to take advantage of new opportunities and face with the modern challenges and new requirements.

**Keywords:** digital revolution, farming 3.0, business strategy, business models, precision farming

## 1. Introduction

Numerous global trends are influencing on agribusiness. Agricultural production needs face with the following main challenges: growing population, increasing urbanization, climate change, technology change. Modern agricultural holdings try to survive in the fast-changing word. Modern food systems face the growing challenges of climate variability, population growth, and ever-changing consumer preferences. Modern farms will work differently than the farms in the last decades. The new agricultural equipment use sensors and information technology. Future agriculture will use sophisticated technologies such as robots, temperature and moisture sensors, aerial images, and GPS technology. The researchers call this kind of change agricultural revolution which let farms be more profitable, efficient, safer, and environmentally friendly. Otherwise, in social-level the demand for the fork-to-fork monitoring of plant production is increasing. With precision farming technology, huge amount of information could be realized about the production process. The society requires the decreasing of environmental damage, ecological sustainability. Both demand make true with precision farming technology (Lencsés, 2016). We are in the middle of new agriculture revolution. The stages of the agriculture are the following (Kovács – Husti, 2018; Lejon – Frankelion, 2015; Popp et al., 2018; Rose – Chilvers, 2018; Varga, 2018), (Figure 1):

1. Labour-intense agriculture: low productivity, enough food for population and the 1/3 of the population needed to work in the agriculture.
2. Green revolution: the adoption of new technologies such as yield variety, chemical fertilizers, agro-chemicals, irrigation, new methods of cultivation, including mechanization. The key leader was Norman Borlaug.
3. Digital revolution / Precision farming:
   variable rate technology, site specific decision, GIS, GPS
4. Smart farming: big data, cloud based, on-line sensors, UAV
5. Robotic farming: robots use in agriculture production e.g. spraying drones, weed-management robots. These technologies are still under development.

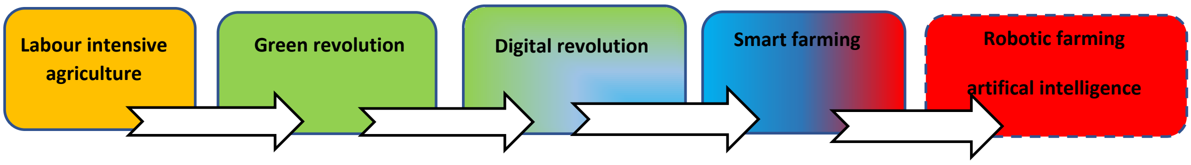


*Figure 1.* Technology revolutions in agriculture production, Own structured based (Kovács – Husti, 2018; Lejon – Frenkelius, 2015; Popp et al., 2018; Rose – Chilvers, 2018; Varga, 2018)

The green revolution has brought to over-cultivation and excessive chemical usage, which has contributed to land degradation and great harms of natural ecosystems. This episode leading to the need of sustainable resource management. The third industrial revolution leads to the digital revolution in the agriculture. Precision farming which is also knows as satellite farming or site specific crop management is the part of digital revolution. The goal of precision farming technology is to optimizing returns on inputs while preserving resources. There is no one exact definition of precision farming technology because these technology is still under development mostly in case of sensors and variable rate technology (VRT). This paper uses the definition on the basis of the European Parliamentary Research Service (2016): 'precision farming, is a modern farming management concept using digital techniques to monitor and optimise agricultural production processes. Rather than applying the same amount of fertilisers over an entire agricultural field. It will measure variations in conditions within a field and adapt its fertilising or harvesting strategy accordingly. Precision farming has several synonyms (Tamás, 2001): site specific production/technology, spatial variable technology, spatial decision supporting system, satellite farming. The smart farming is the development of original precision farming technology (the ideology behind the field production is the same). Romeo (2016) was the first use of the 'Smart farming' terminology. Smart farming is include smart control devices (on-board computers), sensors for agronomic process, automation capabilities (guidance, seed placement, spraying, etc, communication technology (telematics). Smarter machines should use the minimum amount of energy to turn the natural environment into useful agriculture, thus cutting out wasted energy and reducing costs (Blackmore, without year). According to the representative research of Research Institute of Agricultural Economics in 2016 among the Hungarian farmers only 7% used any type of precision farming technology, the majority of the Hungarian farmers still have been only in the 'Green revolution' stage. Only 15% of the precision farmers who used any kind of on-line sensors which could be the base of Smart farming (Kemény et al., 2017). Business model is a concept which has been widespread in business and management sciences since 1990s (Lambert – Davidson, 2012). The focus of the concept is the business logic; as it elaborates what a business actually does and how it makes profit. This concept is related to the creation and deliver of value by a company. According to Magretta (2002) business models are like stories illustrating how an organization work.

Osterwalder et al. (2005) provide a model to design and analyse the business model. This model includes four pillars: 1) product/service, 2) customer interface, 3) infrastructure management, and 4) financial aspects. According to this model, to analyse the pillar of product/service, the value proposition of the business should be analysed. Value proposition is defined as an overall view of a company's bundle of products and services (Ostelwalder et al., 2005). To analyse the pillar of customer interface, three sub-variables should be studied (target customer, distribution channel, and relationship). The target customer is the segments of customers a company wants to offer value to. Distribution channel is considered as the various means of the company to get in touch with their customers. And finally, relationship explains the kind of links a company establishes between itself and its different customer segments. Osterwalder et al. (2005) express that value configuration, core competency, and partner network are the representative of infrastructure management. In this model, value configuration describes the arrangement of activities and resources. Core competency outlines the competencies necessary to execute the business model. Partner network portrays the network of cooperative agreements with other companies necessary to efficiently offer value.

The last pillar of this model is the financial aspects. This pillar contains cost structure and revenue model. Cost structure sums up the monetary consequences of the means employed in the business model. And revenue model describes the way a company makes money through a variety of revenue flows. Decision makers select their business model based on strength, weakness, environmental opportunities and threats. The business models of competitors could be completely different. Competitor who selects the best model and implements it effectively can win the trade and competition.

Osterwalder et al. (2005) discuss the identification of this area is the main step to keep in state of art and to make timely changes. In other word a business model not only helps managers to identify the current situation of each mentioned areas, but also it helps to track the trends and respond dynamically to the transitions. Different reasons force the organizations to change their previous business model. Investments and innovations, information systems, human capital, new technologies are some from the lots of examples of business model innovation driving forces. Hence to respond to these changes the businesses must reconsider their business model. Of course, the aim of agility is not just inactively responding to the environment changes, it is also considered as taking advantages of changes (Dove, 1994; Kidd, 1994; Sharifi – Zhang, 1999).

Innovation in a business model is not simply mean the innovation in services/products or technology (Lindgadt et al., 2009; Massa – Tucci, 2013; Mitchell – Bruckner, 2004). Lindgardt et al. (2009) believe that when innovation in business model is happened that at least two components are reinvented and innovation in just product/service does not count as a business model innovation. According to them the two main parts of the business model are the value proposition model and the operating model. Value proposition model includes following components: target segment, products/services offering, revenue model, operating model, comprises value chain, cost model, and organization. Lindgardt et al. (2009) discuss that since a business model is a multidimensional system changing in more than two of its components leads to changing the whole of the model and it is business model innovation. Whiles, Mitchell and Bruckner (2004) argue that innovation in at least four business model components leads to business model innovation which enables the company to offer new products/service to new segments of the market. Nevertheless, innovation in business model has been always recommended, due to the sustainable competitive advantage is created in business model innovation (Giesen et al., 2007; Mitchell – Bruckner, 2004). Massa and Tucci (2013) also argue that business model innovation consists innovation in content, structure and governance. Amit and Zott (2012) discuss that innovating a business model is usually taking place in three ways: set up a new activity, connecting the activities in new ways, and changing the parties carry out an activity. They need to dynamically trace the trends and to have a proper change management to be able response on time to these changes (Mitchell – Bruckner, 2004). Of course, the aim of agility is not just inactively responding to the environment changes, it is also considered as taking advantages of changes (Sharifi & Zhang, 1999; Dove, 1994; Kidd, 1994).

## 2. Methodology

In case of farmers who want to use precision farming technology there is no standard practice for how the application of the new technology will change their business model (both in the developed agricultural producing countries both in the weaker agriculture countries). This paper wants to give a framework for the farmers how they think about their business model with precision farming technology. In the literature background the development of agricultural technologies and the business model innovation were studied. The aim of this paper to fit to the adaptation of precision farming technology in the business model innovation theory which based on Lindgardt et al. (2009). This case study identifies the competitive advantages of the precision farming technology in the business model point of view.

According to Lindgardt et al. (2009) the business model innovation examined with the following factors:

- Target segment: Which customers do we choose to serve? Which of their needs do we seek to address?
- Product offering: What are we offering the customers to satisfy their needs?
- Revenue model: How are we compensated for our offering?
- Value chain: How are we configured to deliver on customer demand?
- Cost model: How do we configure our assets and costs to deliver on our value proposition profitably
- Organization: How do we deploy and develop our people to sustain and enhance our competitive advantage?

## 3. Results and discussion

Time by time the changes of business models are necessary. For examples because of an investment or innovations e.g. new technology or Enterprise Resource Planning systems goes together with strategic and business model changes. However, the flexibility of agricultural holdings is not limited to specific changes in the environment reactions, the main objective should be the competitive advantages resulting from changes (Dove, 1994; Kidd, 1994; Sharifi – Zhang, 1999).

*Table 1*: Changes of business model element by Lindgardt et al. (2009) thanks to the adaptation of precision farming technology

| **Components of business model** | **CONVETIONAL FARMING** | **PRECISON FARMING** |
|---|---|---|
| TARGET SEGMENT | B2C[1]: people who wants to consume fresh agricultural products<br><br>B2B[2]: business at the food industry who looks for raw materials | B2C: fresh agricultural product's consumers who want to tracing a food and who has a moderate environmental friendly attitude<br><br>B2B: business at the food industry who looks for raw materials and for whom the comprehensive system of traceability is very important |
| PRODUCT OFFERING | Agricultural products e.g. crops, vegetables, fruits. | Agricultural products e.g. crops, vegetables, fruits. |
| REVENUE MODEL | In the agriculture price and yield volatilities are general because of the high-risk factors. | With precision farming technology the yield volatilities become less general because of the more rational input usage. |
| VALUE CHAIN | Whole range of goods and services necessary for an agricultural product to move from the farm to the final customer or consumer. | The members of the value chain is the same than in case of conventional agricultural production. The difference that less chemicals are used with precision farming technology. The rational chemical usage could be a tool for enhancing consumer confidence in the agricultural products. The distribution is not changed. |
| COST MODEL | According to FADN cost structure the costs linked to the agricultural activity of the holder and related to the output of the accounting year.<br>Included: crop-specific inputs, total farming overhead, depreciation of capital assets estimated at replacement value, total external | The cost model is the same than in the conventional farming methods. We need to recalled that the investment of the precision farming technology is higher than of the conventional equipments. |
| ORGANIZATION | Generally, the staff of the agricultural holdings is not well qualified or well educated | The precision farming technology is very sensitive to the digital skills of the staff and management. The management commitment of technology is very important factor in case of the new modern technology |

Source: own research

[1] B2C (Business-to-Customer): process of selling products and services directly between consumers who are the end-users of its products or services

[2] B2B (Business-to-Business): situation where one business makes a commercial transaction with another business

Table 1. presented the main factors of business model in case of conventional and precision farming technology.

Precision farming is also in line with the EU's long-term potential, as set out in the Green Deal Farm to fork initiative. In this, it is strategically important to write crop pests and pathogens in a safe, alternative way. It also aims to make food raising healthier and more environmentally friendly. This preserves the conservation of biodiversity and the protection of the health and well-being of citizens against environmental risks and impacts (Eurpoean Commission, 2020).

## 4. Conclusion

The adaptation of precision farming technology gives a lot of competitive advantage for the farmers. Thanks to the lots of data about the filled and yield the precision farmers could give a chance to better monitoring and tracing for their buyers. The traceability (fork-to-fork thinking) is becoming more important in case of food processing and consumption. There is no change in the form of products but the quality and quantity of it is higher. Thanks to the input optimisation by zones the production risks are lower than with conventional farming and the yield (quality and quantity) are stable. The site-specific input application contributed on risk reduction and also leads to a less environment harmful production which becomes more and more important for the food customers. The big data in the agricultural production enabling the fork-to-fork monitoring. The type of cost is not changed. But the input cost could be decrease and the machinery cost could be increased in the same time with precision farming technology. The precision farming technology used expensive and IT based machineries so the efficient usage of the equipment are more important otherwise the technology could not be profitable. The technology is sensitive for the skills of staff.

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