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# KNOWLEDGE COMMERCIALIZATION AT UNIVERSITIES WITH REGARD TO GEOTHERMAL WATER DEIRONING TECHNOLOGY

**Summary.** The article presents the issues of knowledge commercialization at universities. Geothermal water deironing technology is used as a case study of the technology commercialization process. A description is given to the range of activities carried out in the commercialization of this technology with respect to the analyses, and the choice of strategy and reasons in favour of marketing the technology have been reported. In addition, the article discusses aspects related to the direction and determinants of the process of knowledge commercialization in universities.

**Keywords:** commercialization, commercialization process, geothermal water deironing

# KOMERCJALIZACJA WIEDZY W UCZELNIACH WYŻSZYCH NA PRZYKŁADZIE TECHNOLOGII ODŻELAZIANIA WODY GEOTERMALNEJ

**Streszczenie.** Artykuł przedstawia zagadnienia z zakresu komercjalizacji wiedzy w uczelniach wyższych. Za studium przypadku posłużył proces komercjalizacji technologii odżelaziania wody geotermalnej. Opisano zakres działań zrealizowanych w procesie komercjalizacji tej technologii w odniesieniu do przeprowadzonych analiz, wyboru strategii oraz przesłanek przemawiających za urynkowieniem technologii.

Ponadto w artykule omówiono aspekty związane z kierunkami i determinantami procesu komercjalizacji wiedzy na uczelniach wyższych.

**Słowa kluczowe:** komercjalizacja, proces komercjalizacji, technologia odżelaziania wody geotermalnej

# 1. Introduction

The commercialization of scientific knowledge in the economy is becoming the key factor enabling an entity to gain and maintain a competitive advantage. For this reason, the intensification of knowledge commercialization mechanisms in scientific circles has become an important challenge. This intensification forces the finding of new measures which rationalize the management of the commercialization processes and mostly concentrates on diffusion, knowledge development, a creation of new and more efficient organizational solutions, and an implementation of more effective commercialization models in scientific units.

More and more, activities in the area of technology transfer and commercialization are taking place in an interdisciplinary network environment and result from the cooperation of organizations in the network, including companies, institutions in the R&D sector and public entities, and supporting institutions e.g. technology transfer centers, parks and technological incubators.

The effectiveness of knowledge commercialization is determined by many factors. The commercialization success of research results not only depends on technology and its market potential, nor only on the advancement and preparation level of commercialization, but also on the scientists, their knowledge and their capabilities. The effectiveness of knowledge commercialization is influenced by external circumstances as well, inter alia, the innovative policy, potential recipients, investors and the financial capabilities to carry out and implement the research and the acquisition, transfer and usage of information and knowledge in a timely manner by the participants of this process.

The aim of this article is to analyze the circumstances around the commercialization process of research results, taking the geothermal water deironing technology as an example. The presented geothermal water deironing technology was primarily worked out and developed within the framework of scientific research of the author: Iwona Kłosok-Bazan which was conducted at the Opole University of Technology. A patent for this technology was applied for in February 2013 in the Polish Patent Office, registered under the number of PL 402694 (A1) – which patents the method of treatment, especially for the deironing of geothermal water, and the system for treatment, especially for deironed geothermal water.

## 2. The determinants of success of the knowledge commercialization process at universities

Cooperation, in particular between scientific and business environments, is to be emphasized in the process of commercialization of research results. However, in many reports and publications of the following authors e.x. K. B. Matusiak, J. Guliński[1] the existence of so-called natural ("genetic") barriers of science and business cooperation is stressed. These barriers are created both by enterprises and R&D sector institutions[2].

There are many definitions characterizing *the term of commercialization*. Technology commercialization is defined as the process of delivering new technologies on the market. Technology commercialization includes legal, marketing (market research), financial and quality actions which enable the liberalization of proposed solutions. Knowledge and technology commercialization carried out by R&D institutions, including universities, may be characterized as "the way to provide new incomes by the giving third parties (inter alia companies first) access to knowledge, infrastructure and research results"[3].

Commercialization is a complex process, posing a high risk which depends on a variety of factors. There are different classifications of these factors, most frequently the subject literature presents the division into two fundamental groups: internal and external factors. The factors may assume the organizational, economic, legal, psychological, sociological, market or informational nature (see Koszembar – Wiklik M. 2012[4]). The human aspect of commercialization, knowledge and the entrepreneurial attitude are of high importance. Moreover, ethical aspects and corruption issues are also considerations in commercialization (see the works of Stachowicz-Stanusch A., Simha)[5]. The internal factors include: a character and personality of a person (independence, self-reliance, need for consistent action, lofty aspirations, willingness to receive high earnings, inclination to take risks, domination need, the need to prove one's value, as well), their knowledge, qualifications and abilities as well as

[1] Matusiak K.B., Guliński J.: System transferu technologii i komercjalizacji wiedzy w Polsce – Siły motoryczne i bariery. PARP, 2010

[2] Kierunki zwiększania innowacyjności gospodarki na lata 2007-2013. Ministerstwo Gospodarki, Departament Rozwoju Gospodarki, Warszawa 2006

[3] Palmen L.: Przewodnik pomysł – badania – wiedza – biznes. Usprawnienie procesów komercjalizacji wiedzy w instytucjach sektora badań i rozwoju w województwie śląskim. Miasto Gliwice, Gliwice 2007.

[4] Koszembar-Wiklik M.: Innowacje w zakresie komunikacji marketingowej a kształtowanie wizerunku organizacji, [w:] Motnyk M., Ryśnik J. (red.): Współczesne problemy zarządzania organizacją, Wyższa Szkoła Ekonomiczno-Humanistyczna, Bielsko-Biała 2012.

[5] Stachowicz-Stanusch A., Simha A.: An empirical investigation of the effects of ethical climates on organizational corruption. „Journal of Business Economics and Management", No. 14, sup. 1, 2013.

motivation[6]. The external factors are usually classified as: legal and political conditions including, among others: legal provisions, regulations concerning industrial property, tax regulations, innovative policy, research policy; economic considerations including the access to high risk funds, credit, and market conditions; social circumstances such as the unemployment rate; technological circumstances: technical and technological advancement.

The role of a scientist, who carries out research, is essential at each stage of the commercialization process. It does not mean though, that the researcher should not be supported by the institution which he works for. Help from specialists, who deal with supporting academics in the commercialization process of research results, in the area of law, intellectual property protection, market analysis, professional evaluations, financial sources, negotiations with potential strategic partners, investors and customers, is important. Thus, the policy, the model of commercialization prevailing at a university, and the action of specialized entities e.g. a technology transfer center, a technological park, or a technological incubator are of high importance. Additionally, structural solutions and effective organizational structure with a clear definition of responsibilities and competences are essential[7].

The five following fundamental success factors, which contribute to the success of the technology commercialization model, may be distinguished[8]:

1. A knowledge center – an orientation of the research policy towards entering and acquiring the world market;
2. An active intellectual property policy;
3. An academics' awareness of technology commercialization benefits
4. Access to human and financial capital – the work in networks of cooperation
5. Efficient legal regulations at an institutional and national level.

The instruments of *innovative policy* aimed at reducing the barriers may significantly affect the effectiveness of knowledge transfer from the education industry[9]. As far as the mentioned instruments are concerned, they include: legal, financial, consulting, training, informational, organizational tools etc. The innovative policy may have a significant impact on the knowledge commercialization processes rationalization. This policy is oriented

[6] Bednarz P., Szcześniak A.: Formowanie przedsiębiorstwa technologicznego, [in:] Bąk M., Kulawczuk P. (ed.): Modele biznesowe budowy i rozwoju firm spin-off na podbudowie szkoły wyższej. Instytut Badań nad Demokracją i Przedsiębiorstwem Prywatnym, Warszawa 2010.

[7] Bojar E., Stachowicz J., Machnik-Słomka J., Bojar M.: Zarządzanie strategicznymi projektami w regionie. Zintegrowany system zarządzania unieszkodliwianiem azbestu na składowiskach podziemnych w aspekcie zrównoważonego rozwoju Polski wschodniej. TNOiK „Dom Organizatora", Toruń 2013.

[8] Palmen L.: Przewodnik. Pomysł – badania – wiedza – biznes. Usprawnienie procesów komercjalizacji wiedzy w instytucjach sektora badań i rozwoju w województwie śląskim, Miasto Gliwice, Gliwice 2007.

[9] Stawiarska E., Machnik-Słomka J.: Współczesne kierunki polityki innowacyjnej a współpraca sieciowa w transferze wiedzy z sektora nauki. Zeszyty Naukowe, No. 50. Wyższa Szkoła Bankowa, Poznań 2013.

towards creating appropriate R&D activity conditions, building the socio-economic potential by means of *clusters,* and the territorial groupings of enterprises supported with a R&D institutions' network of cooperation. The universities' potential should be fully taken as an advantage by, among other things, tightening the universities' relationships with the external environment through different forms of network cooperation, and cluster cooperation. Clusters may contribute to eliminating the barriers of business and science cooperation by creating appropriate conditions for the effective realization of research results transfer and commercialization by the participants. In this way, a new innovation-opened market comes into existence. The market enables the current knowledge flow and innovation transfer between the participants of innovation network[10]. Specialized institutions or networks acting in favour of technology transfer, for instance, the Enterprise Europe Network and the National Innovation Network, which may help with technology promotion, technology offers or searching for a technological partner, are playing a more and more important role in this field.

## 3. The geothermal water deironing technology characteristics

Lately, much interest in using geothermal water for balneological purposes has been observed. More boreholes which enable and provide access to hot water form very deep aquifers, are being drilled all over the country. Geothermal energy is heat that is generated and stored in the inside of the Earth, contained in water, gases and rock enthalpy. People have exploited the potential of geothermal energy both to obtain energy and for recreational reasons throughout human history. Basically, it is believed that geothermal water can be defined as underground water at a temperature which does not exceed average annual air temperature nearby. In Poland, geothermal water is recognized as water at temperature above 20°C, in the USA, above 21°C. The ways to make use of geothermal water depend on the temperature of drilled water and its quality.

Unfortunately, the composition of water drilled from deep aquifers prevent its direct utilization. In many cases, a high iron concentration is the reason for this problem.

Although iron is not a compound harmful to health, the presence of iron in water used for balneology causes exploitation problems: a high turbidity of water in the pool; a faster pool basin and whole fitting corrosion; a brown coating on each appliance which handles ironed water. It is necessary to deiron the water before exploitation due to operational and technical problems as well as the law in force.

[10] Dolińska M.: Innowacje w gospodarce opartej na wiedzy. PWE, Warszawa 2010.

The processes of water deironing are well known in water technology. The processes are based on the process of oxidizing dissolved divalent iron, in which trivalent iron is formed. The trivalent iron is discarded from the water through suspension in processes of sedimentation and filtration. It is worth noting that these methods have so far been used mainly in water treatment to make it fit for consumption. The temperature of this process has not exceeded 20°C. Meanwhile, the literature review of authors such as Kowal L., Świderska-Bróż M.[11]; Wowk J.[12]; Sawiniak W.[13] indicates that the temperature, apart from reaction and water mineralization, is one of the basic parameters which has a major impact on the process.

Water deironing is understood as divalent iron ions oxidation in which trivalent iron is formed and then the precipitated $Fe(OH)_3$ compounds are removed in the process of sedimentation and filtration. Geothermal water deironing technology (GWDT) consists of the following specific processes:

- An aeration, which aims at oxidizing dissolved divalent iron into iron formed as suspension and removing carbon dioxide and other gases.
- A sedimentation, which aims at precipitating ferruginous suspensions from the water.
- A filtration, which aims at water purification from suspension remains.

There are many water deironing technologies available on the market. However, only a few of them are effective in warm water deironing. Technologies available on the market have been prepared in order to treat underground water for human supply purposes, in other words to make water fit for consumption. The process temperature fluctuates between 4 and 15°C.

The technology ready to be commercialized utilizes the same processes which are used in underground water treatment. However, applied innovations result in higher effectiveness of the technology as well as a reduction of heat looses brought during the process of deironing.

The technology presented in this study is the first technology adapted to geothermal water treatment for balneological purposes. The proposed solution has a major advantage over existing and till now applied technologies due to the fact that this solution ensures a high effectiveness of iron removal within a broad-spectrum of temperatures, and additionally, the solution limits energy loses. Analysis of literature on patent information based on the Polish Patent Office databases and the free of charge European patent database Espacenet showed a significant advantaged of the proposed technology over technologies registered over the last five years, too. The presented solution is at the cutting edge of applied technologies in

[11] Kowal L., Świderska-Bróż M.: Oczyszczanie wody. PWN, Warszawa-Wrocław 1997.
[12] Wowk J.: Naturalna technologia wody. WNT, Warszawa 2010.
[13] Sawiniak W.: Badania nad zastosowaniem wodorotlenku żelazowego do usuwania dużych ilości żelaza i manganu z wody. Zeszyty Naukowe, s. Inżynieria Środowiska, z. 34, Politechnika Śląska, Gliwice 1990.

terms of the sustainable development rule, whereby it improves upon the effective usage of environmental resources, and sustainable patterns of production and consumption have been treated with priority in accordance with the 2005 renewed EU Sustainable Development Strategy.

## 4. The commercialization process and the adoption of the geothermal water deironing technology commercialization strategy

Due to the high level of risk and high expenditures, the process of technology commercialization ought to be rationally planned, organized and realized in such a way that it will minimize the risk and maximize the benefits.

The model of Jolly, presented in the figure 1, has been applied to determine the phases of technology commercialization development.

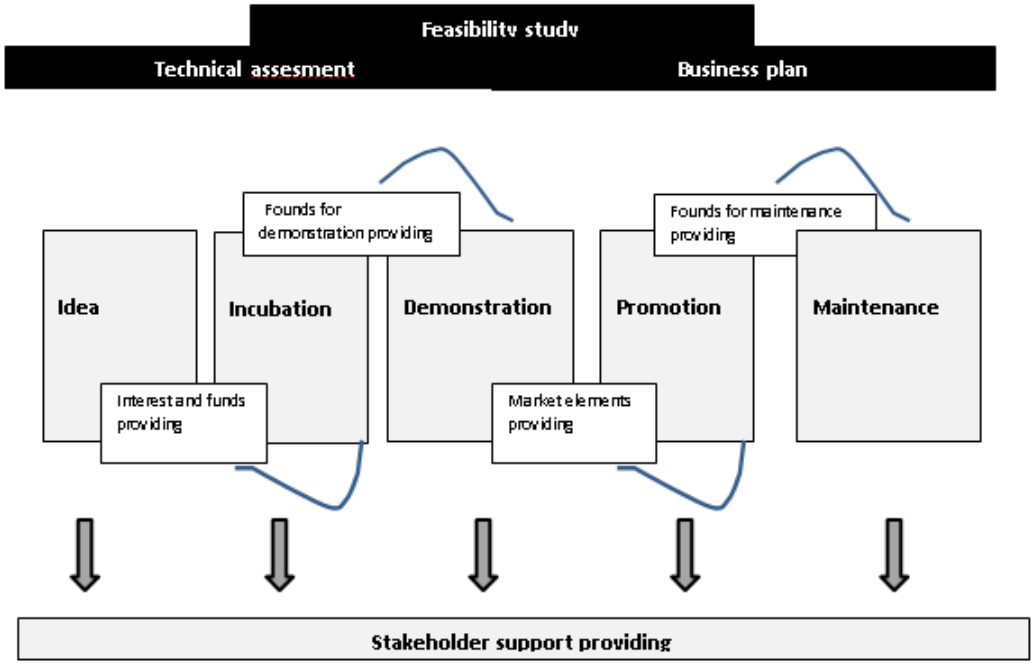


Fig. 1. The process of technology commercialization by V.K. Jolly
Rys. 1. Proces komercjalizacji technologii wg V.K. Jolly
Source: Jolly V.K.: Commercializing new technologies: getting from mind to market. Harvard Business School Press, Boston 1997.

Jolly's model introduces technology commercialization as a process which consists of 5 stages[14]:

- Idea – realizing a potential and uniqueness of the technology, gaining information about the technology;
- Incubation – determining the potential of the technology to be commercialized, verifying ownership rights, preparing a business plan, acquiring external financing of the technology commercialization;
- Demonstration – preparing a draft for the product which may be put on a market;
- Promotion – presenting the product on the market, gathering information related to the putting the product on the market;
- Maintenance – expanding and retaining the product on the market, reaching full productivity of the technology commercialization opportunities.

With reference to the presented model, it can be claimed that the described technology is currently in the second phase of development. At this stage it is essential to analyze the potential of this technology commercialization, to perform the market, financial and legal analysis and prove a lack of patent infringement, as well as evaluate the research team. Thus, the research study's evaluation, intellectual property rights evaluation, and market potential assessment need to be made, and the capabilities to implement the knowledge on the market must be shown.

The analysis undertaken by the author suggests that in light of the study prerequisites, the technology may be successfully privatized due to the fact that the technology bears the features of innovativeness, and in the meantime is connected with renewable energy sources. There are, among other sources, potential funds which could be used while commercializing the technology. Legal rights, the demand for renewable energy sources and market needs are all in favour of the presented technology. Technology analysis has arisen from the market need, because in spite of the constant development of balneological services, there are no technologies precisely addressed to this specific field. Potential investors who deal with building centers of balneological exploitation of geothermal water constitute a target market for the commercialized technology. Considering the high deironing effectiveness of the formulated technology in comparison with those available on a market, operating centers may become potential clients. Operating centers may express the wish to modernize their process of water treatment in order to obtain better quality water. Other factors connected with the knowledge and experience of the author in terms of technology commercialization and the filed patent application argue in favour of achieving success.

[14] Markiewicz D. (ed.): Komercjalizacja wyników badań naukowych – krok po koku. Podręcznik Centrum Transferu Technologii, Politechnika Krakowska, Kraków 2009.

Any possible threats or barriers to further stages of technology commercialization, which have to be mentioned, are other institutions' competition and legislative changes. For the time being, a high market interest in technologies connected with balneology is being observed. Another threat can be posed by an institution (a company, research center) proposing a technological innovation with a similar application which is more competitive in the market. In terms of legal regulations, Poland is not stable in this respect. Therefore, legislative changes in the areas of establishing additional strict standards and imposing limitations to the access of geothermal sources can be anticipated. An unstable financial situation or the lack of clearly stated possibilities to procure funds for research and investments may be possible threats as well.

A proper choice of strategy is essential for the further commercialization of the analyzed technology. A wide range of measures, strategies of knowledge commercialization, can be distinguished in practice. However, three of them are usually mentioned:

- *Sale of a property, invention or technology* which means that ownership rights for business utilization are transferred
- *Granting a licence (exclusive or non-exclusive licence),* which means that ownership rights for business utilization of an invention or technology are available
- *Undertaking a business activity (formation of a spin-off or spin-out company),* which will sell products or render services individually.

The most popular commercialization strategy, which is possible to be implemented by an educational entity which is willing to commercialize its invention is *licensing*. Inventions chosen by the university are under protection, and the right for economic utilization is possible to acquire by buying a license.

*Sale* is one of the most popularized technology commercialization strategies in a business entity's market. A single machine or a processing line is sold with a contained technology. From the company – purchaser – point of view it is a quick and easy way to obtain technology because it is ready to be used. Another form of ownership rights transfer is a sale of *know-how* related to a given technology and a right for using the technology by the purchaser.

*The strategy of individual implementation* of technology according to Chyba Z.[15] can be pursued in the following forms:

- *Spin-off* – an entity which is formulated by dividing/separating from a home unit (an enterprise or other organization e.g. R&D institution) in order to undertake an activity which would be problematic or impossible to realise as part of the mentioned home unit.

[15] Chyba Z.: Klastry przemysłowe a przedsiębiorstwa spin-off. „Ekonomia i Organizacja Przedsiębiorstwa", No. 3(698). Instytut Organizacji i Zarządzania w Przemyśle, Orgmasz, Warszawa 2008.

– *Start-up* – The possibilities to launch start-ups are very often based on investments of business angels and venture capital companies.

Relations between the three measures, or methods of knowledge commercialization are presented in figure 2.

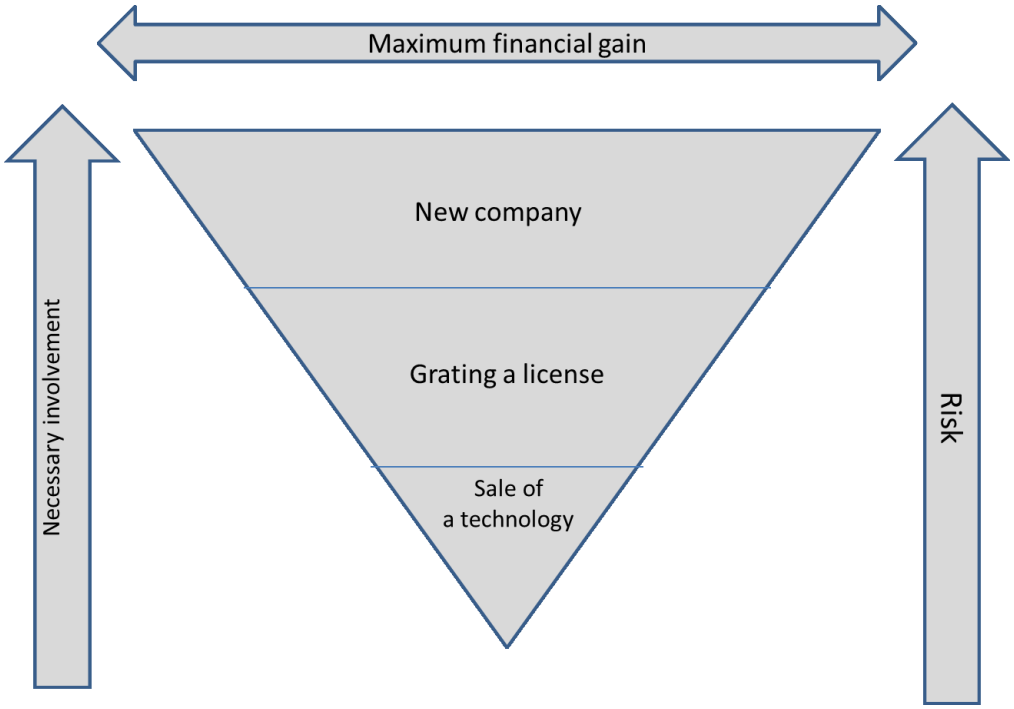


Fig. 2. The methods of commercialization of research and development studies results
Rys. 2. Sposoby komercjalizacji wyników prac badawczo-rozwojowych
Source: Olszewski M., Bek A.: Komercjalizacja osiągnięć naukowych. Przewodnik. „Nauka", No. 4, 2007.

Each of these knowledge commercialization methods has its advantages and disadvantages, which are shown in table 1.

Table 1

Advantages and disadvantages of commercialization methods

| Commercialization methods | Advantages | Disadvantages |
|---|---|---|
| **Granting a license (exclusive or non-exclusive)** | Speed of commercialization implementation, risk limitation, lower costs, ready market | Finance compromise, limited control, need to adjust to requirements |
| **Selling invention or technology to another entity** | Quick profit, speed of commercialization, the least risky , the least labor-intensive | Limited control, fewer benefits, the lowest potential to generate incomes |

cont. tab. 1

| | | |
|---|---|---|
| **Undertaking a business activity (formation of a spin-off or spin-out company)** | Higher flexibility, independence, speed of implementation, possibility to generate long-term benefits, incomes, support of home unit | High risk, weak market position, engaging private funds, the most labor-intensive |

Source: Machnik-Słomka J.: Modele biznesowe spółek spin-off w aspekcie komercjalizacji wiedzy [in:] Balcerzak A.P., Moszyński M. (ed.): Spin-off, spin-out jako instrument budowania przedsiębiorczości akademickiej oraz stymulowania innowacyjności regionu. Polskie Towarzystwo Ekonomiczne, Oddział w Toruniu, Toruń 2011.

Apart from granting a license, selling ownership rights, and establishing a company, (ex.spin-off, spin-out) there also exist the following commercialization methods[16]:

- strategic alliance
- *joint venture*.

***Strategic alliance*** can be defined as jointly assigning the performance of conducting a study, for companies stating the same needs, to institutions or research entities. This procedure enables the companies to share the risk and costs related to R&D. A knowledge and technology transfer may take place by the means of cooperation of several academic centers and a few industrial enterprises as well. Organizations which are members of a strategic alliance learn from each other (remaining competitors), transfer knowledge and commercialize the prepared technology together.

Commercialization by ***a joint-venture*** may take the form of a new enterprise. Partners contribute to the company by providing capital investments, technology and market *know-how*. Companies delivering and acquiring technology conclude a contract defining what each company provides and how the incomes will be shared.

Decision on choosing the method of commercialization has to be made after a thorough analysis of many issues, among others are the financial needs of the project, the field of science, research results, the possibilities to cooperate with a business partner under given circumstances etc. The key element determining the commercialization strategy is the settlement of legal rights for acquiring a project by a producer from a technology author.

It is planned to commercialize the GWDT by selling a licence. The type of licence is supposed to be determined by way of negotiations between the two parties of an agreement i.e. university and company interested in buying a GWDT licence. The technology has been prepared in a research and development institution, which does not pursue its own production activity, and for this reason granting a licence seems to be a good solution. This method creates opportunities for the reimbursement of technology development and preparation costs. Preparing a technological offer, and the offer promotion, in all available innovation and

[16] Głodek P. [in:] Matusiak K. (ed.): Innowacje i transfer technologii – słownik pojęć. PARP, Warszawa 2008.

technology transfer networks are planned after obtaining patent protection. According to many authors ex.[17] J. Stachowicz, network structures (strategic alliances) are one of the dominant organizational forms nowadays, yielding success for enterprises which are gaining in competitiveness and innovativeness.

Other means of technology commercialization, especially forming a spin-off company, are taken into consideration. The term "spin off company" is used for an entity which is established by dividing/separating away from its home unit (in this case from Opole University of Technology) in order to undertake an activity which would be problematic or impossible to realise as part of the mentioned home unit. Company shares are going to be owned both by the author of the technology and the university at which the mentioned technology has been developed – Opole University of Technology. Thanks to this union, the technology is going to be used without restrictions, and a creation and sale of products based on the technology is going to be undertaken. Nevertheless, the distribution of profits, the Opole University of Technology's shares, have to be taken into account. It is possible that after a period of time the company will built up an excellent reputation and position on the market, and the acquisition/buyout of university's shares will be possible. This buyout will lead to the situation that the author of GWDT will become a sole and lawful owner of the company.

## 5. Conclusions

In the process of knowledge commercialization in R&D institutions, including universities in Poland, an entity faces barriers. The process requires some improvements e.g. creating effective commercialization models, applying an integrated and network approach, and expanding the services provided for the benefit of the business.

New knowledge is being created in the process of science research resulting from a remarkable commitment and engagement on behalf of universities, (apart from didactic activity) and dissemination of this knowledge is broadly understood to be in the public interest. However, it is necessary to remember that this knowledge has a measurable character, and a market value of this knowledge can be assessed. This is why the knowledge may become an object of civil legal transactions. The knowledge is often treated as a new potential source of financing, enabling further research to be conducted. However, the

[17] Stachowicz J.: Przewaga konkurencyjna a przewaga kooperacyjna: dylematy współczesnego paradygmatu zarządzania strategicznego, [in:] Rokita J., Grudzewski W. (ed.): Zarządzanie strategiczne w warunkach nowej gospodarki. GWSH, Katowice 2001.

knowledge and technology transfer, and providing its commercialization, is a very complex, multistage, time and cost consuming process. The passage form the idea to market is a long journey, which, providing it is appropriately planned, may bring satisfaction and success. On the other hand, committing grave errors at the stage of planning, the procedure may end in a fiasco, even though the concepts were really innovative and interesting.

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