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***Abstract*—The process industry faces a strong need to increase product quality and reduce operating costs and its environmental footprint. Plant-wide monitoring and control is a requirement for achieving economically and environmentally efficient operation. The Coordinating Optimization of Complex Industrial Processes (COCOP) project's objective is to define, design and implement a concept that integrates existing industrial control systems with efficient data management and optimization methods, and provides a means to monitor and control large industrial production processes. This paper looks at the COCOP development from the business perspective of a copper-smelting pilot case. Business Model Canvas and Business Environmental Map methodologies were used in the pilot case workshops for studying potential business models and business environments related to the COCOP solution.**

Keywords — Optimization, Modelling, Business model, Business environment

I. Introduction

Typically, the business potential of an idea is estimated when preparing a research project, but after a successful funding decision, the work focuses on innovating some fancy technical features [1]. Typically, the business aspect is re-examined after the development work, when the product or service is to be launched to markets. The best results are achieved with continuous collaboration between business people and research people. The ongoing research and development project "The Coordinating Optimization of Complex Industrial Processes", COCOP, has done business studies at the same time as the development activities. Today, the process industry faces a strong need to increase product quality and reduce operating costs and its environmental footprint. These needs are most often business based, and these needs can be fulfilled in many ways. Actually, there are many ways to improve production efficiency, depending on the focus, e.g., the production process itself, transport and logistics, human factors and so on [2], [3]. COCOP focuses on complex plants, with continuous and batch unit processes, where plant-wide monitoring and control are needed to ensure economically and environmentally efficient operation [4]. The COCOP -project's generic objective is to define, design and implement a concept that integrates existing industrial control systems with efficient data management and optimization methods and provides a means to monitor and control large industrial production processes [4]. The COCOP project has identified two business objectives for the research: 1) to reduce operation costs by optimal performance of the processes that allows a reduction of the use of energy and raw materials, the number of defects/rejects, etc., and 2) to increase the productivity [4]. Additionally, three social objectives also have strong links to the business objectives, and have been identified as follows. Firstly, to improve the working conditions of plant operators by developing new process control tools, which support operating work by providing new ways to control the process. Learning and development of competences will also be addressed. [4] Secondly, to strengthen the societal and personnel development perspective by including the designed technological innovation in the concept of a social-innovation process. The development process will be integrated into a broader company strategy. This will be done by integrating all relevant stakeholders and end users, and thinking of the implementation and impact right from the beginning of the process.[4] Thirdly, to strengthen the competitiveness of the European process and automation industry, which will result in job retention, exportable high-value IT products for the industry and the corresponding jobs, and wellbeing in Europe. [4]

This paper looks at the COCOP development from the business perspective and tries to identify the challenges through one case study. Within the case study, the business studies are done to ensure the right track in research and development, and to evaluate the COCOP solution through practical challenges.

II. The Design Methodology / Approach

Österwalder's (2010) Business Model Canvas (BMC) and Business Environmental Map (BEM) tools and methodologies were used in use-case workshops for studying potential business models and the business environment of the COCOP stakeholders [5]. The BMC is aimed at finding out the existing business model implementation and the development of business strategies [5]. The BMC covers nine key areas of any business: key partners, activities and resources, costs, value proposition, customer relationships and customers, sales channels and revenue. External forces and trends shape business models and the business environment. To describe and to study the environment where the business operates, BEM is organized into four areas: Market Forces, Key Trends, Industry Forces and Macro-Economic Trends. The macro-level business environment aspect needs to be taken into account when studying the potential business models for any business. For example, business models in healthcare must comply with EU-level and national regulations. In the entertainment industry, technology has enabled innovative business models to flourish and cater to new ways of consuming films or music. Sometimes disruptive technologies substantially change the entire business environment and new kinds of business models have the opportunity to enter the markets.

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This paper defines the trends and forces related to the COCOP case example through Business Environmental Map analysis. Osterwalder et al. created the Business Model Environment tool to help in asking specific questions that can uncover new business model ideas [5]. However, untapped opportunities are often identified in an ad-hoc and unstructured way. Someone with good intuition will identify an opportunity that others cannot see (e.g., a new technology, an unmet need, a new regulation) and will transform it into a growth engine.

The COCOP project covers different process industry cases. The use cases are related to the steel and copper industries, and a later project will evaluate the COCOP solution in the chemical treatment and water treatment processes [4]. However, this paper focuses on the copper-smelting pilot case, where the optimization will comprise a converter and anode-furnace scheduling, and setting the target matte grades and feed rates of flash-smelting furnaces [8]. Detailed advisory tools will be implemented for controlling unit processes to improve factors such as temperature, slag chemistry and impurities. The prototype will be tested at an actual operating copper smelter plant. [8] This paper presents the initial findings from BMC and BME workshops related to the copper-smelting case. This paper does not focus on the process optimization problem itself, but only on the business view of the tool development.

III. Key findings

The key question in the COCOP project's business and exploitation planning is who is making the offer, what they offer, and who are the customers for the results? As a starting point, the optimization of complex industrial processes is an ongoing challenge in the very competitive market of the process industry [3], [7]. Commercially available, plant-wide optimization solutions for copper smelters based on process models do not currently exist. Siemens, for example, have a commercial tool for process control, but the solution is not plant-wide. There are many different systems in place in the main control room and they represent different generations of user-interface technologies, for example: Valmet DNA, Siemens Simatic, and ABB 800xA. The COCOP solution can be generally described as a real-time optimization system for complex process industry plants, which benefit from having plant-wide monitoring and control by using the model-based, predictive, coordinating optimization concept [4]. The concept is based on decomposition-coordination optimization of the plant operations: the overall problem is decomposed into unit-level sub-problems, so then the solutions of sub-problems can be coordinated to a plant-wide optimal schedule using high-level coordination. Actually, decomposition-coordination optimization can be used for many purposes, like energy grid optimization [8]. This will support the plant operators in understanding the functioning of the plant as a whole, including the areas traditionally beyond their control, and to make better decisions within their part of the process. However, the challenge is not only technical; business opportunities should also be taken into account during the development of the tool. That provides the main motivation for the study this paper presents.

In the copper smelter case the control tool developed in the COCOP project has a unique value proposition offering an online solution for plant-wide optimization. The decomposition-coordination method utilized allows already proven first principle models for optimizing the unit processes to be used and extended to a plant-wide solution with the coordination layer. The tool's aim is to provide more stable process and better capacity utilization while reducing the number of process disturbances and improving environmental performance. The social innovation aspect of the COCOP project ensures that the copper smelter control tool will be well accepted and used by the process operators, as the end user perspective is already taken into account in the development. It also provides an ideal platform for training the process operators by creating transparency between unit processes, and by making it easy to estimate the effects of single control actions on the overall performance of the plant.

A. Business Model view

Typically, copper plant business development today focuses on increasing the production rate, lowering specific production costs and lowering specific emissions [8]. Within the copper case, the following selected requirements have been identified [9]:

- Maximize the Flash Smelting Furnace (FSF) feed rate
- Maximize the amount of copper scrap (recycling) added to the converters and anode furnace (increase of copper amount from matte to anode copper)
- Keep the SO2 emissions under the legal limits and as low as possible
- Minimize oil usage in the anode furnaces and FSF
- Minimize propane usage at the anode furnace
- Increase recovery of copper from slag
- Minimize the fluctuations in matte grade to facilitate production stability

During the research, how the COCOP solution will fulfil the above requirements in practice was discussed. As the most important part of the business model is the value proposition, these mentioned requirements should be turned to the copper smelter's offerings. Accordingly, we have identified the following value proposition topics, when applying the COCOP solution in practice:

- Better capacity utilization
- Increased value of process and lowering operational (processing) cost
- More stable process, risk mitigation
- More sustainable operations
- Better access to remote expert support

In the copper industry, several customers have been identified: large global mining companies, small and medium-sized mining, metallurgical companies in developed countries, as well as local mining and metallurgical companies in emerging regions [5]. According Outotec's Sustainability Report, their customers are either investing in new processing plants or modernizing their existing plants to increase the profitability of their operations, improve their resource efficiency, or reduce their emissions, energy consumption or fresh water use [9]. When looking at the customer list above, their investments and improvement targets should support the demand for the COCOP solution. The existing value chain of the COCOP solution in the copper case will be as shown in Figure 1.

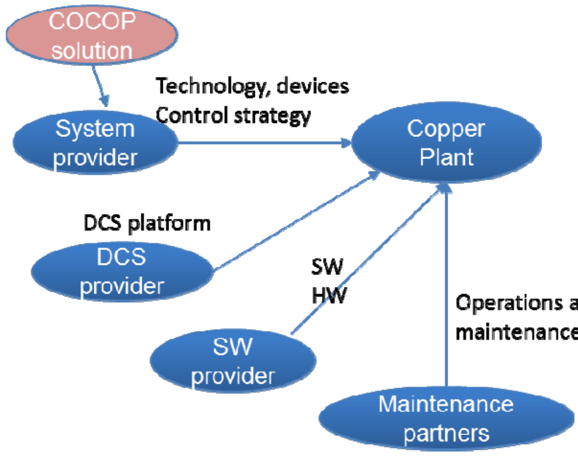

Fig. 1. Copper case value chain

For the COCOP solution, the challenge will be the revenue models. There are many options for earning logic in this kind of business environment, where a traditional product based business is turned to services and operations are strongly supported by software solutions. Actually, today, the digitalization of industries is changing business settings. The trend of "Something as a Service" can radically change revenue streams. New performance and value based revenue models will be formed in the digital era [10]. The value capturing mechanism aims to translate value-in-use into financial value for the service provider [10]. Value-based and pay per result revenue models are quite challenging. In fact, the COCOP solution can provide huge advantages and cost savings for the copper industry companies, but the value of the solution should be argued well before successfully implementing new revenue models in practice. The rest of the business model building blocks are case specific and not relevant for this conference paper. Actually, the entire business model canvas for the case company is strategic content of the company, and cannot be published in this paper. However, the above topics define generalized findings, which are the focus of this paper.

B. Business Environmental view

After the business model drafting, there is a natural continuation to studying the Business Environmental Map, by identifying different forces around the COCOP solution. As mentioned before, the BEM is organized into four areas: Market Forces, Key Trends, Industry Forces and Macro-Economic Trends. Starting with market forces, copper is produced globally on all continents. Copper industry markets are global trading markets and the most important trading venue is the London Metal Exchange. The biggest copper producer is Chile followed closely by China and Peru. Nowadays, new smelting capacity investments have recently been made mostly in China. The top ten copper production country ranking in 2015 is given in the picture below.

Rank	Country/region	2015 copper production (thousand tonnes)
	World	19,100
1	Chile	5,760
2	China	1,710
3	Peru	1,700
4	United States	1,380
5	Congo, Democratic Republic of the	1,020
6	Australia	971
7	Russia	732
8	Zambia	712
9	Canada	697
10	Mexico	594
	Other Countries	3,800

Fig. 2. Example of Top 10 copper producing countries in 2015 [11]

It can be noted that no single country within the EU reached the Top 10 list in 2015. However, there is significant copper production within the EU in countries like Finland, Sweden, Germany, Poland and Spain. The demand for metals is expected to increase as the quality of life increases globally. World demand for copper is expected to rise driven by electrification of households, electric cars and increased demand for appliances, computers, mobile devices etc. As the copper industry has not been investing in new projects that much, the markets are expected to be in a slight supply deficit within the next few years [12]. Therefore, the demand for digital solutions optimizing the production efficiency of the smelters can also be considered to increase in the future.

Secondly, the identified BEM's Key Trend is related to the process industry in general, and as such also to the copper industry. The most dominant trend is the digitalization and the Internet of Things (IoT) of everything. Today there is a strong trend to automate everything, like cars, ships and even whole processing facilities. Especially from the COCOP project point of view, the trends on process and resource efficiency are the most relevant big trends. So it can be said that there is a clear trend supporting the aims of the COCOP project.

The third area in BEM is the Industry Forces. Traditionally, equipment manufacturers and process automation suppliers (like Rockwell and Siemens, for example) have had an important digitalization-related role in the industry. During the workshop it was questioned if, in the future, players with an IT-background, like Amazon and Microsoft, or other players utilizing their platforms could enter the process automation markets with their offerings? In such a case consolidation amongst players might happen and partnering could be possible in some areas. However, the COCOP solution might have its specific role in the process industry, as it is based on academic research, and physical models and will be tested in multiple industry cases.

The Macro Economic Trend is that the price of copper has fluctuated highly within the last ten years based on the macroeconomics. There has been a continuous increase in copper prices since 2016, as shown in Figure 2 [13].

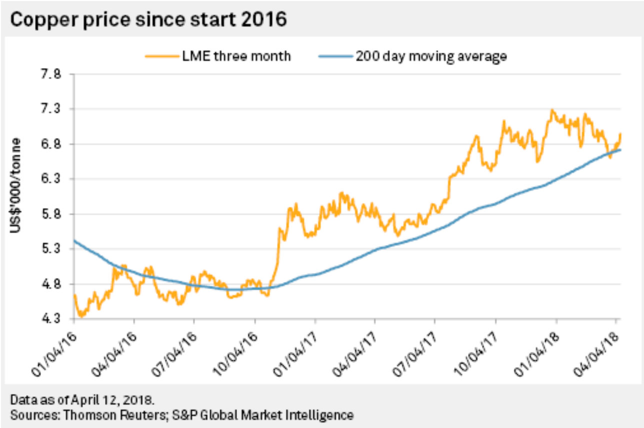

Fig. 3. Copper price since 2016 [13]

The total copper exchange stocks at the end of March 2018 were at their highest level in over 10 years at 907,485 tons [13]. The fluctuating copper prices have traditionally affected investments made in the industry and the copper price will also have an effect on the demand for the COCOP solution. Often when the copper price decreases, the producers start cutting their investments and focus on the most critical projects. Software-based optimization solutions can offer high a return on investment with short payback times, and as such they are often also attractive investments when the markets are not booming.

IV. Discussion

The COCOP-project's exploitable results have demand and need not only in the steel and copper sectors currently studied in the project, but in the complex process industry in general. The producers in the EU and other western countries are facing increasing competition from low cost countries while the demand for metals is shifting more and more towards China. In order to maintain the competitive edge, production optimization solutions developed in the COCOP-project are needed. The markets for such solutions are expected to be on a solid foundation, as the demand for metals is only expected to increase in the future while the potential for automation is also increasing. From the technical perspective, cloud based big data solutions are the next generation approach, which might need to be take in account in the COCOP solution [14]. The current use case for COCOP's exploitable results in the copper industry look very promising from the exploitation and business potential perspective. In the end the main objective is to enable plant-wide monitoring and control by using the model-based, predictive, coordinating optimization concept in integration with local control systems. The COCOP solution will allow plant operators to:

- approach optimal production and reduce operation costs
- increase sustainability (improved energy and resource efficiency with less greenhouse gas emissions)
- improved working conditions of plant operators by the new process control tools, which support the daily operating work
- increased competitiveness of the European process and automation industry, resulting in job retention, exportable high-value IT products for the industry and the corresponding jobs, and wellbeing in Europe.

Despite the advantages listed above, there are some risks related to the successful exploitation of the COCOP solution in these sectors, but these are often expected when developing such new technologies and can be overcome with proper risk mitigation. Additionally, during the following phases of the COCOP project, applicability to other process industries will be studied and the related business potential estimated to get more feedback about necessary solution features and functionality in different operations. Transferability analysis will be done to chemical and water treatment processing industries. These new case studies are definitely a clear future research topic for COCOP, which will validate wider COCOP results.

As stated at the beginning of the paper, often the business perspective is lost somewhere among the joy of creating something new and exciting [1]. Learning from previous research, the COCOP project decided to begin the exploitation planning at an early phase. However, early business planning typically means that some of the details like cost and pricing of the solution cannot yet be covered in much detail. The project team concluded after the business model workshop that the methodology utilized and the related discussions have been very fruitful and have been good for sharing market perspectives. The selected Österwalder's BMC and BEM are good methods for introducing a business related perspective for the project's stakeholders. The commercialization and business strategy settings can already be improved during the development, not only as the last part of the project. The business modeling work will continue until the end of the COCOP project, and this will no doubt improve the business potential of the project's results. It was identified that, for example, the commercial vision of the COCOP project should be defined and agreed within the consortium and the exploitable results and related IPR matters should be identified more clearly. Typically, everyone can utilize all the background and the results during the research, but the contracts and rights after the project should be agreed during the research. In the COCOP project, there might also be some opportunities for new stakeholders or joint ventures to take the main commercialization role. Generally speaking, the roles and identification of commercialization partners will be one of the key topics in COCOP’s business studies by the end of the project. As having clear ownership plays an important role in the commercial success of any research project, it is good to include–and maintain–the business perspective as early as possible in any research project.

Acknowledgment

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