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# **Examples of SMEs value creation in Industry 4.0 using VE methodology**

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## **ABSTRACT**

Based on academic and industrial approach, applying Value Engineering methodology, authors aimed to define the areas where value creation fulfilled by small, medium sized enterprises can function as best gears of innovation and what are the challenges a VE professional shall come across.

To reach that goal experiences of value engineering efforts in 3 Industry 4.0 related projects were analyzed, key findings are presented in the article.

## **I4.0 RESEARCH OVERVIEW**

„Transform Or Die: What Will You Do In The Digital Economy?” [8] this question was proposed by leading experts of SAP<sup>1</sup> and has been chosen by the authors since it perfectly summarizes the fears, motivation and uncertainty related to I4.0.

The question: „What will we do in the digital economy?” has nowadays been asked by leaders, managers of companies of all type and size, small-big, start-up or mature, from industry, services, education sector, the threats and opportunities emerged with I4.0 had some effect at all.

Considering the above mentioned, it is not surprising how intense is the research activity around I4.0. Experts tackling the area may orient themselves relying on numerous sources published by the worlds leading technology consultancy agencies and governments. Researches, surveys, position papers and guides are at reach, example projects and case studies are shared to support professionals. Most referred are Gartner, Mckinsey, Roland Berger, Deloitte, EPRS, Acatech, Festo and Rexroth. Those, who offer the technology solutions underlying I4.0, the major industrial users of the technology, and the big advisory firms offering leadership support in adoption of the approach.<sup>2</sup>

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<sup>1</sup> Head of SAP HANA International Customer Community. Puneet Suppal is the Customer Co-Innovation & Solution Adoption Executive at SAP.

<sup>2</sup> Literature research carried out in the three projects provided the theoretical basis of the paper. List of reports, analysis and educational materials about I4.0 can be viewed in the quotation notes.

When it comes to efforts of smaller firms, generally they face the same dilemmas, and turn to the same sources for information as large market players, and this was the case of the 3 example project this article introduces.

**Referred research results show the clear need for value engineering to be applied in the models and processes of Industry 4.0 projects.**

Regarding the purposes of application of the VE methodology, let us cite the author of the Firm of The Future: „Companies in the future will still win by achieving a lower or better cost position, delivering superior customer experiences, or controlling an industry standard. But virtually every element of how firms pursue these strategic goals will look quite different.” [3]

Customized recommendations can, however, only be made with regard to the subject matter of the investigation, taking to account all specific details of the situation. However, we can state that from the point of view of value planning systems, any constituents, processes, process elements, products and services can be the subject of analysis.

## **EMPIRICAL STUDY**

Goal of the authors was to investigate how VE is applied in I4.0 related projects and identify aspects of value creation that can be offered by SME-s. So the first question was what I4.0 means for the professionals applying VE methodology in the projects.

In order to get an answer to that and to draw conclusions, three value analysis projects were have been selected and analyzed. Criteria of their selection was that the company had recently accomplished a VE project, and in the project they have incorporated I4.0 technologies or services.

All three projects were executed in 2017, with the support and involvement of a CVS-PVM value engineering advisor.

The cases belonged to three different companies, operating in different industries, targeting different markets. There were major differences in the life phase of the company and the managerial approach and requests regarding the value planning process.

What all projects had in common was the application of the value analysis approach and the connection to I4.0.

The following table provides an overview of the main characteristics of the companies and the goals of the value engineering projects<sup>3</sup>.

**Table 1. Overview of the projects**

PARAMETER	COMPANY I.	COMPANY II.	COMPANY III..
<b>Company's Size</b>	Medium Size	Small	Micro
<b>Industry</b>	Industry	Healthcare Provider	IT
<b>Age Of The Company</b>	Mature	Newborn	Start Up
<b>Market</b>	HU & Global	HU & Global	HU & Global
<b>Goal</b>	Increase Efficiency	Development Of Business Modell	Product Development
<b>Customer Attitude</b>	Steady Progress	Solid Basis For Launch	Breakthrough Success
<b>Relation To I4.0</b>	I4.0 In Focus	I4.0 In Perspective	In I4.0 Environment

Two companies are active on non-IT fields, healthcare services and industry, but aware of the opportunities of I4.0 and conscious users and adopters of the technology. The 3rd one is a start-up company, with information technology core profile.

As mentioned before, each company has chosen VE methodology to make improvements, the choice of methodology was common but the exact purpose of analysis and the circumstances of application varied per project.

**Table 2. Overview of the projects**

PARAMETER	COMPANY I.	COMPANY II.	COMPANY III.
<b>Area of analysis</b>	Logistics	Service development	Software development
<b>Goal</b>	Increase efficiency using toolset of I4.0	Definition and design of the core elements of the service	Incremental innovation, development of a basic use case
<b>Team size (person)</b>	9	6	5
<b>Connection to I4.0</b>	One of the projects priority goals	I4.0 serves as a key pillar of the service	I4.0 core goal of development
<b>External experts</b>	System architect, IT consultant	IT system developer (architect), consultants	HR expert, potential customer
<b>Duration (expert hours)</b>	42	30	33
<b>Results</b>	Reduction of time-to market, losses, improvements in quality, better use of workforce	Novel service elements (defined, validated)	Validated development goals

<sup>3</sup> Assessment focuses on high level project characteristics and the phenomena experienced in connection to the I4.0 during the value planning, details of the execution are out of the scope of this paper.

The main features of the value design projects were also different. Purpose of applying value planning by Company I. was to improve the logistics process. By company II., it aimed to define and develop a new service to customers. Goal of the the third one was the actual software development.

From the aspect of the assessment of the projects, it has to be betoned that all projects were closely related to I4.0. Connection to I4.0 – either as user of the technologies or ecosystem or as developer – brought special characteristics and challenges to the value planning process, affecting many areas, like the way of how teams had to execute the value planning proces, or the number and profile of external experts involved to the analysis, which is highlighted in the summary (Table 3.). Project overview (Table 2.) also clearly shows that beside the close connection to I4.0, relation to the phenom varied project by project with different links by each. General characteristics of the projects are summarized in Table 2., but some curiosities worth sharing additional thoughts.

### **Company I.**

Designing to build on and utilize I4.0 in logistics development was a clear priority for the first company. By that case, I4.0 solutions are being implemented gradually at the company, which *results in a continously changing range of applicable solution alternatives. This proposed a fascinating challenge for the VE team.* It was a typical case of dual-drive innovation, when a strong need for development concured with a technology push.

### **Company II.**

Developing their business modell to deliver groundbreaking healthcare services, Company II. to had a strong drive not only to utilize I4.0 as an environment, but establish their modell on I4.0 technologies. *For that reason management needed an assessment of a broad portfolio of technologies and applications.* Hence their business modell and revenue streams are strongly affected by their techonology choices, solution alternatives had to cover application of I4.0's smart solutions, data mining, multitasking, omnichanel's adaptation capabilities, cloud-based services, and the use of "conversational platforms".

### **Company III.**

In the case of Company III, the start-up, VE planing methodology was used to support for the development of a software product. Speciality of the application development project was the need for a broad stakeholder analysis, and supporting the team to ensure the technology compatibility of the solution alternatives. Expectations of users had to be considered, but also the compatibility issues of the IT systems, devices and common solutions had to be mapped.

*By that project, key to success was the involvement of external experts. VE planning methodology was an essential tool to ensure structuring the information and evaluation of the alternatives.*

## VALUE GENERATION IN RELATION TO I4.0

Overview of the cases suggest that SMEs can not be considered just as simple users of I4.0, their role is more complex. Assessment of the cases came across the following three roles of the SMEs as contributors generating value in I4.0.

### **Value for the I4.0 ecosystem generated by SME's contribution:**

#### **- Adapt and utilize the existing development results for I4.0**

Making their choices with selecting existing technologies SME's have a minor but important contribution to foster the adaptation of I4.0.

In each of the projects, teams have built on the already existing solutions, softwares, systems, technologies of I4.0, and have decided to use experts to design adaptation. For example, by Company I. further development of an existing ERP system included the integration of a manufacturing system<sup>4</sup>, opening room for further improvements.

#### **- It creates the basis for the next steps of development**

Beside their role as customers, as examples of projects of the Company II. and III. show, SMEs also develop components and applications that can form part of the system. Beyond their obvious role as users, SMEs can and should be considered as active contributors in forming the ecosystem. By developing their own solutions, these small players can set the basis for new connections to end users or other businesses.

In the three projects, some of the solutions recommended by the value analysis teams included solutions that were assessed by experts as sufficient basis of further developments.

By the case of Company II, during the service development need for evaluation of the selected support systems – e.g. analytics and smart monitoring tools - provided room to establish long term organic development.

#### **- The companies are becoming active players in the innovation ecosystem**

The chosen services either mean the basis of their activities, or, being at an early stage of the lifecycle, they can not afford making a wrong bet in their technology choice, these small players seek to evaluate opportunities along long-term cost-quality principles. With this attempt they are becoming more and more conscious partners in the ecosystem. Observations showed that I4.0. related development projects transformed the relation between the IT Suppliers and the Principals of the Companies.

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<sup>4</sup> Softwares supporting optimization of manufacturing.

## VE RESULTS

In each of the three cases, the value planning teams have met special challenges, that arose as a consequence of the project goals connection to I4.0. Challenges called for specific actions during the VE project phases.

One of the major ones could be easily guessed by practicing experts and consultants, that connects to the goal setting. Uncertainties in the technological environment and circumstances<sup>5</sup> made the finalization of project scope and focusing on priorities more complicated than usual. That speciality was present by all of the cases, and required a disciplined and grounded approach from the VE teams.

After successful closure of the projects, the observed phenomena were structured and paired to the way they have been managed or addressed in the VE job plan.

Table 3. provides an overview of the structured set of the observed phenomena, the attributes that influenced the work of the value planner (column 1.) and the impact that managing them had on the implementation of the Job Plan (column 2.). Only the most typical factors are summarized in our table.

Detailed assessment is limited to the mentioned three cases, however, the fact that the experienced phenomena occurred in each of the cases, suggests a potential for generalizability of the findings.

**Table 3.**  
**The impact of changes generated by I4.0 on the activities of the VE job plan**

<b>I4.0 SPECIFIC CHALLENGE*</b>	<b>HOW IT WAS ADDRESSED IN THE VE JOB PLAN</b>
HIGH UNCERTAINTY	Involvement of experts Creation of alternatives High abstraction level Research, incorporating prognosis Monitoring during follow-up Consideration of soft aspects
HIGH RISK AT BROAD SPECTRUM OF ACTIVITIES	Repeated risk analysis in the different phases of the job plan
CHANGES IN STAKEHOLDER CHARACTERISTICS	Increased priority of stakeholder analysis Mapping of the ecosystem Analyse potential collaboration forms Benchmarking

<sup>5</sup> Internal or external circumstances, eg. ongoing developments at other departments, changes, developments, rearrangements in IT infrastructure, legal regulation of data privacy, etc.

INCREASE OF THE NUMBER OF FACTORS THAT AFFECT PROJECT OUTPUTS	<ul style="list-style-type: none"> <li>Application of novel methods for information collection</li> <li>Same information –from various sources</li> <li>Credibility check of information</li> <li>Increased collaboration with the partners</li> <li>Involvement of experts</li> <li>Benchmarking</li> </ul>
INTERNAL KNOWLEDGE BASE IS INSUFFICIENT	<ul style="list-style-type: none"> <li>Integration of project-relevant knowledge</li> <li>Benchmarking</li> <li>Exchange of experiences</li> <li>Literature research – researches, prognosis, case studies</li> <li>Involvement of external experts</li> </ul>
UNCERTAINTY IN THE LIFE CYCLE PROGNOSIS OF THE RECOMMENDED SOLUTIONS	<ul style="list-style-type: none"> <li>Create a solid basis for project life cycle estimations</li> <li>Risk analysis</li> <li>Staged approach to solution development</li> <li>Monitoring during execution and operation</li> </ul>
RECOMMENDED SOLUTIONS VARY ON BROAD SPECTRUM	<ul style="list-style-type: none"> <li>Consider multiple sources for solution for a function</li> <li>Compare solutions with needs and functions</li> <li>Comparison of alternative solutions</li> <li>Manage soft aspects while comparing solution alternatives</li> </ul>

Lenght and scope of this paper limits going to the very details of each activity, but the most important observations were the following:

Caused by the novelty of the I4.0 and general uncertainties regarding optimal adoption, a **high degree of uncertainty** was perceptible during the preparation phase of the project. That meant that during the discussions regarding the project theme, scope and objective, or later the validation and the potential introduction of the solution alternatives, the team had a tough time to handle the dimension of timing and life cycle.

Two question were repeated, for that, the practicing experts shall have a strategy to support the team in finding answers: *What is the period of time while project result will benefit the company? What time, what lifecycle can the team plan for?*

The effect of exponential development and very broad area of the I4.0 domain, as mentioned previously, is characterized by a considerable degree of uncertainty. That not only called for repeated iteration about the project goal, but, paired with the VE methodologies high abstraction level approach, *resulted in a broader set of solution alternatives and required an increased number of distant variants to be discussed.*



In the same setting of circumstances, working in the context of I4.0, another major question was *how can we confine the area that shall be developed to promise the best outcome for the organic growth of the company?*

While setting the goals of the VE planning process, close attention was paid to define the focus of the project.

From strategic perspective of the projects, each of the three Principals chose the “tactic of small steps” – steady, groundly progress reached by incremental development, but reached by choosing a solution of the highest technical standard.

Defining a solution of high quality standard

- a) in a rapidly developing area with many competing technical solutions,
- b) with similar functionalities but different technological background,
- c) with the highest possible level of certainty to support the decision

has significantly increased the importance of exploratory activities for obvious reasons, and *efforts to handle and minimize these technology related uncertainties were present in each project, along the entire VE planning process.*

Phenomenon captured under the category „**Changes in stakeholder characteristics**” calls for attention that external and internal stakeholders may initiate significant changes in their own scope of operation and responsibilities, even during the timeline of the project. The perception, monitoring and consideration of these intentions and emerging novel solutions broaden the scope of risk factors, and requires proper management.

Thinking in ecosystem-perspective and the closer co-operation with stakeholder were identified as important implications of managing VE planning in I4.0. projects, in all our three examples.

Though the strategic approach of the leadership, and the I4.0. environment accompanied by uncertainties were similar factors in each of the cases, different tactics have been applied to reach the optimal solution.

By Company I., the case of the development of logistics of the industrial player, optimal solution was reached by renewing the contract with and extended scope with the supplier of the existing IT system, meanwhile making an effort to find and select new partners for co-operation with high development potentials on the field of I4.0.

„**High risk at broad spectrum of activities**” refers to increasingly complex environment, affected by factors of which some are predictable with a strong domain specific knowledge, but many are unpredictable the domain analysts either. In addition to that, effects of these factors may interfere, and that generates strong changes in the

external environment. Some changes happening in the I4.0 - bring newer and newer aspects, stakeholder and expectations to our project. This means further increase in the number of factors the teams need to work with, and reaches a limit where proper methodology, the application of VE approach can be key.

Our view on why value design is one of the most effective tools for managing complexity has already been published [15].

The **number of factors influencing the development efforts** was high in the three evaluated projects. VE expert and teams have answered to this in multiple ways. Known solutions, such as the involvement of external experts, literature research and benchmarking remained part of the toolbox, but their application has become more extensive. Experts had to step up in utilizing a great abundance of tools of value methodology and focus on ensuring to reach actionable and customized recommendations.

Beside existing ones, new methodologies and tools have also been applied in the projects. For example, the application of ZBB, Zero Based Budgeting, was necessary to assess the impacts of the recommended solution alternatives. By Company I., the development efforts transformed the entire basis of the project, therefore the former budget information and budgeting approach built on the financial information of the past would not have been useful.

In the other two projects, the developments were designed relying to a system that was under implementation, with no necessity for the application of ZBB.

**Considering multiple solution alternatives** has always been a decisive feature of value design, and seeking solutions with high quality requirements forced the teams to put more emphasis on that effort in our sample projects. Teams identified multiple potential solutions for the same function from several sources, which was an interesting professional challenge, due to the broad portfolio of offerings in I4.0. We have also shifted to the more demanding professional methods – as application of CRM systems, use of social media and crowd solutions and analytics – to manage uncertainties and risks in projects.

Understanding needs and defining solutions on high abstraction levels was typical for each of the three projects mentioned, and helped in the fast adaptation to the changes in project scope.

## CONCLUSIONS

This paper aimed to share experiences with professional audience interested in VE methodology and seeking examples of application in I4.0 settings.

Three different projects were executed in 2017 with formal involvement of VE professional, and each project had connections to the I4.0. This generated new circumstances - compared to less technology intensive projects – and this summary collected and structured some findings, highlighting specific challenges and lessons learned.

Authors shared their experiences in managing VE planning projects of SMEs, with connection to I4.0 to contribute to the practical knowledge of VE experts.

That may start debate and information exchange between professionals, and contribute to the literature of I4.0 project management from practical point of view.

As a conclusion, the following are to be kept in mind by those - VE - project managers who work or will work in the area of I4.0:

**Exclusively the experiences of the past are an insufficient basis for planning, and the future is uncertain.**

Methods, tools, used in previous projects may not be sufficient for today's projects. Challenges and risks pairing project management in exponentially developing technology environment needs new approaches. IT does not mean that existing models are useless, rather calls for a more creative use and openness to adapt to actual settings. A good example for that was the zero based budget planning by Company I.

**Value engineering method offers a unique communication platform for different experts.**

Technology development projects – including all types of information technology related development effort – requires representatives of different fields of expertise to work together for a common goal. VE planning as a formalized and moderated effort offers a common communication platform for the stakeholders, where distortion-free, coordinated, formalized, discussions can take place, and interpretation and clarification of arguments is becomes – to some extent – standardized by the value engineering approach. VE planning framework forces the collaborating experts to define dimensions of value together and use that set of paradigms as a framework while elaborating solution alternatives.

**I4.0 must not be overlooked, even if the project goal has no direct connection with it.**

Examples show that even in projects, that are not primarily focusing on I4.0-related developments can benefit a lot considering I4.0. Benefits may include easing further developments, and offering optimization opportunities in organizational development processes.

**Results and effects of I4.0 are present in the toolset and context of value planning.**

Tools and technologies applied in I4.0 can be used in many steps along the VE process, for example, by outcome- and lifecycle modelling, when designing product or solution increments, in the information collection phase of value planning and analyzing and processing information during creative phases.

A I4.0 serve as the basis when seeking for, or developing a solution.

**The task of the value engineering expert is to acquire and apply the relevant knowledge, and it's integration to the methodology.**

## LITERATURE

1. Abonyi J. - Mislivetz F. (2015). Ipar 4.0 megoldások kialakításának feltételrendszere. „Korszerű műszaki, informatikai és modellezési megoldásokra épülő döntéstámogató rendszer kifejlesztése elektronikai összeszerelő üzemek költség- és energiahatékony irányításához” VKSZ\_14-1-2015-0190, OTKA 116674., Pannon Egyetem.
2. Acatech (2013). Securing the future of German manufacturing industry Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working Group, April 2013. National Academy of Science and Engineering. Available at: [http://www.acatech.de/fileadmin/user\\_upload/Baumstruktur\\_nach\\_Website/Acatech/root/de/Material\\_fuer\\_Sonderseiten/Industrie\\_4.0/Final\\_report\\_Industrie\\_4.0\\_accessible.pdf](http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report_Industrie_4.0_accessible.pdf)
3. Allen, J., – Root, J., – Schwedel, A. (2017). The Firm of the Future , April 12, 2017 *Bain Brief*. Available at: <http://www.bain.com/publications/articles/firm-of-the-future.aspx>  
BCG (2015). Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries, April 9, 2015, BCG. Available at: [https://www.bcg.com/publications/2015/engineered\\_products\\_project\\_business\\_industry\\_4\\_future\\_productivity\\_growth\\_manufacturing\\_industries.aspx](https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx)
4. Bosch Rexroth AG (2018). Dictionary of Fluid Technology. Innovations and Trends from Industry for Educational Institutes – (Rexroth Bosch) DCA Brochure. Drive & Control Academy - Industry 4.0. Available at: [http://www.christiani.de/pdf/89433\\_vorwort.pdf](http://www.christiani.de/pdf/89433_vorwort.pdf)
5. EC (2015). Digitalisation for productivity and growth Industry 4.0 Briefing September 2015. Available at: <https://ec.europa.eu/digital-single-market/en/news/list-digitising-european-industry-initiatives-across-europe>
6. EC (2016). List of initiatives for Digitisation of Industry from Member States and Regions in Europe, April 28, 2016. Available at: <https://ec.europa.eu/digital-single-market/en/news/list-digitising-european-industry-initiatives-across-europe>
7. Fehér, N. (2016): Ipar 4.0 -> Logisztika 4.0, avagy milyen lesz a logisztika a jövő gyárában. LIM BGE Gazdálkodási kar Zalaegerszeg 2016.
8. Feldman, S. --Suppal, P. (2015). Transform Or Die: What Will You Do In The Digital Economy? Digitalist. October, 2015. Available at: <http://www.digitalistmag.com/digital-economy/2015/10/12/transform-die-will-digital-economy-03562025>
9. Feldman, S. Suppal, P. (2015). Why Fearing Digital Transformation Is A Big Mistake – And How You Can Overcome It. Digitalist. November, 2015. Available at: <http://www.digitalistmag.com/digital-economy/2015/11/11/why-fearing-digital-transformation-is-a-big-mistake-and-how-you-can-overcome-it-03766752>
10. FESTO (2018). Képesítés az Ipar 4.0-hoz. Festo-didactic.com Letöltve: <http://www.festo-didactic.com/hu-hu/fokuszban/kepesites-az-ipar-4.0-hoz/?fbid=aHUuaHUuNTUzLjM0LjEwLjc3ODcuNDMyOA>
11. Gartner (2017a). Gartner Says by 2020, At Least 30 Percent of Industrie 4.0 Projects Will Source Their Algorithms From Leading Algorithm Marketplaces March 21, 2017. Available at: <https://www.gartner.com/newsroom/id/3646717>.
12. Gartner (2017b). Top Strategic Predictions for 2018 and Beyond, Gartner, 2017. Available at: <https://www.gartner.com/technology/research/predicts/>
13. Gyartastrend (2016a). Jövő gyára - Magyar vállalatok az ipar 4.0-ban 2016. április 01. Available at: [http://gyartastrend.hu/jovo-gyara/cikk/magyar\\_vallalatok\\_az\\_ipar\\_4\\_0\\_ban](http://gyartastrend.hu/jovo-gyara/cikk/magyar_vallalatok_az_ipar_4_0_ban)
14. Gyartastrend (2016b). Ipar 4.0 -Egyre többen alkalmazzák a gyártásban. 2016. Október 26. Letöltve: [http://gyartastrend.hu/jovo-gyara/cikk/egyre\\_tobben\\_alkalmazzak\\_a\\_gyartásban](http://gyartastrend.hu/jovo-gyara/cikk/egyre_tobben_alkalmazzak_a_gyartásban).
15. Hoffer, I. – Katona, V. (2013). Komplex módszerek előretörése. In: Budapesti Kereskedelmi és Iparkamara (szerk.) Innováció - megújulás - növekedés: VI. Országos Tanácsadói Konferencia. Konferencia helye, ideje: Budapest, Magyarország, 2013.03.21 Budapest: Budapesti Kereskedelmi és Iparkamara, 2013. Könyvrészlet/ Konferenciaközlemény/ Tudományos [2745379]
16. IMEX (2017). Ipar 4.0 a szűrőtechnikában ? IMEX filtertechnika. 2017 Március 17. Letöltve: <http://imex.filtertechnika.hu/hirek/olvas/2017-03-17-ipar-40-a-szurestechnikaban->

17. Innomine Group Kft (2016). IPAR 4.0 - Fogalomtár, fontosabb tanulmányok, legfőbb szereplők -. innomine Group Kft. 2016.07.28.. Letöltve: [http://innomine.com/wp-content/uploads/2016/08/Ipar\\_Szotar\\_Innomine.pdf](http://innomine.com/wp-content/uploads/2016/08/Ipar_Szotar_Innomine.pdf)
18. Ipar 4.0 (2018). Az Ipar 4.0 Nemzeti Technológiai Platform Szövetség (I4.0 NTP). Ipar 4.0 Nemzeti Technológiai Platform. Letöltve: <https://www.i40platform.hu/rolunk>
19. Kiss, E (2017). Emberközpontú Ipar 4.0 2017. május 10. Computerworld. Letöltve: <http://computerworld.hu/computerworld/emberkozpontu-ipar-4.0.html>
20. Kulcsár, Gy.(2016). Diszkrét termelési folyamatok számítógépes tervezése és irányítása. Miskolci Egyetem. Letöltve: <http://slideplayer.hu/slide/1982316/>
21. Logisztika.com (2017). 4.0 stratégia bevezetése az Ekol-nál. Logisztika.com. 2017-04-26 Letöltve: <http://logisztika.com/4-0-strategia-bevezetese-az-ekol-nal/>
22. McKinsey (2015). How to navigate digitization of the manufacturing sector. McKinsey & Company. Available at: <https://www.mckinsey.de/2015-03-16/how-navigate-digitization-manufacturing-sector>
23. Miniszterelnöki Kabinetiroda (2016). Magyarország-Digitális-Startup-Stratégiája. Letöltve: <http://www.kormany.hu/download/d/8c/e0000/Magyarorsz%C3%A1g%20Digit%C3%A1lis%20Startup%20Strat%C3%A9gi%C3%A1ja.pdf>
24. Molnár, L. (2016). Ipar 4.0 a gyakorlatban 1.-3. rész. Hogyan lehet Európában a világszámára versenyképesen gyártani?. Techmonitor. 2016. február. Letöltve: <http://www.techmonitor.hu/piacmonitor/elemezes-velemenypar-4-0-a-gyakorlatban-1-resz-20160219>
25. Nemzetgazdasági Minisztérium (2016a). Irinyi terv az innovatív iparfejlesztés irányainak meghatározásáról. Budapest, 2016. február. Letöltve: <http://www.kormany.hu/download/d/c1/b0000/Irinyi-terv.pdf>
26. Nemzetgazdasági Minisztérium (2016b). GINOP-1.1.3-16 Termelő KKV-k digitális és automatizációs fejlesztéseinek élénkítése érdekében „Ipar 4.0” mintaalkalmazások kialakítása. Letöltve: <https://www.palyazat.gov.hu/ginop-113-16-termel-kkv-k-digitlis-s-automatizcis-fejlesztseinek-lnktse-rdekben-ipar-40-mintaalkalmazsok-kialakta>
27. Nemzetgazdasági Minisztérium (2017). GINOP-1.2.8-17 Kis- és középvállalkozások ipari digitalizációhoz (IPAR 4.0) kapcsolódó fejlesztéseinek támogatása., Available at: <https://www.palyazat.gov.hu/ginop-128-17-kis-s-kzpvllalkozsok-ipari-digitalizcihoz-ipar-40-kapacsold-fejlesztseinek-tmogatsa-1>
28. <https://www.palyazat.gov.hu/ginop-128-17-kis-s-kzpvllalkozsok-ipari-digitalizcihoz-ipar-40-kapacsold-fejlesztseinek-tmogatsa-1>
29. Pászti-Márkus, E: (2016). Tanulmányok az „Ipar 4.0” hatásairól a német és a nemzetközi munkaerőpiacra, 2016. február 26.
30. Pfeiffer S. – Suphan, A. (2015): Der Mensch kann Industrie 4.0. Impressum Kurzfassung zum Working Paper: Pfeiffer, Sabine; Suphan, Anne (2015): Der AV-Index. Lebendiges Arbeitsvermögen und Erfahrung als Ressourcen auf dem Weg zu Industrie 4.0. Working Paper 2015 #1 Finalfassung, Universität Hohenheim, Fg. Soziologie.
31. PWC (2014). Opportunities and Challenges of the Industrial Internet, PWC study, 2014., Available at: <https://www.pwc.nl/en/assets/documents/pwc-industrie-4-0.pdf>
32. PWC (2016). Industry 4.0: Building the digital enterprise, 2016 Global Industry 4.0 Survey, PWC. Available at: [www.pwc.com/industry40](http://www.pwc.com/industry40)
- Ringham, U. (2015). Digital Transformation And The SME. Digital SMEs ready to offer technologies and skills needed for construction companies to join Industry 4.0. Digitalistmag. 2015 November 3. Available at: <http://www.digitalistmag.com/smb/2015/11/03/sme-digital-transformation-03702592>
33. Schwab, K. (2016): The Fourth Industrial Revolution: what it means, how to respond Available at: <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/>
- Ziegler, S. (2013). PC-alapú vezérlés: „A dolgok internetének” ideális technológiai platformja Ipar 4.0 - megvalósítás ma, bizonyított vezérlési architektúrákkal, Marketing Communications, Beckhoff, PC Control 02 | 20136.