Knowledge management in the assembly process of small hydro power plants

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Abstract
Europe leans towards cleaner and more efficient energy production. The Renewable Energy Sources Directive of European Union sets mandatory national targets for renewable energy shares of final energy consumption in 2020. This fact makes the investments into renewable power not only inevitable, but also viable because of the guaranteed feed-in tariffs. Since hydropower represents a significant share of renewable power in Slovakia and small hydro power, in contrast with large hydro, is still being developed, it is crucial for companies producing technology for small hydro to capture their knowledge and know-how. This has to be done in order to ensure high efficiency of turbines and quality of machinery as well as coping with the increasing age average and fluctuation of skilled employees in manufacture.

Introduction

The capability of managing the company knowledge is a crucial factor in today's economy. It is becoming a standard, where the knowledge is being thought of as one of the most valuable commodity that is embedded in the product, especially while talking about sophisticated technological products. (Wild, 2008)

While knowledge is increasingly being viewed as a commodity or intellectual asset, there are some paradoxical characteristics of knowledge that are radically different from other valuable commodities. These knowledge characteristics include the following (Dalkir, 2005):

- Using knowledge does not consume it.
- Transferring knowledge does not result in losing it.
- Knowledge is abundant, but the ability to use it is scare.
- Much of an organization's valuable knowledge walks out of the door at the end of the day.

The expansion of computing, advent of the Internet, World Wide Web, has made unlimited sources of knowledge available to a wide range of people. Forty-five years ago, nearly half of all workers in industrialized countries were making or helping to make things. By the year 2000, only 20 % of workers were devoted to industrial work – the rest was knowledge work (Dalkir, 2005) (Barth, 2000).

Knowledge management (KM) has however became a major issue in academia and industry only in the last 30 years (Nonaka I., 1995). KM has at least three roots.

- Suppliers of information technology and academics in this field have developed opportunities of supporting knowledge reuse and knowledge creation by, for instance, artificial intelligence, knowledge-based systems, and Internet applications, (Hans-Horst, 2004) (Antonie Jetter, 2006)
- Organization and human relations professionals and academics have recognized the need for academically challenging jobs and for using the opportunities of an increasingly highly educated work force in modern societies and (Antonie Jetter, 2006)
- Strategic management has recognized, especially for firms in western societies, competition based on motivating people to work harder will not be effective and, instead, the optimal use of intellectual capabilities may be the best source for sustaining competitiveness in our global economy. (Kostoff RN, 1997)

Knowledge and Knowledge Management

Knowledge is not easily measured or audited, so organizations must manage knowledge effectively in order to take full advantage of the skills and experience inherent in their system and structures as well as the tacit knowledge belonging to the employees of the firm. Prior studies defining knowledge management are shown in the following table. Knowledge management is a managerial activity which develops, transfers, transmits, stores and applies knowledge, as well as providing the members of the organization with real information to react and make the right decision, in order to attain the organization's goals. (K.A. Kanagasabapathy, 2006)

(Gupta, 2000)	KM is a process that helps organizations find, select, organize, disseminate, and transfer important information and expertise necessary for activities
(Alavi, 2001)	KM is managing the corporation's knowledge through a systematically and organizationally specified process for acquiring, organizing, sustaining, applying, sharing and renewing both the tacit and explicit knowledge of employees to enhance organizational performance and create value
(Bhatt, 2001)	KM is a process of knowledge creation, validation, presentation, distribution and application
(Holm, 2001)	KM is getting the right information to the right people at the right time, helping people create knowledge and sharing and acting on information
(Horwitch, 2002)	KM is the creation, extraction, transformation and storage of the correct knowledge and information in order to design better policy, modify action and deliver results
(Bergeron, 2003)	KM is a business optimization strategy, that identifies, selects, organizes, distills, and packages information essential to the business of the company in a way that improves employee performance and corporate competitiveness
(Robert J. Thierauf, 2006)	KM is related to wisdom management in that wisdom is the umbrella that brings together not only knowledge in the form of business intelligence and optimization, but also provides the means to assist decision makers in reaching optimal and wise decisions over time.

Significance of the Renewable Power in Slovakia

While comparing Slovakia with the rest of the EU28 countries it is dependent on the import of energy more than the EU28 average. In the year 2009 the dependence of Slovakia on import reached 66.4 %, thus making it the most energy dependent country from V4. The average import dependency in EU27 in the year 2009 was 53.9 %. Just to compare, the Czech Republic dependence on import in year 2009 was only 26.9%, thus making it the least energy dependent country in V4. (Eurostat, 2011a)

The energy production of Slovakia consists mainly from nuclear power, however it is important to notice that there is also a considerable share of renewable energy sources (RES). 15.5 % of the electricity is produced from RES, and therefore Slovakia has the biggest share of RES in V4 countries and is also the closest to the European average – 16.7 % in the year 2008 (Eurostat, 2011b). It is obvious that Slovakia pursues a goal of substituting the nuclear power generation for power generated from RES. The import of gas and oil is mainly from Russia, Slovakia however imports coil as well. The sector that is the most energy demanding is the industry, while the consumption is less than half in transport, households and services compared to the industry. (Eurostat, 2011c)

The Slovak energy efficiency is relatively high, in comparison with the EU27 average, while the CO2 share is low. Slovakia produces the least amount of CO2 emission among all the V4 countries and its share on global emissions was only 0.12 % (British Petrol, 2010). Slovakia has relatively uniform energy mix, since no source of power is dominant in the energy consumption (opposed to the energy production).As seen on the following graph, excluding RES, each of the sources have even share. (European Union, 2011)

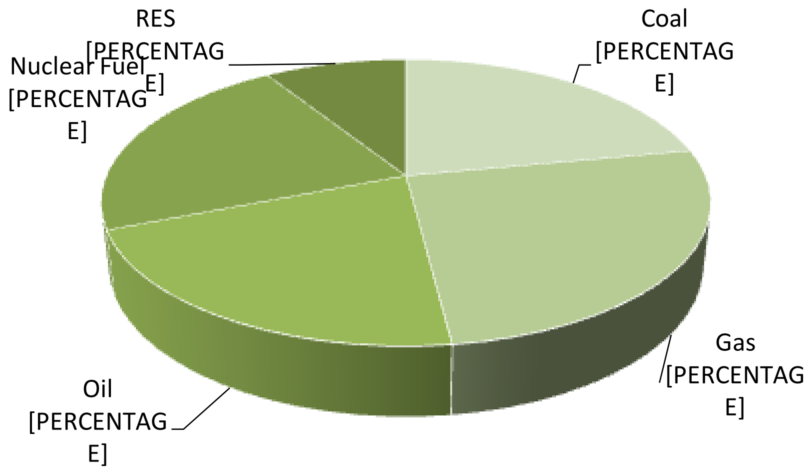


Figure 1 Energy mix of Slovakia in 2011 (Eurostat, 2011d)

RES

Currently RES account for 16 % of the domestic electricity consumption (5.2 TWh). The total available technological potential of RES in Slovakia could increase the share of electricity produced from RES to 24% in 2020 and to 27 % in 2030. The most perspective RES for heat production is biomass, where the annual potential, suitable for energetic usage accounts for 75.6 PJ. Biomass is also one of the most perspective source for electricity production. Despite these facts, hydro power is still the most used RES and small hydro keeps developing in Slovakia. While talking about the rest of the RES (wind power, geothermal energy, solar power), these sources represent only, so to say, additional sources of energy, because their unreliability and uncertainty of energy supply. (Slovak Innovation and Energy Agency, 2013)

Research Background

Slovakia offers significant future potentials for several kinds of RES options which are waiting to be exploited in the forthcoming years. In contrast to above, current RES deployment is at a comparatively low level. Currently, the key support instruments of RES-E in Slovakia is a feed-in tariff. The Regulatory Office for Network Industries sets feed-in tariff rates annually, taking into account the index of national core inflation. The revision of feed-in tariffs every year however brings some uncertainty into the RES-E market. On 19 June 2009, Slovakia adopted a new Law on the Promotion of RES and High-Efficiency Cogeneration in order to foster the attractiveness of investments in RES technologies and to meet the country's EU targets. Under this new support scheme, a feed-in premium will be available for RES-E producers. The fixed tariffs are determined for different types of RES technologies on the basis of installed capacity and the date of commissioning the plant. The feed in tariff has been determined in such way that the pay-back period is 12 years. The new support scheme is available for the following RES technologies: hydropower, solar, wind, geothermal, biomass, biogas, sewage gas and biome thane. The feed-in premium scheme will be based on a premium payment on top of the basic electricity price. A producer of RES-E will be entitled to a premium for 15 years after the initial operation, reconstruction or modernization of a power plant. RES-E producers have the right to a premium if the total installed capacity is up to 10 MW. In the case of wind energy, producers have right to a premium if the total installed capacity is up to 15 MW. (Gustav Resch, 2010)

Because of these reasons, building small power plants is becoming more and more attractive investment. Construction of additional large hydro power stations now seems unlikely, due to both to environmental concerns and to the high costs of providing under-served rural areas and mountainous communities with additional electricity supplies via the construction of large dams. In these circumstances, the construction of additional small hydro stations could be a more cost efficient and less environmentally intrusive solution.

More than 190 small hydro power plants are currently in operation in Slovakia. The construction of additional small hydro power plants by Slovakia's electricity generation company (and owner of large hydro power stations, Slovenske Elektrarne), is therefore anticipated – particularly in the Vah river basin. (United Nations Development Program, 2012). Just recently a small hydro power with an installed capacity of 0.315 MW plant has been connected to the grid by Slovenske Elektrarne. (Slovenske Elektrarne, 2014)

Because of the above mentioned facts it is crucial for companies producing the technology for small hydro power plants to have an operative knowledge management, where they can capture the company know-how and drive the company to better results.

How to Capture the Knowledge in the Assembly Process

Since the demand for small hydro power plants has increased in last few years, the companies in the sphere of small hydro development stand in front of a task that is not easy at all. They need to be more efficient, capture their knowledge and improve their production and assembly process, so they can achieve shorter lead times with less manufacturing faults.

One of the biggest issues for turbine manufacturers is to hire skilled and smart workers in manufacturing and field service. These employees together with engineers are the driving engine for a mechanical engineering company dealing with hydro power. Another problem, which however is not going to be discussed in this article is the high age average in these (manufacturing and field service) professions. While hiring young employees to the manufacture, employers often have to go below the set requirements, just to get the labour force. Sadly, young employees often miss technical thinking.

Mainly because of these reasons, authors of this article tried to create a guide that would help to capture the know-how of skilled workers and help to imagine the final result of the assembly for the workers with less skills or technical thinking. These "guides" have been called Part Sheets. These part sheets have been developed for main subassemblies of the whole turbine from penstock to draft tube.

It is important to notice, that the manufacturing of turbines is rarely in a form of mass production, even in world leading companies. Each turbine could be called a "prototype" and that is why Part Sheets cannot be considered unchanging. They have to be looked at more like a way how to set the standards on a certain level, keep the updates, improvements and know-how in them and therefore the standard for the following turbines can leverage from the past. The part sheets will vary from project to project in small details, however the principle and template remains the same, to make the assembly process easier mainly, but not only to, the manufacturing workers.

To sum up the main groups that benefit from the Part Sheets usage:

- **Manufacturing workers/Field Service/Assembly workers** – Part Sheet is a great additional material to drawings. It has been observed that majority of labour workers looked at and used Part Sheets before searching for drawings.
- **Logistics department** – Since Part Sheets contain a table of all the used stocks for a subassembly shown. That makes the communication between logistics department and manufacture easier, since only Part Sheet number can be used to order, or Part Sheet number + item number. This enables on-time delivery of all the components, often as a whole, therefore downtimes, when a bolt or a screw has to be looked for in manufacture drop out.
- **Project management** –It was often the case, that new project managers had only little or no experience with hydro power, therefore some terms were unclear, or even the purpose of a certain part. Part Sheet visually explains the purpose of the part and its position in the whole assembly, therefore misunderstandings can be avoided.

Part Sheets Examples and Results of Part Sheet Usage

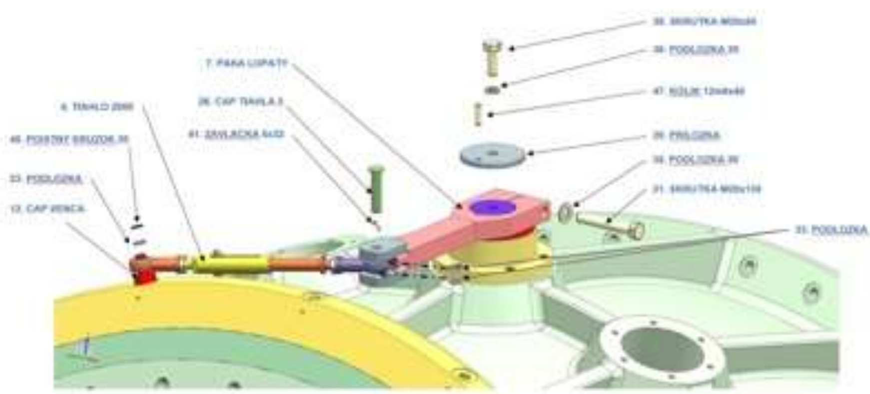
As mentioned before Part Sheets contain a list of used stocks. But their outline is not only formed by that. They are formed by 2 main parts:

- The 3D part, where the subassembly is shown in an exploded view together with all the stock names indicated.
- A list of all the stock used with their serial number, item name, item count and its type.

At first, let's have a look at an example of a Part Sheet and its content:

Mounting of the Rod and Vane Arm for Project n.47

Identification of subassembly and project



3D exploded view of the subassembly

No.	Item	Count	Type	Date finished	Signature
4.	Rod 2000 CO.-09-0800040/1	1	SA		
7.	Vane arm CO.-09-0800045/1	1	SA		
12.	Stud of the ring CO.-09-0800041/1	1	CO.		
20.	Plate CO.-09-0800018/1	1	CO.		
23.	Washer CO.-09-0800039/1	3	CO.		
26.	Pivot rod 2 CO.-09-0800043/1	1	CO.		
30.	Screw M20x50 DIN 933 8.8 Zn	1	STD		
31.	Screw M20x130 DIN 931 8.8 Zn	1	STD		
35.	Washer 20 DIN 125 Zn	1	STD		
36.	Washer 20 DIN 7980 Zn	1	STD		
41.	Split pin 5x32 DIN 94 Zn	1	STD		
45.	Circlip 20 DIN 471 Zn	1	STD		
47.	Pin 12m6x40 DIN 7	1	STD		

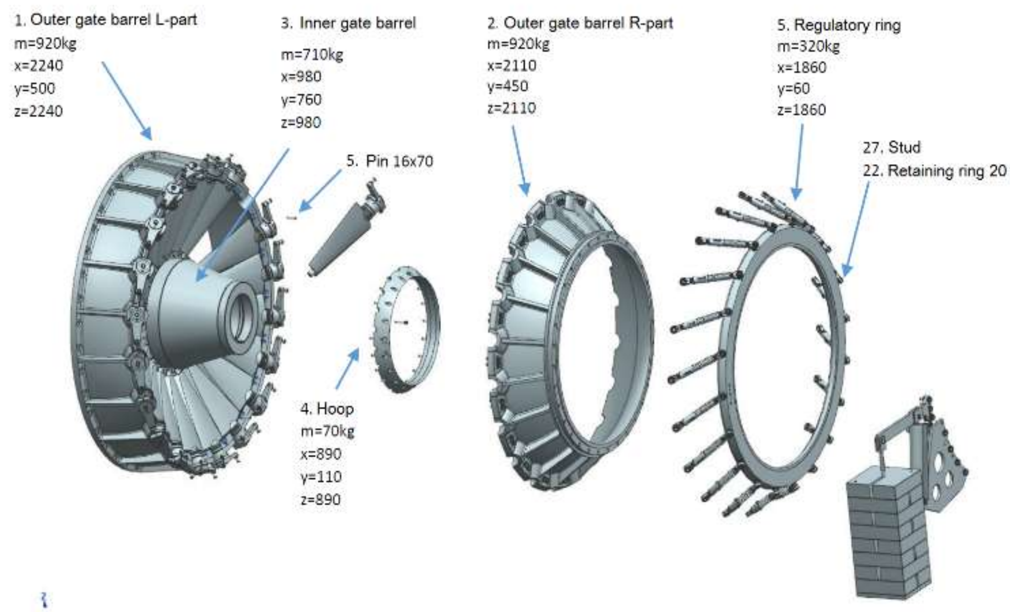
List of items, item count, their type, date of their assembly and signature of the responsible employee.

Legend

Legend:

1. The positions shown in the table are identical with the positions at drawing CO.-09-0800037/1
2. STD – part to buy; CO. – part manufactured in our company; SA – Sub Assembly

Following images show the 3D exploded view of outer gate barrel on a Part Sheet and steps during the inner gate barrel installation while following the Part Sheet.



Conclusion and Further Research

As per today Project Sheets for eight subassemblies have been launched. Two parameters have been observed, time saving and error rate. These are continuously monitored and will be statistically compared with assembly times and errors before the Part Sheet usage. So far significant time saving has been observed while assembly process, but also in logistics department while ordering goods. The error rate in assembly process has decreased slightly, however the error rate in logistics department has decreased considerably. These time savings and error rate decrease is mainly observed for more complicated subassemblies (wicket gate rod, runner, etc.).

The next stage is aimed to get more data and quantify all the impacts of these Part Sheets. Time savings need to be quantified and Part Sheets, with small changes, need to be used in different projects, to evaluate their versatility.

Part Sheets shall play an important role in the company know-how, since each improvement in assembly, whether it is a reduction in material used, or reduction of components that leads to the same or a better performance is registered in a part sheet and leads to Part Sheet improvement. Therefore the next project can be done in the same or improved quality than the previous one. And most importantly, with Part Sheets keeping record of all the improvements and practices a loss of a skilled labour force does not necessarily have to mean a loss of the company knowledge and know-how.

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