國立交通大學

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碩 士 論 文

“Chemosvit Energochem a.s.”能源生產的投資決策

Investment Decision for Energy Production in
Chemosvit Energochem a.s.

研 究 生：羅易瑋

指導教授：唐瓔璋

中 華 民 國 九十九 年 六 月

National Chiao Tung University

College of Management

Thesis

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ABSTRACT

The recent years of our planet are characterized by the struggle of humankind between the constant onward development and challenges facing its own evolution without devastating the environment inevitable for its existence. Governments, international authorities and corporations dedicate their best endeavor to decelerate and eliminate the destruction we have been causing to our planet in last decades, whereupon, much more effort is manifested to bring the representatives together in order to deliver tangible results to sustain our own environment. These aspirations are reflected in numerous international agreements and country-level regulations, which should motivate the enterprises and individuals at microeconomic level to contribute this global struggle.

This thesis aims to study the recent advancement in regulations and technology research to face the challenges of sustainable environment and green energy sector as a prerequisite for the case analysis, which represents the microeconomic level of such environmental appeal.

The subject of this study is a Slovakian enterprise, Chemosvit Energochem a.s., which is the main supplier of energy and heat to the corporation Chemosvit Group a.s. The membership in European Union results in the compliance with European and Slovakian regulations in green energy sector and so generates new impositions for the enterprise in its production process. The need to invest into the new technologies for energy and heat production was recognized in Chemosvit Group a.s. in the late 2006. In the year 2007, several alternatives, as presented below, were evaluated to estimate the most efficient and economical way of electric energy and heat production, from which the most sustainable alternative will be selected in the year 2010 with the consequent investment in 2011.

1. Only Boilers.
2. Boilers + Boilers for Biomass.
3. Boilers + Geothermal source.
4. Boilers + Solar Energy.
5. Cogeneration with Gas Motors.
    a. 2 x 1 MW = 2 MW (Two motos of 1 MW)
    b. 2 + 1 MW = 3 MW (1 motor of 2 MW and 1 motor of 1 MW)
    c. 2 x 2 MW = 4 MW (2 motors of 2 MW)
    d. 2 x 2 + 1 MW = 5 MW (2 motors of 2MW and 1 of 1 MW)
    e. 3 x 2 MW = 6 MW (3 motors of 2 MW)
    f. 5 x 2 MW = 10 MW (5 motors of 2 MW)
6. Cogeneration with Gas Turbine.

The alternatives are evaluated in this thesis using the methodology of cash flow and payback method analysis based on various assumptions for the future evolvement of upcoming 8-year period, which are combined in order to deliver more accurate results without significant bias in numerical calculations. The results of this thesis are aimed to help in the investment decision-making process prior of choice of alternative in winter of the year 2010. Their objective is to supply Chemosvit Energochem a.s. with complementary information and data for their decision, which may serve as an alternative source to the company`s own internal processes.

The outcomes of the analysis show that the most sustainable and efficient way of energy and heat production may be delivered through the method of Cogeneration with Gas Motors. Whereupon, further investigation of the most appropriate configuration of the gas motors is performed, which resulted into the conclusion of proposal for the choice 5.3: Cogeneration with Gas Motors in the configuration of 2 motors of 2MW each. Furthermore, considering the environmental challenges our planet is facing and basing on the conclusions from the analysis, recommendations for an additional improvement of energy production are proposed in the ultimate part of this thesis. It is believed that the more efficient saving method of trigeneration: electric energy, heat and cooling production, can significantly contribute to the cost savings of Chemosvit Energochem a.s. reducing so the emissions in our environment and finally protecting our planet.

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I owe my loving thanks to my parents and brother. Without their encouragement and understanding it would have been impossible for me to finish this work.

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ABBREVIATIONS

Greenhouse Gases	GHG
Organization for Economic Cooperation and Development	OECD
United Stated Environmental Protection Agency	US EPA
International Organization for Standardization	ISO
European Union	EU
United States of America	USA
International Energy Agency	IEA
Energy Information Administration	EIA
Tradable Renewable Energy Certificate	TREC
Tradable Renewable Certificate	TRC
Renewable Energy Certificate	REC
Kilo-Watt-hour	KWh
Mega-Watt-hour	MWh
Carbon Dioxide	CO_2
United Nations Framework Convention on Climate Change	UNFCCC
Slovak Crown	SKK
Eurozone Currency	EUR
Gross Domestic Product	GDP
North-Atlantic Treaty Organization	NATO
Slovenské Elektrárne (Slovak Electricity Company)	SE
Východoslovenské Elektrárne (East-Slovakian Electricity Company)	VSE
Tatra National Park	TANAP
Independent Power Producers	IPPS
Research Institute of Chemical Fibers	VUCHV

KEYWORDS

Greenhouse Gases

Emissions

Green Energy

Solar Energy

Biomass

Hydraulic Energy

Geothermal Energy

Cogeneration

Trigeneration

Green Certificates

Kyoto Protocol

Slovak Energy Sector

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I. INTRODUCTION

In the eternal struggle for survival, the man has achieved surprising levels of development in science and technology. As never before, we began to see the contradiction between the man and nature, which manifests itself through natural environmental conditions that threaten the security of our planet.

The proponents of the theory of climate change claim that the problems of pollution and ecological deterioration are far from random events and casuistic situations. They are the result of industrial chemical processes and the burning of vast quantities of organic fuels that cause severe damage; destroy forests, lakes, rivers and seas. These processes are also a cause of global warming, mostly due to the large scope of gas, carbon, nitrogen and sulfur emissions, which impose the ozone layer holes enabling the gradual warming of our planet and consequent melting of the ice beyond polar circle. Due to these serious circumstances, representatives from 36 countries gathered together in December 1997 to sign the Kyoto Protocol, which represent a significant international agreement on environmental protection named after the Japanese city where it was initiated. The delegation agreed upon the reduction of the global emissions of Greenhouse Gases (GHG) by 5.2% based in the levels of the year 1990. Under this agreement, the signatory countries should ensure that between 2008 and 2012 the pollutant emissions decrease by 5.2% below those recorded in 1990. At the subsequent Bonn Summit this limit was reduced to 1.8%, since a risk of non-ratifying the Protocol was relatively high. It is estimated that 75% of emissions of greenhouse gases, which had been accumulated in the atmosphere over the past 50 years, were mostly generated by industrialized countries, where only 20% of the world population lives. The remaining 25% of emissions has occurred in developing countries, where the remaining 80% of the world population lives.

Traditionally, the introduction of regulations to reduce the air pollution caused by production and manufacturing activities has been seen as a factor that raises costs of the firms, since they must respond to these regulations through new investments and consequent expenses. By the normal course of business, additional operations are commonly required. Accordingly, it is generally felt that there is a tradeoff between environment preserving business and the firm`s competitiveness, moreover the competitiveness of all national economy. Furthermore, to the extent that environmental regulations lead to higher costs or potential suspension of more profitable investment opportunities, it is generally expected that the rate of economic growth is as a result of the introduction of environmental regulations reduced. In developing countries the urgency of reconciling the objectives of environmental protection and accelerating the development process is even greater than in developed countries, which is due to the persistence of serious unsolved social and economic problems.

The dynamics of technological change in developing countries is considerably different than in developed countries, by reason of essence of developing countries dependency on foreign sources in order that they are able to technologically modernize. On this basis, neoclassical economists recommend the openness to international flows of goods, capital and technology with the aim of inducing both processes of modernization and improvements in productive efficiency of private firms as to facilitate their access to frontier technologies.

In the end, there is a "radical pessimism" that calls for drastic redefinition of lifestyles and consumption, pointing to deindustrialization, de-urbanization and decentralization as ways of returning to ecological balance[1]. Some of the authors call a global redistribution of resources from North to South as an approach to simultaneously solve the problems of global pollution, as well as the poverty in developing and underdeveloped countries.[2]

According to OECD[3] the continued economic growth in conjunction with appropriate environmental policies can at least under certain conditions generate a process of innovation and diffusion of technologies supporting sustainable development. The economic costs of meeting most of the environmental objectives should not be implausible, given that they are appropriate policies. With reference to OECD[4], when public policy or consumer preferences raise levels of environmental protection, the positive spillovers on the competitiveness of firms and nations may arise, by reason that they stimulate the technological change, investments and increase the productive efficiency of private firms, especially when pollution is reduced at source. Thus, countries with strict environmental standards will have in the future competitive advantages in the growing market for technologies, equipment and services.

Several countries have launched initiatives to stimulate the diffusion of preventing the pollution, struggling to show the possibility for firms of finding the opportunities to reduce the pollution and at the same time, raise their competitiveness. In addition to the cases, which generated net reductions in total costs of the firms, it is common that innovative companies use their expertise in environmental matters not only to promote the corporate image and gain consumers preference, but as a weapon against less efficient competitors,

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1 Bahro, Rudolf (1984) "*From Red to Green: Interviews with New Left Review.*" Trans. Gus Fagan and Richard Hurst. London: Verso Editions, 1984.

2 Sutcliffe, B (1995), "*Development after Ecology*", In: Bhaskar, V. y Glyn, A, 1995.

3 OECD (1992), "*Technology and the Economy. The key relationships*", OECD, Paris, 1992.

4 OECD (1995), "*Report on Trade and Environment to the OECD Council at Ministerial Level*", Paris.

whereas the tightening of environmental standards penalized them later on[5]. The rationale behind, from the standpoint of environmental policy, is that to the extent that such options are perceived and implemented, the firms will achieve similar relative better results in terms of reduced pollution at costs much lower than implies a system based solely on the existence of penalties for polluters.

The success of voluntary programs, surpassing environmental goals such as those implemented by the U.S. EPA[6], are also relevant indicators in this regard. Preliminary evaluations indicate that the intentional surpassing may be motivated by a desire to influence the consumer preferences, improve the image of the signature or anticipate future stricter regulations. Some analysts suggest that firms may also gain upon the authorities imposing more stringent standards, in order to increases the compliance cost of competitors, especially, when the technology is not easily imitable. Similarly, many firms are adhering to voluntary programs and eco-labeling seeking to achieve environmental certification of ISO:14000 type, since this involves the possibility of obtaining not only positive publicity but also efficiency gains in production processes, meanwhile improving internal environmental management.

It is noted that the industrial firms in developed countries are increasingly adhering to the approaches to prevent environmental pollution, mainly motivated by the promise of finding less costly solutions to reduce such pollution. Some studies roughly estimate that in the industrial sector, often a reduction in pollution levels between 20 to 30% can be achieved without any capital investments and another similar percentage can be obtained with

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[5] O´Connor, D., Turnham, D. (1992). "*Managing the Environment in Developing Countries*", OECD Development Centre, Policy Brief N° 2, 1992.

[6] Arora, S., Cason, T. (1995), "*An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program*", Journal of Environmental Economics and Management, Vol 28, 1995.

investments that can be repaid within a month[7]. Based on the evidence collected through various case studies, some authors suggest that the most dynamic firms in sectors such as mining are "moving" toward the technological frontier to achieve a simultaneous reduction in environmental as well as production costs.[8]

Furthermore, it is estimated that environmental technology research in developed countries will focus in the future increasingly on the areas related to the approach of pollution prevention. There are three factors driving this movement:

a. New regulatory frameworks that emphasize prevention rather than cleanup;
b. New environmental standards developed by international institutions such as the ISO;
c. The economic benefits of more efficient manufacturing processes, in partly stimulated by the rising costs associated with the provision of material contingent liabilities pollution and energy costs.

As it was mentioned above, the firms can achieve important reductions in the levels of pollution without losing their profitability.

The Energy sector in European Union (EU) which represents 27 countries and more than 450 million energy consumers has become more volatile to changes of prices. The oil and gas prices has doubled since the year 1994 and according to the European Union Report on Energy Issues the consumption increased by 20% in the last years[9].

In compliance with this study, the energy demand in the EU continues to rise by 1-2% per year and over 80% of the energy is produced by fossil fuels, gas and coal. The main

[7] Hanrahan, D. (1995), "*Putting Cleaner Production to Work*", Discussion Draft, World Bank, 1995.

[8] Warhurst, A. (1995), "*Technological Change and Environmental Policy: Environmental Performance, Production Efficiency and Competitiveness*", Research Proposal, 1995.

[9] European Commission, "Standard Eurobarometer 258 - TNS Opinion & Social", December 2007. Energy Issues pp. 2.

challenges in the EU are:

- The increasing demand (1-2% increased every year).
- Scarcity of energy supplies.
- Dependency on energy imports.
- Irreversible ecology effects.

As was pointed before, the energy and the so called "green technologies" are becoming key factors in the EU policies. The purpose of this thesis is to evaluate the chosen alternatives for energy and heat production at the subsidiary of holding company Chemosvit Group a.s., *Chemosvit Energochem a.s.* and review the investment decision considering the best option to decrease the emissions of the greenhouse gases in a cost-effective and reasonably low risk manner, as well as to analyze, which of the alternatives regarded for the generation of electricity and heat are more suitable for *Chemosvit Energochem a.s.*

Chemosvit Group a.s. is one of the biggest manufacturing and service holding companies located in the heart of Europe, Slovakia, which is a member country of European Union and so it is required to carry out the obligations approved by institutions of European Union. The variety of the manufacturing activities ranges from machining, flexible and convertible follies (packaging materials) production, plastics to polypropylene yarns productions. The company is well known around the world serving more than 150 customers on the globe. Except for several production facilities situated in Slovakia, Czech Republic, Finland and Ukraine, the Chemosvit Group a.s. provides financing, transportation and energy services, all delivered through its subsidiaries.

The need to invest into the new technologies for energy production was recognized in Chemosvit Group a.s. in the late 2006. As a member of European Union, Slovak Republic and so consequently the enterprises located in its territory are committed to support the introduction of alternative energy sources and environmentally friendlier production methods. Considering the sustainability of its environment and corporate responsibility Chemosvit Group a.s. decided to seek for the new “greener” alternatives of electric energy and heat production in its subsidiary *Chemosvit Energochem a.s.*, and so comply with green standards and certificates recognized not only among European Union members, but among the players in the global market as well. In the year 2007, several alternatives were evaluated to estimate the most efficient and economical way of electric energy and heat production. The main customers of *Chemosvit Energochem a.s.* are the subsidiaries of the Group and the town Svit. According to the proposed schedule, the new production facility has been planned to start its operations in 2011 with prior investment in the winter of 2010, which may deliver all heat and power requirements to its customers as in the year 2007. The year 2007, as the year prior to the financial crisis, was taken into account as basis year for electric energy and heat consumption by *Chemosvit Energochem a.s.* customers, moreover, prices of all necessary devices, fossil fuels, electric energy and heat prices were based on the same year. The main reasoning behind, is to eliminate any significant differences in consumption which were recorded in the year 2008 and caused due to the low demand in the global markets. The crisis subsequently influenced all the subsidiaries of Chemosvit Group a.s. causing lower production volumes and so reduced the requirements on *Chemosvit Energochem a.s.* Even if the investment decision-process started in 2007, due to the financial savings it was suspended during the year 2008, however, it was reinitiated again in the year 2009.

During the summer months of 2009, the author of this study had the chance to visit the facilities of Chemosvit Group a.s. He was guided by the Chief Financial Officer, Ing. Balog, which gave him an assignment to propose a different method of evaluation the criteria for alternative choice proposed in 2007. The investment is scheduled to be made in the winter of the year 2010 and beginning of 2011. In the summer of year 2009, the work in this project was started, which became the baseline for this thesis and hopefully, it may contribute to the management of *Chemosvit Energochem a.s.* with new perspective view on the alternatives proposed in 2007 and so support the decision-making process.

The thesis is divided into six main chapters followed by the conclusions and recommendations. The second chapter is dedicated to the wide scope of literature review, beginning with the theoretical aspects concerning the green energy sector, which presents the overview of main environmentally friendly methods of power production with consequent emerging issues of each green energy approach. All of the methods may serve as a guideline for the evaluation of alternatives introduced in the subsequent experimental parts. Thereinafter, to provide a complex overview of green energy sector, a part of literature review is dedicated to the green certificates and carbon dioxide regulations, which may considerable influence the investment decision. Furthermore, the financial aspects of the decision-making process are analyzed from the theoretical perspective in the second part of chapter two, in which the terms used for the analysis are described and explained more in details presenting the various points of view covered in the literature. This theoretical framework serves as a basis and justification for the further analysis of alternatives described in the experimental part of this thesis.

The next third chapter presents the research methodology, materials and information sources used in this thesis. The chapter four introduces the history, economy and energy consumption in Slovak Republic. Besides, chapter five is dedicated to the overview of the enterprise *Chemosvit Energochem, a.s.*, concerning mostly the operations, customers, emerging issues and challenges, which are to be analyzed in the subsequent parts.

Finally, the sixth chapter is devoted to the overview of the present situation of *Chemosvit Energochem a.s.* and alternatives chosen in the year 2007. Consequently, each of the alternatives is described in detail, stipulating the financial data into the analysis basing on the very same year considering the framework presented in chapter two. Thereafter, the results among all alternatives are compared, founding from which, the most cost effective and sustainable alternative is selected. The final part of this chapter contributes the investment decision with six different configurations, which can arise from the selected alternative and so improve the choices themselves in more reasonable and "green" manner.

The conclusion summarizes the proposed methodology for evaluation of alternatives and reasoning behind the selected choice. This result may contribute to the decision-making process of investment opportunity into the new energy production facility as well as to the evolution of sustainable environment not only in Slovak Republic, but in European Union as a whole. Furthermore, considering the environmental challenges in the regions and basing on the results from the chapter five, recommendations for the additional improvement of efficiency in energy production are proposed in the ultimate part of this thesis, which can considerably contribute to the highly efficient, cost – saving method of electric energy, heat and cold production by *Chemosvit Energochem a.s.* assist so to the better environmental protection of our planet.

II. LITERATURE REVIEW

This chapter is devoted to the literature review, which may serve as a basic framework for the analysis in the subsequent part of this thesis. The first section of this chapter is dedicated to the overview of the green energy sector, which is considered to be a prerequisite of further understanding of the various methods of environmentally friendly and sustainable energy production, as well as the regulations and challenges related to these issues. In the second part, the theoretical framework for investment decision-making process is presented to provide the support for deeper analysis of the energy and heat production alternatives in Chemosvit Energochem a.s.

2.1. Overview of the Green Energy Sector

In the year 1973, the oil world market manifested a considerable price increase and mirrored itself in serious oil crises which influenced great portion of the globe. It was this moment that revived concerns about future supply and price of energy. The outcome of the crises made the countries, which were greatly dependent on these sources of energy and suddenly faced high fuel costs, to start consequently looking for options to reduce the dependence on nonrenewable sources of energy.

One of the options to reduce this dependence on fossil fuels as the main source of energy was to reconsider the better use of solar energy and its various manifestations such as secondary wind energy, hydropower and several forms of biomass, the so-called renewable energy. In the mid-seventies, multiple research institutes all around the world organized working groups and initiated the construction of equipment for renewable energy systems. It also gave the chance to a lot of companies to take an advantage of the opportunities offered for the development of these technologies, given the high prices of conventional energy.

In the eighties, scientists found evidence of the increasing concentrations of gases that cause the greenhouse effect in Earth's atmosphere, which have been attributed to the burning of fossil fuels. This resulted in a global call to make alternatives to reduce current levels of greenhouse gases, leading to a rethinking of the potential importance of renewable energy to create new sustainable systems. As a result of this call, many countries, particularly the developed ones, established commitments to limit and reduce greenhouse gas emissions from greenhouse renewing interest in applying its policies to promote renewable energy.

Today, more than a quarter of a century after the so-called oil crisis, various technologies of renewable energy has matured and evolved, increasing reliability and improving its profitability for many applications. As a result, countries like USA, Germany, Spain and Israel have a very rapid growth in the number of facilities that use solar energy directly or indirectly through its secondary manifestations.[10]

2.1.1. *Renewable Energy Sources and the Emerging Issues*

Currently, various renewable energy sources are known in the global market. The present methods of energy production use natural sources, such as sun, wind, water or biomass, which are generally considered to be abundant or indefinite and supplied for "free". Except for these energy sources, other techniques were developed to rationalize the resources used for energy production, and so provide more sustainable and "greener" processes. In general, these techniques can be integrated under the name of cogeneration, or even more efficient trigeneration.

10 PV News, vol 20. Mar 2001

2.1.1.1.Solar Energy and Its Various Manifestations as Renewable Energy

Solar energy is manifested in various forms and its application has been essential for the development of a mankind. These forms are called renewable because they are forms of energy that are renovating or redoing over the time and are so abundant in the earth, or will last for hundreds or thousands of years, either we use them or not.[11] According to Ramachandra (2006) "*The Renewable energy resources are those having a cycling time less than 100 years. These resources are renewed by nature again and again, and their supply is not affected by the rate of consumption.*"[12]

The solar energy received by our planet is the result of the nuclear fusion process that takes place inside the Sun. From all the energy produced by this process in the Sun, our planet only receives less than a billionth part. That energy, which takes less than eight minutes to cross more than 145 million kilometers from the Sun to the Earth, is however, an enormous amount in proportion to the size of our planet. Solar energy is manifested in a spectrum that is composed of ultraviolet, visible and infrared light. Upon reaching Earth; it firstly loses its ultraviolet part, which is absorbed by a layer of ozone in the upper atmosphere. Once in the atmosphere, the infrared light is lost either reflected or in the clouds, which are capable to reflect up to 80% of solar radiation that reaches them. The rest reaches the surface, either directly or indirectly as a reflection of the clouds and particles in the atmosphere. The solar radiation reaching the earth's surface can be converted directly into electricity or heat. The heat can be used directly as heat or it can produce steam and generate electricity.

[11] Bull, S. R. 2001. Renewable energy today and tomorrow. *Proceedings of the IEEE*, 89: 1216-27.
[12] Ramachandra, T.V. (2006). " *Spatial mapping of renewable energy potential*", 2006.

Photovoltaic systems

The photovoltaic cells are primarily made of silicon plates. When the silicon is added in relatively small amounts with very specific characteristics, unique electrical properties are obtained in the presence of sunlight: the electrons are excited by the photons associated with the light and move through the silicon to produce an electric current. This is known as the photovoltaic effect. The conversion efficiency of these systems is about 15%, so a square meter can provide 150 watts, enough power to run a medium TV.

According to Bilgen et al. (2004) this kind of electricity form is expected to be relatively cheap in the future and in the next decade it is expected to reach the price bellow 10 cents per kilowatt hour. Hoogwijk and Wina (2008) argue that not only the price of the solar energy in the future will be lower; also the efficiency will increase considerably.

Solar thermal systems

The flat solar systems or flat solar collectors are devices, which under the condition of solar radiation exposition transmit the heat to a fluid. Using the flat solar collector, the fluid can be heated up to temperatures of 200 ^{o}C. Concentrated solar systems are those that work in the manner of allocating the sunlight into a focal area, being able to locate it around a point or along a line. This set of procedures or devices requires monitoring mechanisms, as the line of incidence varies throughout the day and during the year. These systems can achieve temperatures of several hundred degrees Celsius and in special cases even thousands of degrees.

Nathan and Daniel (2006) argue that the energy that the sun gave to the earth only in one hour is enough to provide the entire humanity for one year with energy[13]. If this is true, why

[13] Lewis. N, Nocera D.(2006). "*Powering the planet: Chemical Challenges In Solar Energy Utilization*".

is the solar energy not used more widely in the world? One of the problems with this kind of energy is that it is used at the same time it is collected; meanwhile it is necessary to buy expensive batteries. Another disadvantage is the high prices of the solar panels. Comparing to fossil energy, solar energy is diffuse. The solar energy would be never the primary source of energy of our societies until the price per KWh will be cheaper than the fossil energy.

2.1.1.2.Wind Energy or Wind Power

Winds occur from the differences of pressures created by the heat of Earth's atmosphere, moving the large masses of air from high pressure areas to the low ones. Approximately 2% of all the sun energy that reaches the Earth becomes wind, but only a small fraction can be exploited, since most of these winds occur at high altitudes or over the oceans and seas. Furthermore, it is considered that only winds with an average speed between 5.0 and 12.5 meters per second are usable.

The wind has a kinetic energy (air mass in motion) that can become a mechanical or an electrical energy with help of wind turbines, which are composed by an array of blades, generator and tower, mainly. The wind turbines can be classified according to the position of its axis into horizontal or vertical. In very general terms, with a wind turbine, of which the blades have a diameter of 40 meters and are subject to winds with average speed of 8 meters per second, the capacity of 600 kW can be produced, which is enough to provide electricity to a housing estate of 200 apartments. Bilgen (2004) argues that the US has been increasing his capacity of wind power energy, meanwhile, in Europe the most active countries in this field are Germany and Spain. The huge contrasts are the Asian and Latin American countries, which are not developing it potentials. For example, India and China only developed a small fraction of its capacities.

The disadvantages of the wind energy are mainly the esthetic factors. Because of the low specific weight of air, wind energy requires the use of large machines (50 meters or more) that change the landscape esthetics. Also, the noise caused by the rotors of wind turbines when turning constitutes a noise, although it is usually a lower than 50 decibels. In some cases, these devices can also cause the death of migratory birds, as well as unfavorable magnetic fields.

2.1.1.3.Hydraulic

The energy from the sun also creates the evaporation of water contained on the surface, but mainly in the oceans. This moisture builds up in clouds that travel long distances and deposits in the form of rain over mountains, away from the sea. The water accumulated in streams forms rivers. This flow, which can be expressed in Great Falls or in many streams, is the source of hydropower.

In many cases, this energy is deposited as potential reservoirs and is transformed into usable energy by moving it to lower levels. Moving water pushes rotating devices that convert mechanical energy to electricity. For example, to achieve a capacity of 3,000 kW, which is enough to satisfy 1,000 apartments, it requires a waterfall of 100 meters with 3 cubic meters per second of flow. This is done widely in any mountainous area of the planet with regular regimes of rain. According to Bilgen et al. (2004), "in some regions like North America, Western Europe, Pacific, and OECD countries more than 65% of the economically potential water is already in use meanwhile in countries like Sub-Saharan Africa, less that 18% is in use. In Latin America and Caribbean nearly 44% is tapped. The OECD countries have an operational capacity of 80%"[14] Moreover, less than 1/3 of the capacity of the world has been developed to produce electricity.

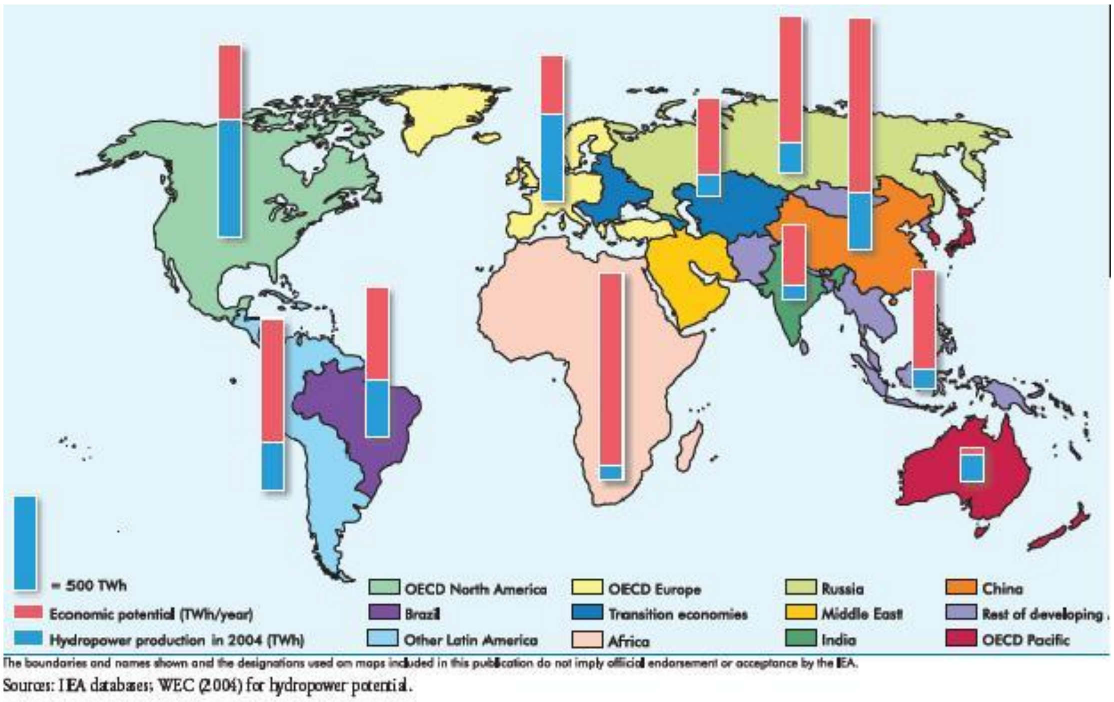

Figure 2.1: Worldwide Overview of Hydropower Production in the Year 2000

Source: IEA Database, WEC (2000) for Hydropower Potential.

The Figure 2.1 shows the worldwide potential of the hydropower market. According to the International Energy Agency`s World Energy Outlook (2006) the trend is that worldwide hydropower capacities will increase from 2% to 7%, mainly in the developing countries[15]. Hydraulic power energy is by far the most used of all the renewable energy sources but not everything about hydraulic power is good for the environment. Goldsmith and Hildyard (1984) analyzed what was happening to more than 30 dams, from which most of them are located in the humid tropics of underdeveloped regions. It has to be noted that in none of the

[14] Bilgen et al.(2004). "*Renewable Energy for a Clean and Sustainable Future*", Energy Sources, Part A: Recovery, Utilization and environmental Effects, Vol. 26, No. 12, pp. 1119-1129.
[15] OECD/IEA - 2006. International Energy Agency. World Energy Outlook.

cases the poverty and hunger at the local level was not eliminated. Not much unless they have "*improved the environment*."[16]

One of the biggest problems with hydraulic energy is that in most cases the dams are situated in the densely populated areas. Also, the displaced communities face the problems of a degraded environment. The dams usually caused that the fertile valleys were flooded and the residents were relocated on marginal land, forced to seek work as workers. The region of the dam becomes producer of "*ecological refugees*." In some cases new diseases arise, causing public health problems of major proportions. Large dams inevitably affect the life of aquatic ecosystems throughout the entire river, limiting the supply of nutrients downstream, preventing the reproduction of migratory species and accumulation of toxic substances such as biocides, detergents and industrial wastes. The pond becomes a common place for the discharge of sewage and garbage. Eutrophication and development of pests such as water hyacinth prevent the lake to be productive in the long term.

2.1.1.4.Biomass

The plants accumulate energy through the process of photosynthesis, which is fed by solar energy, separating the carbon dioxide molecules, accumulating carbon as hydrocarbons and releasing oxygen. The conversion efficiency of solar energy stored as organic matter (via photosynthesis) is very low, with an estimated ceiling of about 3%, although some commercial forest species reach in conversion efficiencies up to 1%.

[16]Goldsmith, E., Hildyard , N. (1984). “*The Social and Environmental Effects of Large Dams. Worthyvale Manor, Camelford*”.

Firewood

The most common form of solid bio-fuel is the firewood, which even now covers almost 50% of energy needs in developing countries. Charcoal is another form of solid bio-fuel. The crop residues of grain can be exploited to run small power plants. Even in this era it remains important to use wood as source for energy production. Some countries concentrate on plantations of fast growing trees such as eucalyptus, called energy plantations, with the purpose of wood production used as bio-fuel. A cubic meter of such wood is sufficient to allow 5 people to heat water for 108 baths of 15 minutes each. Hoogwij[17] and Graus (2008) argue that the cost of biomass depends mainly on the climate and soil conditions. The table below shows the residues of biomass in the world taking into the consideration the potentiality of each of the regions.

Table 2.1.: Ranges of the Biomass Energy Potential in the World

An estimate of the ranges of the biomass energy potential (EJ/yr)

	Residues			Energy Crops		
	Low	High	Assumed	Low	High	Assumed
Africa and Middle East	4	11	7	15	69	38
Asia	13	32	23	25	96	53
Oceania	1	1	1	0	32	16
Latin America	2	25	15	2	66	34[a]
Non-OECD Europe and FSU	3	7	5	48	112	80
North America	7	36	17	15	60	38
OECD Europe	2	5	5	9	15	12
World	*32*	*117*	*73*	*162*	*450*	*271*

Source: Hoogwjk M. and Graus W. (2008). "Global potential of renewable energy".

[17] Hoogwijk M. and Graus W. 2008: Global potential of renewable energy sources: A literature assessment. Ecofys, March 2008

Fermentation

The processes of alcohol fermentation and distillation are known and used by human societies since ancient times. Through this process it is possible to obtain ethanol, an alcohol which is currently used as fuel to replace gasoline or alternatively used as a mixture of both of them. Sugar cane, sweet sorghum, fruit and sugar beet crops are readily convertible to ethanol, all based on the sugar fermentation obtained with soft pretreatments such as pressing, cutting or washing of crops. Fermentation processes have large conversion efficiency, slightly above 85%. The intensive use of ethanol can be motivated by their ability to replace gasoline or usage as a component of gasoline oxygenate and antiknock mainly in two ways.

- Gasoline vehicles (90% gasoline and 10% ethanol by volume), which is done without any modification to the engine.
- Ethanol as a gasoline substitute. A mixture of 85% ethanol and 15% gasoline is a viable fuel for light vehicles, which can operate with any proportion of ethanol mixed with gasoline, with the maximum 85% limit. Some buses and trucks with appropriate modifications to their diesel engines can run on almost pure ethanol.

Biogas from Landfills

Biogas is also produced in landfills, which contain a proportion of wet organic waste, and where there are suitable conditions for anaerobic bacteria to proliferate to digest such wastes that produce methane and carbon dioxide inside the filling. For example, a landfill in with 5.6 million tons of solid waste produces enough biogas to power a plant of 5 MW of capacity to operate for 10 years.

There are many challenges for the renewable energy such as the price per KWh for various sources energy. The Figure 2.2 depicts the potential energy that can be obtained in the long run from various resources of renewable energy.

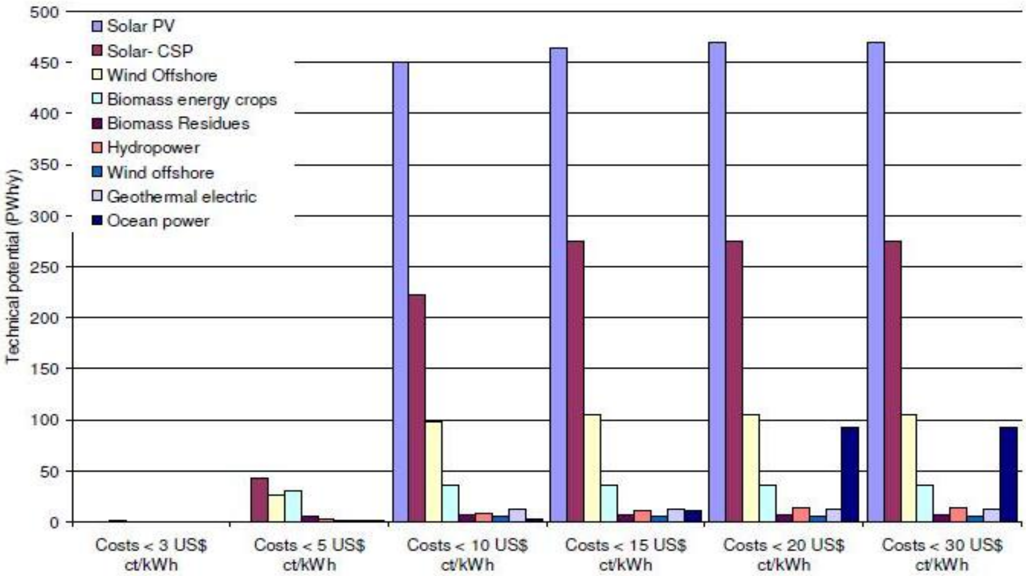

Figure 2.2: Global Potential of Renewable Electricity Sources at Different Cost Categories on the Long Term

Source: Hoogwjk M. and Graus W. (2008). "Global Potential of Renewable Energy".

As shown in the Figure 2.3, the investment cost of the renewable energy will decrease according to the International Energy Agency in the future.

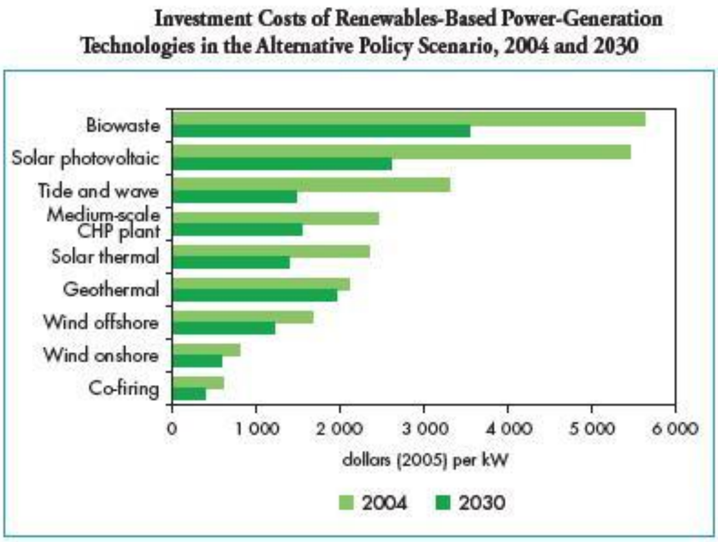

Figure 2.3: Investment Cost of Renewable-Based Power-Generation Technologies

Source: International Energy Agency, World Energy Outlook 2006.

The use of efficient and controlled biomass technology is recent and presents problems for its novelty, the energy density is lower in biomass production and yields are slightly lower than the ones of fossil fuels. According to Dermibas (2004) "*The compositions of biomass among fuel types are considerable variable, especially with respect to inorganic constituents important to the critical problems of fouling and slagging. Alkali and alkaline earth metals, in combination with other fuel elements such as silica and sulfur, and facilitated by the presence of chlorine, are responsible for many undesirable reactions in combustion furnaces and power boilers.*"[18]

[18] Dermibas, A. (2004). "*Potential Applications Of Renewable Sources, Biomass Combustion Problems In Boiler Power Systems And Combustion Related Environmental Issues*", Progress in Energy and Combustion Science, Vol. 31, Issue 2, 2005, pp. 171-192.

2.1.1.5.Cogeneration

Even if the cogeneration of energy is not by definition a renewable energy it can increase the efficiency of the energy spent. Cogeneration is the process by which it is possible to obtain both electricity and useful thermal energy (steam, hot water, ice, cold water, and cold air, for example). The advantage of cogeneration systems is that it increase energy efficiency as it uses both heat and mechanical or electrical energy of a single process, rather than using a conventional power plant, where the heat needs additional conventional boiler.

By generating electricity through a generator or alternator, driven by a heat engine or a turbine, the heat from the fuel only possesses the efficiency ranging from 25% to 40%, and the rest is dissipated as heat. The advantage of cogeneration is that the heat energy does not dissipated into the atmosphere or water, thus, it reutilizes the waste energy from the boilers. According to Ramachandra (2006) "*very high efficiencies can be achieved with cogeneration*". A recent study by the International Energy Agency (IEA, 2006), estimates that emissions in 2050 will be doubled comparing to the current status. This alarming scenario can be partially avoided, if using the cogeneration systems to increase the efficiency of energy supply. In fact, the installed electric power in cogeneration systems for the industry has grown considerably in recent decades, producing great energy and financial savings. But in developed countries, the potential for cogeneration in the industry has already been exploited.[19]

The main problems with the cogeneration are as follows:

- Poorly conceptualized projects, interconnection agreements to the grid, environmental impact permits, policy decisions on fares and fuel prices.

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[19] OECD/Iea - 2006. International Energy Agency. World Energy Outlook.

- In most of the cases, the fossil fuels are still consumed, even with an improved efficiency.[20]
- For the installation of cogeneration systems, air intakes and outlets for the combustion are needed.
- The efficiency is directly related to the use of heat generated, which is not always possible due to lack of demand.
- Need of maintenance.

2.1.1.6.Trigeneration

Similarly to the cogeneration, the trigeneration is not a renewable source of energy but can improve the efficiency of the energy consumption. It is defined as green energy as well as the system that combines the power generation with air-conditioning systems, and allows extending the operation period for demands of cold and heat. Generally, it is a conversion of heat into the cold through absorption machines. Santoyo (2003) argues that the trigeneration can improve cogenerations systems up to 10%[21].

The trigeneration as it is related to cogeneration have almost the same problems such as:

- In most of the cases the fossil fuels are still consumed, even with an improved efficiency.
- The efficiency is directly related to the use of cold generated, which is not always possible due to the lack of demand.[22]
- Need of maintenance.

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[20] Horlock, J.H. (1997). "*Cogeneration—Combined Heat and Power (CHP)",* Krieger, Malabar, FL, 1997.
[21] Santoyo J. (2003). "*Trigeneration: An alternative for energy savings*", Applied Energy, Vol. 76, Issues 1-3, September-November 2003, pp. 219-227.
[22] Meunier, F. (2002). "*Co- and Tri-Generation Contribution to Climate Change Control*", Applications of Thermal Energy, Vol. **22, No.** 6 (2002), pp. 703–718.

*2.1.2. **Green Certificates***

The green certificates are an international mechanism to reduce pollutant emissions to the environment; they are one way of the three proposed mechanisms in the Kyoto Protocol for reducing emissions that cause global warming or greenhouse gases. There are various types and denominations for the green certificates as follows:

- Green Certificate, TREC, TRC, REC
- Tradable Renewable (Energy) Certificate/Credits
- Renewable Energy Credit / Green tags

The green certificates system provides financial incentives for private companies to contribute to the improvement of environmental quality giving them the right to pollute as exchangeable commodity with a set price in the market. A green certificate represent a ton of carbon dioxide, benefiting companies that do not pollute or reduce pollution to have the right to sell the certificate in the global market and the companies that pollute to buy them.

While some call it "abatement mechanism", the term is regarded by others as a mistake since they have devised to try to reduce levels of carbon dioxide, or CO_2. However, the carbon dioxide gas is not a pollutant but far from it is the foundation of plant life and therefore animal life on the planet. Without CO_2 there would be no life on Earth. [23]

The GHG emission reductions are measured in tons of CO_2 equivalents, and one green certificate equals to one ton of that longer CO_2 emitted into the atmosphere. It may be sold on the carbon to the industrialized countries according to the nomenclature of the Kyoto Protocol. The types of projects that may apply for certification include, for example,

[23] Morthorst, P.E. (2000). Energy Policy , Vol. 28, Issue 15, December 2000, pp. 1085-1094.

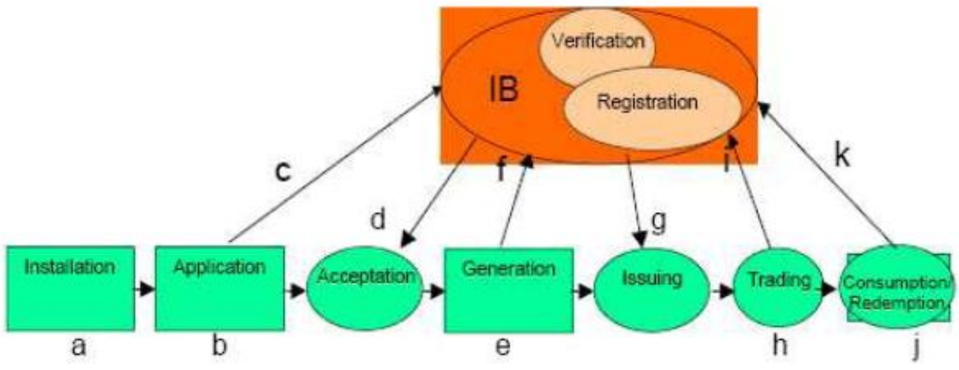
generation of renewable energy, energy efficiency improvement process, forest, lakes and rivers clean, etc.

In an attempt to reduce emissions that cause global climate changes such as global warming or greenhouse, the major industrialized countries except the United States and Australia have established an agreement creating quantified targets for reducing gas emissions of greenhouse gas (GHG) by 2012: the Kyoto Protocol[24]. The institution responsible for delivering these bonds is the United Nations. The requirement that companies need to meet to receive them is to demonstrate new investments in cleaner technologies.

The mechanism (which applies only to new investments) is as follows:

- Studies to determine the level of reducing gases.
- Make a presentation at the United Nations.
- Delivery of certificates (for approval).

The life of one green certificate is depicted in the Figure 2.4.



Source: Renewable Energy & Energy Efficiency Partnership

Figure 2.4: The Life of Green Certificate

[24] Gan L., Eskeland, G.S. (2007). "*Green Electricity Market Development: Lessons from Europe and the US*", Energy Policy, Vol. 35, Issue 1, January 2007, pp.144-155

Countries that sell the highest number of the green certificates are shown in the Figure 2.5.

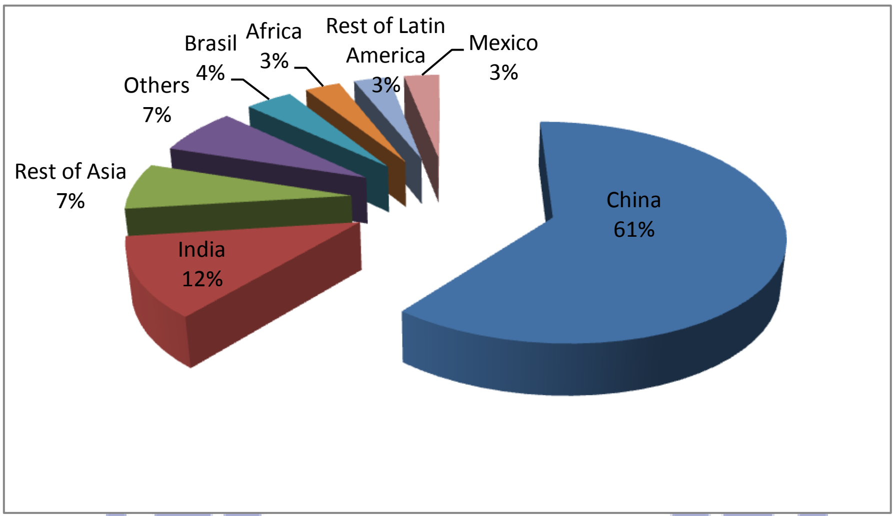


Figure 2.5: Territorial Structure of the Amount of Green Certificates Sold

Source: WRI Carbon Finance

Countries that buy the highest amount of green certificates are depicted in the Figure 2.6.

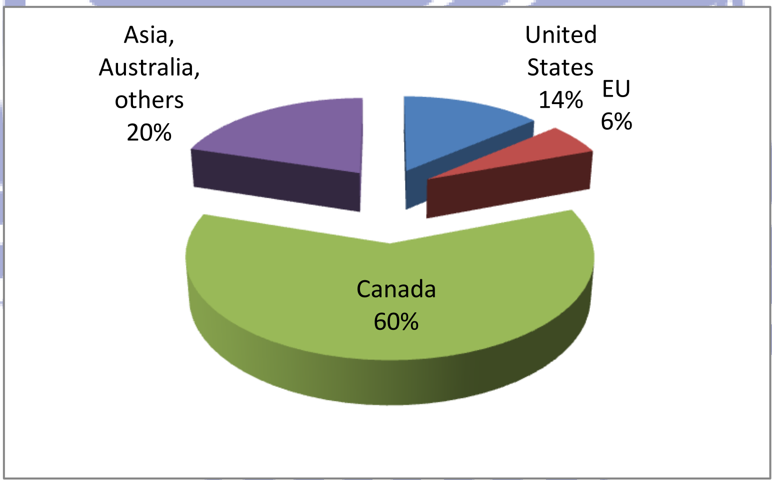


Figure 2.6: Territorial Structure of the Amount of Green Certificates Bought

Source: Source: WRI Carbon Finance

Markets of green certificates experienced significant growth in the last years, but this market is greatly instable. Today the green certificate market has been the most effective way to combat climate change in terms of reducing emissions, thus, it faces an uncertain future.

2.1.3. ***Carbon Dioxide Regulation***

The carbon dioxide is a colorless, odorless and with a sour taste. Its molecular structure is composed of one carbon atom bonded to two oxygen atoms, i.e., according to chemical nomenclature, CO_2. Its density is roughly 1.5 times denser than air and dissolves in water at a rate of 0.9 volume of gas per volume of water, always at 20 degrees Celsius. The emissions regulation for carbon dioxide is a set of specific limits to the amount of CO_2 that can be released to the environment. The Table 2.2 shows the actual and predicted amount of tons of worldwide CO_2 emissions.

Table 2.2.: Worldwide CO_2 Emissions

	United States	**Rest of OECD**	**China**	**Rest of Non-OECD**
1990	5,020	6,517	2,293	7,689
2006	5,894	7,688	6,018	9,417
2020	5,905	7,918	9,417	12,111
2030	6,207	8,174	11,730	14,067

Source : Outlook 2009, Reference Case EIA (April 2009).

The Figure 2.7 depicts the worldwide carbone dioxide emissions for the period of 1990-2030.

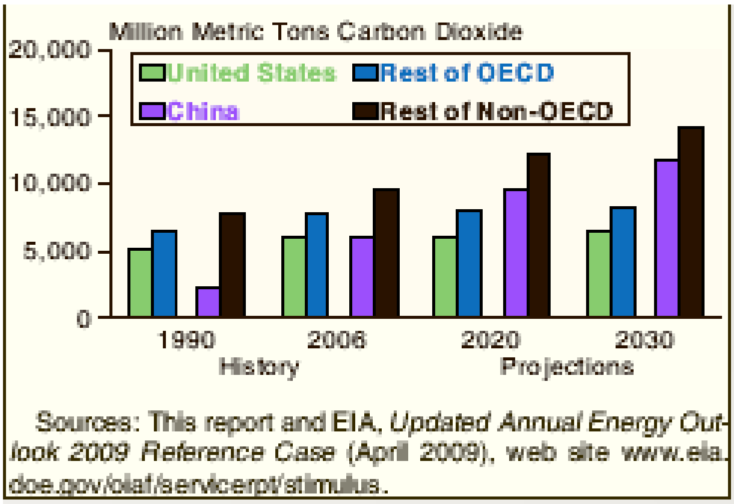


Figure 2.7: World Carbon Dioxide Emissions by Region, 1990, 2006, 2020, and 2030

The Figure 2.8 shows the size of the countries in respect to their CO_2 pollution contribution. So in this case the countries with highest amount of CO_2 emissions are USA, China and Japan.

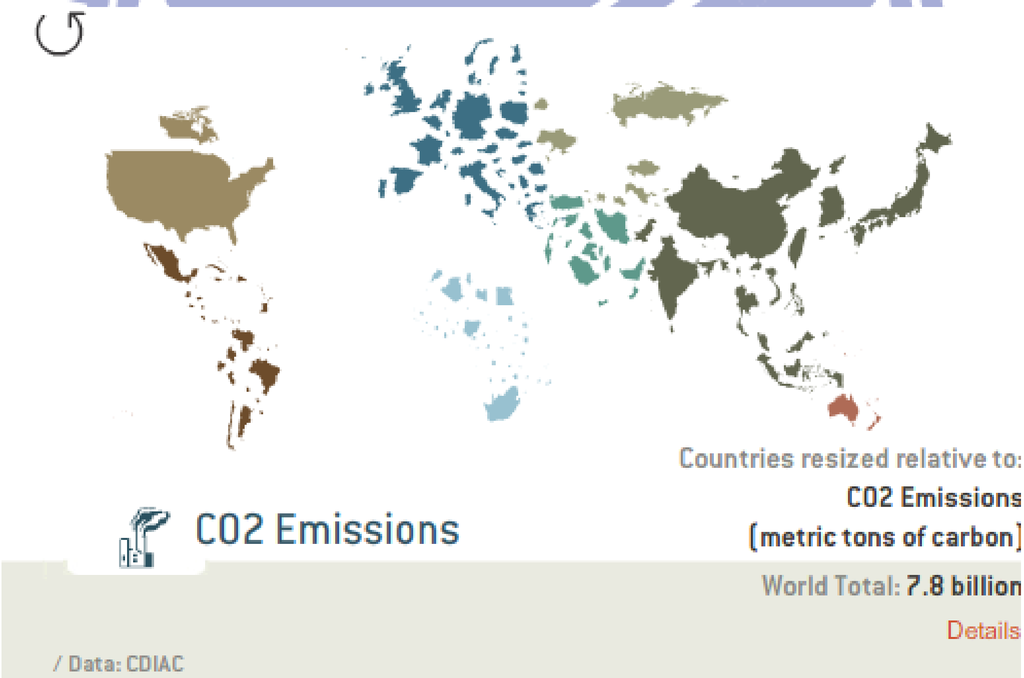


Figure 2.8: Geographical Contribution to the World CO_2 Emissions

Source: Report of Carbon Dioxide Information Analysis center, 2009.

The Kyoto Protocol forces that emissions of greenhouse gases in industrialized countries should be reduced at least 5% below 1990 levels for the period of 2008 to 2012. The protocol was signed by 83 countries in the year 1997. In 2001, there were already 180 countries that ratified it. However, from the major emitters only the EU and Japan signed the agreement, while China, Australia and the United States decided to stay out. In 2005 the Protocol successfully entered into action, which was due to Russian signature, when it reached the needed quorum.

The global objective is to reduce emissions by up to 5% comparing to the level from the year 1990, yet the emission quota is set by each country. The EU countries have committed themselves to a reduction of 8%, meanwhile Japan set it on 7% and the United States, if ratified the Protocol should set their quota by 6%. On the contrary, it is recognized that emerging countries like China, India and Brazil should potentially increase their emissions, which is the same for the rest of developing countries (countries with low income, or simply poor countries).[25]

2.1.3.1.The implementation by European Union

The EU as a whole set the objective of "1990 minus 8%", but this 8% proceeds to an internal distribution of the load, setting highest reductions in certain countries, lower for others, and even allows that emissions will increase for some. As a guideline for promoting and monitoring compliance with these objectives, the EU has established the Community framework for emissions trading. The first phase of the scheme, from 2005 to 2007, was largely experimental in nature, primarily to gain experience on the functioning of that market. The following, from 2008-2012, coincides to the Kyoto Protocol with the first compliance period itself.

[25] Kara, M. (2006). "*The Impacts Of EU CO_2 Emissions Trading On Electricity Markets And Electricity Consumers In Finland*", Energy Economics, Vol. 30, Issue 2, March 2008, pp. 193-2.

This mechanism of 'market designed' chasing following the guidelines agreed by governments at the UNFCCC, introduced in the decision making process of the companies the cost (market price) of CO_2 emitted by requiring that each affected facility cover (justify) their emissions by providing that they have a cost in the market. The bottom line is, therefore, that companies have an economic incentive to reduce their emissions.

2.1.3.2.United States Open the Way to Regulate CO2 Emissions

The decision to regulate CO_2 emissions prepares the way for the Environmental Protection Agency (EPA) to establish standards on how much carbon dioxide can be emitted from factories, buildings and American cars; although the Congress has yet to rule on a law about it. The agency signed decisions declaring six greenhouse gases: carbon dioxides, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride, as a threat to public health under the regulation called 'Clean Clear Act ', making them subject to government regulation.[26] The EPA is "now authorized and directed to make reasonable efforts" to reduce emissions of greenhouse gases.[27]

2.2. **Evaluation of Investment Decision**

The presently available literature suggests various models and equation of evaluation of an investment decision. It is often very difficult to choose among several alternative projects and find an optimal decision. The decision-makers usually do not decide about one single project, thus, a bundle of projects or alternatives. Each of these projects includes a number of individual projects, which not only incorporated the technology investment, but potential research and development, personnel training and deployment. When the decision-maker is

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[26] Gan L. (2005). "*Green Electricity Market Development: Lessons From Europe And The US*", Energy Policy, Vol. 35, Issue 1, January 2007, pp.144-155.
[27] Fargione, J. (2008). "*Land Clearing and the Biofuel Carbon Debt*", Science Express, February 2008: Vol. 319. no. 5867, pp. 1235 – 1238.

dealing with greater amount of alternatives, he has to foresee what all of these projects are, however, he needs to recognize the economic value each of the project can deliver to the enterprise. Even if it is often impossible to foresee all the factors influencing the individual projects, the important step in their evaluation remain the objective of maximization of economic value over the period of time [Favaro, 1999]. Investment decision techniques are usually referred to as methods of capital budgeting, which seek to maximize the wealth of shareholders. The projects the managers face to choose from can be characterized as mutually exclusive, independent or contingent projects [Copeland et.al. 2005]. Mutually exclusive projects are a set or bundle of project from which only one project; respectively alternative can be chosen, naturally, the project that maximizes the shareholders` value. In the case of Chemosvit Energochem a.s. the set of mutually exclusive projects/alternatives was selected in the year 2007, and respectively, only one of these projects can be chosen for the final realization and implementation. Many authors propose rules such as the net present-value, payback method, accounting rate of return or internal rate of return for evaluation of an investment decision [Copeland, 2005; Hirschleifer, 1958;].

On the other hand, several scholars reject the internal rate of return as an investment criterion [Hirschleifer, 1958; Copeland, 2005], as it is often in contradiction to the results of net present value. Even if there are various supporters for the net present-value rules, this is often only a partial indicator of optimal investment and under some conditions it gives incorrect results [Hirschleifer, 1958]. Furthermore, it implicitly assumes precommitment and therefore ignores sources of additional value that may be contained in the managerial flexibility of project improvement over the period of time and so net present value can undervalue the alternatives [Copeland et.al, 2005].

Cash flow statements are often used to summarize activities over a span of time and enable the management to predict the future cash flows as well as to determine the performance of a company over a period of time. Cash flow from investment activities in which a company acquires a dispose of plant, property or equipment [Horngren et.al, 2006]. The investment decisions are reflected into the cash flow and provide so better monitoring abilities. In the case of Chemosvit Energochem a.s. the investment decision incorporates new technologies, equipment as well as buildings. Therefore, it is important to estimate the cash flow over the period of time and compare the individual results for each of the alternatives. The forecast of costs and benefits and their comparison with cash flow over the period of time are according to Favaro et.al (1999) "the best available measure of the economic worthiness of the investment" (pp.10). However, these measures are most suited for the businesses with foreseeable future and the stable operations over long time. Currently, numerous techniques of cash flow forecasting and management exist; however, many of them differ in the accuracy and detail, as well as the method of time and money integration [Park et.al. 2005].

The simplest method of provided the picture about the projects over a specific period of time is to construct exact cash flow of each alternative [Copeland et.al, 2005, pp. 36]. This method offers fundamental comparison of alternatives with necessity to estimate the investment expenses, operational revenue and expenses over the period of time, which enables to develop a balance of cash flow over the period. To provide a better measure for comparison, a cumulative balance of cash flows in the span of time may supply the management with better overview about the projects and maximization of shareholders` value. The balance cash flow incorporates depreciation, interest, taxation and other payments and so provides the "clean" view over the investment decision in the future. In this manner, the cash flow for investment decision purposes includes many incremental cash flows attributable to the project.

The payback method is simply a number of years it takes to recover the initial cash outlay on a project. The period of payback of a project to be invested in is the amount of time it will take for the after-tax cash inflows from the project to accumulate to an amount that covers the original investment. In the case of uneven cash flows during the period, the after-tax cash flow has to be accumulated on a year-to-year basis. The payback period will be defined after the accumulated amount equals the initial investment.

The payback method has indeed some disadvantages, when comparing with other methods of measurements of investment decision; however, it is widely used in the practice [Hilton, 2008]. The first reason is that it provides a roughly screening of the investment alternatives, without considerable cost and time requirements. The management can recognize from the payback period, if the project meets the minimal criteria set for the evaluation and may so reject this alternative in the very beginning of the evaluation process. Moreover, for small or medium enterprises cash is often substantial and crucial tool to proceed with business. If the payback period of an investment is too long, the enterprise will lack essential cash for its operations.

The usage of payback method itself is partially arbitrary as it ignores the cash flows after the date of payback, which is chosen as cutoff date. Furthermore, the payback method is often use to evaluate small investment decisions as it is much more easier to decide basing on the payback. Thus, in the reality, payback method and net present value often lead to the same decisions even though it is ignoring possible high cash inflows beyond the payback period [Ross et.al, 2007]. The companies usually combine several measurements of evaluating the investment decisions. Payback method is often used in conjunction with cash flow analysis, as it is not wise to rely only on one method itself [Copeland et.al, 2005]. This thesis will concentrate on the cash flow analysis of each alternative over the period of 8 years. Consequently, I will compare the cumulative balance of cash flow of all alternatives. To provide more accurate results, the cumulative balances will be compared with payback method and subsequently the choice of alternative will be made [Ross et.al, 2007].

Due to the time limitation of this thesis, the other methods of investment decision evaluation were not incorporated. Except for the net present value or internal rate of return, the return on investment analysis would be appropriate. Return on investment is one of the most common “investment-center performance measure” [Hilton, 2008] and it aims to achieve clarity in the decision-making process. The indicator is often used to analyze the economic value of projects executed in the pursuit of business strategy adopted by a firm [Erdogmus et.al, 2004].   The calculation of return on investment organizes projects` costs and benefits, or alternatively the cash flow of the firm, into a useful profitability measure. The cost-benefit analysis allows to translate the measured or estimated data into monetary terms and forms so the basis for valuation. In conjunction with the cash flow analysis and payback method, the analysis can provide more accurate results. However, the scope of this thesis is not interfering behind these two measures and so it leaves the space for the further research in this topic.

III. METHODOLOGY

The experimental and analytical part of this thesis begins with the insight into history, economy and energy sector of Slovak Republic. The information and materials in this part were compiled from various sources of international organization, journals and printed literature, which are dedicated to analyze the issues related to Slovak Republic. The next chapter is devoted to the Chemosvit Energochem a.s., history, structure and main operations. The materials were collected from internal resources of the company, such as internal reports, Annual Reports, Memorandum, Financial Statements, Balance Sheet, Newsletters and Corporate Responsibility, as well as public information published on the websites. Furthermore, data was gathered upon personal interviews with representatives of Chemosvit Energochem, a.s. as well as Chemosvit Group a.s.

The chapter six begins with the overview of present situation and energy consumption levels of Chemosvit Group a.s., whereas these data was extracted from the internal sources of the company. To proceed with the analysis of the alternatives selected in the year 2007, number of information and data was collected from all of the subsidiaries of Chemosvit Group a.s. as well as town Svit, which are the main customers of the analyzed company. However, most of this information is highly confidential and their publishing could lead to the loss of competitive advantage in the subsidiaries, therefore, only selected information is provided in this thesis to enable sufficient insight into the methodology. The data for the calculations include extensive financial and operational information from all of the subsidiaries, considering the huge number of the machinery, operating hours, winter and summer months, as well as prices of the fossil fuels, electric energy and heat in the year 2007.

The six alternatives for the energy production in Chemosvit Energochem a.s. were selected in the year 2007 by the representatives of the company. The Slovak Crown was used as the baseline for calculations mostly due to the fact that the financial data used are extracted from the financial results (financial statement, balance sheet and internal financial data) from the year 2007, when the alternatives for energy and heat production were defined and started to be taken into consideration. Moreover, the exchange rate between EUR and SKK fluctuated during the year 2007 and first half of the year 2008 significantly mostly due to the financial shocks in the global markets, so in the method of using SKK may try to avoid discrepancies in the numbers used as a baseline. Furthermore, to provide consistent results in one currency among the chosen period, it is preferred to perform the calculations in Slovak Crown. To convert these numbers into the EUR according to the exchange rate valid in that period can cause an unexpected bias in numbers and so result into misleading alternative choice. On the other hand, current fixed exchange rate of EUR/SKK 30.1261 may easily enable to convert my results into EUR, if it is required.

The alternatives are presented in the beginning of part 6.2. Each of them represent different set of possibilities of energy and heat production, from which one should be chosen in the end of year 2009. The result of investment decision will be realized since the beginning of the year 2011, after which the new machinery and facility will be put into implementation. All of the choices represent mutually exclusive projects, from which only one can be adopted. The alternatives incorporate the first alternative N.0, which assume the unchanged present situation of Chemosvit Energochem a.s. with required investment into maintenance. All other alternatives combine various methods of energy production, concentrating on the environmentally sustainable issues. The alternative N.5 consists of 6 further configurations that have to be taken into account and therefore the calculation and analysis is executed separately in the part 6.3. In addition to provide better contribution to the green energy issues and rationalizing of production, further recommendation to the selected alternatives was elaborated, which incorporate new dimension of efficiency.

To evaluate the alternatives, a framework was developed, which is applicable to every individual project and enable so comparability among the results. Firstly, for each of the alternative a figure of the nominal value of power plan, in terms of new equipment, installations, turbines or other necessities is constructed. This figure provides better picture of the alternative and enable so easier visual comparison. Hereinafter, the breakdown of necessary investments of each alternative is provided considering the required devices that need to be installed, property where the installation is appropriate and incorporating reserve of 10% to avoid any discrepancies which can be caused by variable prices. Each of the alternatives includes the investment into the maintenance of current equipment, independently from the choice of alternative. Prior to the elaboration of cost and revenues for each project, several assumptions were depicted to encompass the changed the company can face in the future. The analysis postulates eight successive time periods of equal duration (1 year): initial period of investment and application development and the periods of operations and maintenance. The assumptions made by the representatives of Chemosvit Energochem a.s. in the year 2007 are based in the historical and statistical data from previous years. To avoid a variance in results with the company data, the same assumptions are taken into consideration in this thesis. Chemosvit Energochem a.s. is in the process of evaluation of the alternatives using other measurement methods, such as net present value and internal rate of return, which is the reason these methods are not a subject of calculations in this thesis. The author was personally asked to use different methods for evaluation of these alternatives to supply the company with more results for investment decision. Therefore, the assumptions stated by Chemosvit Energochem a.s. are used in the same manner in the analysis of this thesis as follows:

- Increase of Natural Gas Prices by 3% per year.
- Increase of Biomass prices to 80% equivalent of natural gas prices.
- Increase of purchased Electric Energy prices by 3% per year.
- Increase of Heat and Electric sales prices by 3% per year.
- Increase of Electric Energy consumption by 1% per year.
- Consumption on the level of the year 2007.
- Overall Investment covered from loan/ paid by credit.
- Interest rate 5 %
- Yearly loan payment 20 mil. SKK.
- Depreciation from the investment over 8 years.

The justification for the expected increase of electric energy and natural gas prices by 3 % is supported by the Energy Information Administration, which predicts the same average rate of annual increase.[28] The consumption of electric energy in the Slovak Republic is gradually decreasing since the deregulation of the industry in 1999. However, the consumption of electric energy of enterprises is further increasing by 1% annually[29]. The increase of biomass prices to 80% equivalent of natural gas prices is analyzed in various studies[30], in which the biomass in EU and USA remains an expensive alternative to the fossil fuels[31]. The company presumes to cover all the initial investment from the loan which will be supplied with the interest rate of 5%. The yearly payment of the loan represents the amount of 20 million SKK and the depreciation from the investment as regulated by the law stretches through 8 years.

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[28] U.S. Energy Information Administration: Annual Energy Outlook 2010.
[29] International Energy Agency: World Energy Outlook 2008, pp. 78-85.
[30] Graham et.al. (2006) „Economics of Biomass Production in United States." In: Bioenergy Feedstock Information Network.
[31] Moller-Olsen, K. (2008) "International Price Trends of Biomass." Report on Bioenergy, Ministry of Food, Agriculture and Fisheries of Denmark.

Considering these assumptions, revenue from heat production and electric energy production were calculated. These items required an extensive prior calculation of revenue income per each customer, taking into account the number and age of machinery, operating period and season, as well as consumption recorded by town Svit. Thus, many of this information are confidential and therefore are not published in this thesis. Indeed, the total revenue in the initial year of investment (early 2011) serves as a baseline for further calculations. The table of costs and revenues is constructed for each of the alternatives for 8 consecutive years beginning with the year 2011. Again, the currency remains in thousand SKK per year, not EUR, to avoid discrepancies in the data which are acquired from the year 2007 and support the comparison with the company's resources.

The table of operating expense for each alternative incorporates the operating expenses for heat and electric energy production, fossil fuel expenses, cost of purchased electric energy from the grid, depreciation and taxation, all of which consider the aforementioned assumptions. Lastly, the table of cash flow for the period of 8 years is constructed for every alternative incorporating the revenues and expenses, interest rate payment, loan payment, taxation, and lease. The resulted balance of cash flow is cumulated for the period of 8 years to enable the comparison among all of the alternatives. Similarly, above described diagram and table are elaborated for all the alternatives and configurations selected for the evaluation. The method of cash flow used in this analysis is justified in the chapter of literature review. Hereafter, to support and review the results from cash flow analysis, a payment method was implemented and incorporated for all the alternatives. The results from both measurement methods were compared and presented as a conclusion.

IV. OVERVIEW OF THE HISTORY, ECONOMY AND ENERGY SECTOR OF SLOVAK REPUBLIC

Slovakia is a small country in the heart of Europe. The country's history is characterized as an important crossroad of different cultures (Austro-Hungarian Empire, Roman Empire and The Celts). In the last century, Slovakia remained part of the Austro-Hungarian Empire until the year 1918. After the First World War the Hungarians were one of the defeated powers. Until that time the Hungarian Empire was a multinational empire in which different communities were fighting for their autonomy. At this time, Slovakia achieved its independence and with the Czech Republic it becomes part of a country of two Slavic nations (Czechoslovakia)[32].

In 1948, Czechoslovakia fell into the hands of communism, it should be pointed that before the communist era, Czechoslovakia had been distinguished as the most democratic of all European states and one of the most developed in the world[33]. In 1989, Czechoslovakia overthrown the communism government with the pacific "Velvet Revolution" and since then a new stage in Slovak history began.

In the fall of 1992, Czechs and Slovaks negotiated the details of the dismantling of the federal government and it was on November 1992 when the Federal Assembly voted for the dissolution of Czechoslovakia. The 1st January, 1993, the Czech Republic and Slovakia became independent and sovereign states.

The territory of Slovakia has an area of 49 035 km2 and has borders with five countries: Czech Republic, Hungary, Austria, Poland and Ukraine. Bratislava is the capital of Slovakia located only 55 km from Vienna, 290 km from Prague and 160 km from Budapest.

[32] Kirschbaum, S.J. (1995). "*A History of Slovakia: The Struggle for Survival*", New York, St. Martin's Press, 1995. xvi + 350 pp.
[33] Lijphart,A. (1992). "*Democratization and Constitutional Choices in Czecho-Slovakia, Hungary and Poland 1989-91*", *Journal of Theoretical Politics,* 1992; Vol. 4; pp. 207.

According to the World Bank, in 2008 the population of Slovakia reached 5,406,626 people.[34]

4.1. **Economy of Slovakia**

The evolution of the Slovak economy is a good paradigm of how much can be achieved in a relatively short time by applying a correct economic policy. After being an isolated country from the European integration process ten years ago, today the country with its economic performance became "the tiger of Central Europe" with a GDP growth rates above the European average.

When this small country of 5.4 million split from the Czech Republic in 1993, there were many skeptics who thought the country will not be able to survive without the "big brother Czech". The truth is that the Czech Republic had a better starting position as part of Czechoslovakia in which Czech had more industries in the territory of doubled size than in Slovakia.[35] Although the first years of independence were quite chaotic for Slovak Republic, the reforms that were initiated in 1998 placed the country on an economically track and it was in 2006, when Slovakia was awarded the title “economic tiger of Central Europe”. One of the biggest reforms of the economy was the introduction of a general taxation called "flat rate". This tax rate was of 19%, which was implemented both on the income of all natural and legal persons regardless of the amount.

Moreover, the Slovak cheap and skilled workforce, new labor laws, which were more favorable to the employer and direct state aid to investors enabled Slovakia to become an attractive destination for foreign investors. Another important factor was that the country began rapid path toward membership in European Union and NATO, reducing so the

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[34] http://data.worldbank.org/country/slovak-republic, retrieved 28th April, 2010.

[35] Smith A. (1998) “*Reconstructing the Regional Economy, Industrial transformation and Regional Development in Slovakia*”, Edward Elgar Publishing Limited, 1998, UK.

uncertainty and creating more sense of stability. The accession took place on 1st May, 2004, when Slovakia together with seven other post communistic countries (Czech Republic, Poland, Hungary, Slovenia, Estonia, Lithuania and Latvia) and two other countries Malta and Cyprus joined the EU.[36]

Earlier this decade and just after all this reforms, Slovakia began to experience a rapid increase of foreign investments. The entry of investments culminated in 2006, when the volume was tripled compared to the previous year level of 1,915 million EUR, primarily due to the introduction of two major car factories, which were the French Peugeot and South Korean Kia.

Slovakia is a small and greatly open economy, in which the sum of exports and imports accounted for 157.5 % of GDP in 2007. Since its accession to the European Union on 1st May, 2004, no longer tariff barriers exist for products originated in the European Union. The very same year Slovakia entered to NATO, which facilitated better relations with North American countries.

The entry to the Schengen Agreement in 2007, paved the way for Slovakia to enter the Eurozone. The adoption of Euro currency in Slovakia was possible thanks to the excellent performance of the Slovak economy between 2004 and 2008. In this period, the country became an economic leader in the region and the rate of GDP growth was among the highest within the European Union.[37]

On 1st January, 2009, Slovakia entered the Eurozone, becoming the second post-communistic country to adopt the Euro. The Figure 4.1 shows the GDP growth of various

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[37] Ručinská, S. (2009) "*Competitiveness of Slovakia and the Economic Crisis*", Central European Journal of Public Policy, Vol. 3, No. 2, December 2009.

countries in the year 2009, in which Slovakia recorded the third highest percentage of GDP growth in the world following China and India. This big expansion of the economy is caused by excellent geographical position that makes the country a bridge between West and East Europe and by the proximity of Bratislava to three other European capitals (Budapest, Prague, Vienna), which is an attractive conglomerate to many logistics companies. Furthermore, four of the factors that have attracted foreign investors in recent years are: very favorable fiscal conditions, cheap and skilled labor, presence of three car factories and the spectacular growth of the Slovak economy.

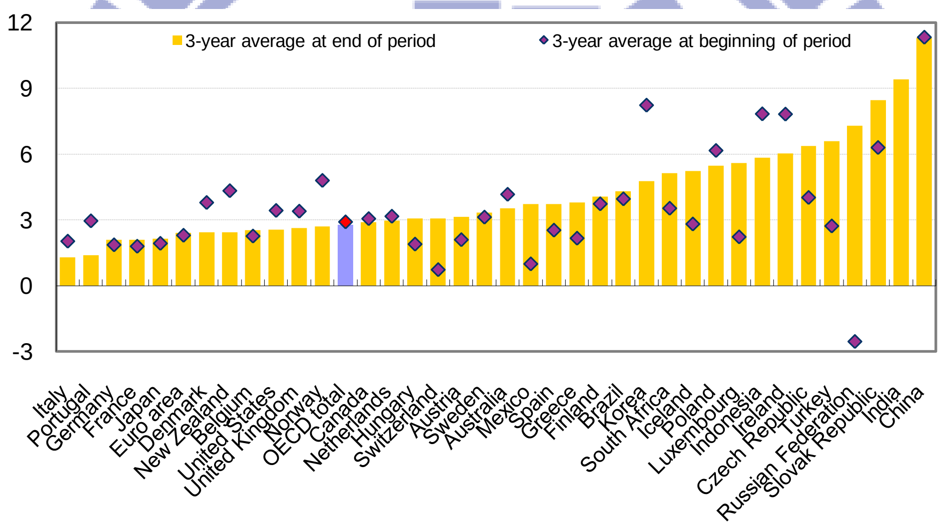


Figure 4.1: GDP Growth per Country, 3-year Average

Source: OECD Factbook 2009: Economic, Environmental and Social Statistics.

4.2. **Energy Sector in Slovakia**

The Slovak Republic ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 25th August, 1994. It's goal under UNFCCC was to stabilize greenhouse gas (GHG) emissions at 1990 levels. As a result of economic restructuring, this goal was not difficult to achieve for Chemosvit Group a.s. The company was already 20%

below the levels of the year 1990. Under the Kyoto Protocol of 1997 (signed by Slovakia on 26^{th} of February of 1999), Slovakia is expected to keep its GHG emissions at 8.0% below its 1990 levels in the period of 2008-2012. The other commitment made by Slovakia is the so called "Toronto Target" identified in the first NC as the national target. This target requires Slovakia to reduce its energy related CO_2 emissions by 20% from the 1988 level.

The need to comply with the above mentioned targets, along with the environmental requirements of EU, introduces additional challenges to the requirement of Slovakia`s overall energy sector restructuring. In the process of the liberalization of the domestic energy sector and scheduled opening up to competition with foreign power suppliers, Slovakia is facing the need to balance the goals of market competitiveness with environmental considerations.

The presence of independent cogeneration projects is a healthy trend which ultimately contributes to the competitiveness of the whole electric energy sector. Yet, creating an independent power production sector usually faces significant start up problems. The traditional barriers to cogeneration worldwide lie in the willingness of monopolistic power suppliers to accept and encourage independent power production. The most frequent manifestation of the barriers are unwillingness to purchase outputs above owner usage, punitive charges or requirements for back up and maintenance power, as well as unwillingness to pay the full avoided costs that are legimately due the project. The degree to which these common barriers are present in Slovakia needs to be clarified.

The national power generation and transmission company Slovenské Elektrárme (SE) has an installed capacity of 6,118 MWe, or 88% of Slovakia's total. The remaining capacity resides with three regional electric companies and other electricity producers. There are many industrial sites which cogenerate electricity and industrial process heat. Some of these utilize coal and are either obsolete or otherwise uneconomic, or do not meet emissions regulations. These and other industrial sites that do not presently cogenerate are possible targets of opportunity for independent power developers. The largest example of such and opportunity that is being pursued is the 85 MWe combined cycle power plant under construction at the East Slovakia Steelworks (that had been acquired by U.S Steel Corp.= that will utilize blast furnace gas as fuel.)

Slovakia is currently planning to restructure its power system and privatize some assets, including those of SE. It is expected that generation will be separated from transmission, and sold to private owners. In the process of restructuring, the three regional electric companies are expected to become distribution companies, with their power plants also offered for sale. It is expected that local governments will be given 49% of the shares of the power plants in their districts. Shares of the eastern regional company, Východoslovenské Elektrárne (VSE), are expected to be offered for sale first, then the other two companies will follow. VSE is supplying power to the company Chemosvit Group a.s.

Along with the planned privatizations, price liberalizations is central to the market transformation in Slovakia's energy sector in line with EU policy. The artificially low prices (stemming from cross-subsidized retail prices, which do not allow the distribution companies to operate profitability) have been a serious deterrent to private investments in Slovakia's electric sector. The new legislation on price control will abandon price gaps[38]. In favor of establishing a regulatory authority to approve price increases (following the approach adopted in Poland and the Czech Republic), the 1998 Law on Energy was amended in July 2001 to set up such a regulatory body, which started discharging its duties since 1st January, 2003. This body, called the Office for Regulation of Networks Industries,

[38] Rousek J. (2001) "*Energy Economy of the Slovak Republic: Current Situation and Future Outlook*", International Journal of Global Energy Issues, 2001.

took over the energy control functions of the Ministry of the Economy as well as the price-setting functions of the Ministry of Finance for electricity, natural gas, and district heating. It is expected that the funding for the Office will come from fees assessed on the companies being regulated. Slovakia plans to harmonize its energy laws with the EU and to eventually eliminate cross-subsidization.

V. CHEMOSVIT ENERGOCHEM A.S.

The joint-stock company Chemosvit Energochem a.s. is a 100% subsidiary of holding company Chemosvit Group a.s., which is a 100% private company with majority shareholders from the management and employees. The company was formed from the former energy division on 1st January, 1997 and it is situated in the town Svit. The main operations of Chemosvit Energochem a.s. is the production of electric energy and heat, as well as subsequent supply and distribution of the energetic services.

Chemosvit Group a.s., with its headquarters in Slovakia, is a group of 6 subsidiaries and 6 joint ventures operating in several countries and exporting to more than 150 countries. Chemosvit Group a.s. consists of a various companies involved in the production, converting and sales of flexible films intended for packaging and for the electro-technical industry, production and sales of plastics, polypropylene yarn and machinery.[39] The core business of Chemosvit Group a.s. is shown in the Figure 5.1.

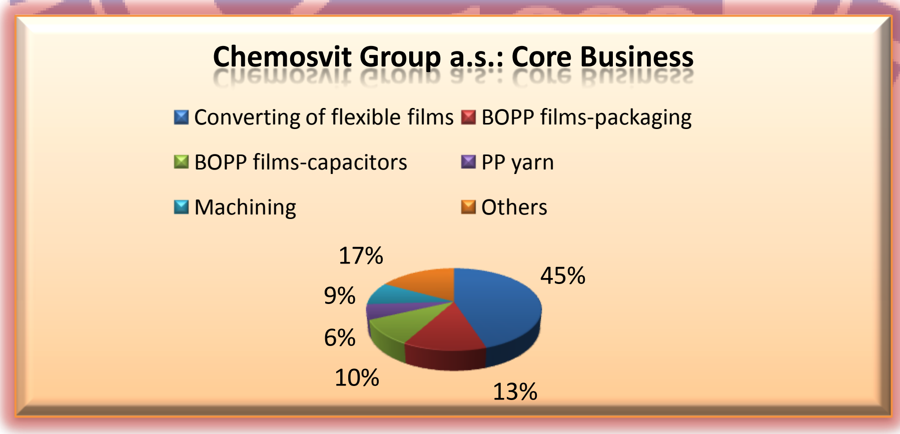


Figure 5.1: Overview of Core Business of Chemosvit Group a.s.

Source: Chemosvit Group a.s, Annual Report 2009

[39] www.chemosvit.sk

5.1. **History and Structure of Chemosvit Group a.s.**

The history of the company dates back to 1934, when the famous entrepreneur Thomas Bata chose the region to establish a new factory for the production of viscose rayon, which supported its already established manufacturing facilities for shoes production.

Table 5.1.: History of Chemosvit Group a.s.

1934 - Manufacturing site and the town of Svit established by the Bata's company

1935 - Viscose rayon

1936 - Cellophane films

1938 - Flexographic printing (rubber plates)

1939 - Establishment of own vocational school

1939 - Machinery and foundry

1951 - PA staple rayon production (terminated in 1993)

1964 - Polyethylene films and products

1965 - PP staple rayon production (terminated in 1971)

1967 - Packaging machines

1972 - Rotogravure printing

1974 - PA bulk continuous filament (BCF) (terminated in 1993)

1977 - Biaxial-oriented polypropylene (BOPP) films

1980 - Polypropylene yarn

1989 - Thin BOPP films for electro-technical industry

1992 - Production of cast films

1994 - Company privatization

1995 - Terichem a.s. - production of BOPP films for the electro-technical and packaging industries

1996 - Chemosvit Fibrochem a.s. - production of polypropylene yarn

Strojchem a.s. - machining

Chemosvit Energochem a.s. - production and supplies of heat, electricity and water

VAT Lutskplastmass - plastic product manufacture (the Ukraine)

JV Chemosvit Luckchim Ltd. - flexible film converting (the Ukraine)

1997 - Chemosvit Bohemia a.s. - marketing and sales of flexible films (the Czech Republic)

Chemosvit Environchem a.s. - processing of plastic waste and using it as secondary raw material

1999 - CJSE Terichem Luck - production of BOPP films for the electrotechnical and packaging industries (the Ukraine)

2002 - **Chempack a.s.** - manufacture of packaging machines

2004 - **Terxpro Films Private Limited** - production of BOPP capacitor films (India)

Zlievareň Svit a.s. - production of castings made of cast steel and grey cast iron

2005 - **Chemosvit Folie a.s.** - production and converting of flexible films

Chemosvit – CLP a.s. - marketing and sales of stand-up pouches

2006 - **ZAT Strojchem Lutsk Ltd.** - machining (the Ukraine)

Source: www.chemosvit.sk

The Chemosvit Group a.s. is integrated by Chemosvit a.s. and Finchem a.s.. The Group has 13 subsidiaries and six joint ventures. The Chemosvit Group a.s. has a broad range of activities and services and it is currently the largest producer and processor of materials of flexible plastic packaging in Slovakia. The annual capacity of production of films and laminates reaches more than 30 000 tons. The structure of the Group is shown in the Figure 5.2.

Figure 5.2: Structure of Chemosvit Group a.s.

Source: Chemosvit Group a.s, www.chemosvit.sk

The entire Group has its headquarters in Svit, Slovakia, but also it owns the facilities in the Czech Republic, Finland and Ukraine. The Group employs nearly 4000 people in several countries around the world. The subsidiaries and joint ventures include the following productions:

• Cast iron and cast steel foundry;

• Sub-units of supplies of machinery, mainly for food and chemical industries;

• Horizontal and vertical packaging machines production and assembly;

• Multifilament polypropylene yarns and socks;

• Films and biaxial oriented polypropylene for electro-technical industry;

• Plastics recycling and secondary raw materials for the production of plastic products for households and industry.

The subsidiaries of Finchem a.s provide the following services to Chemosvit Group a.s.:

• Transportation and Transmission;

• Financial Services;

• Road transport and car sales;

• Service and maintenance;

• Electricity / heat production and distribution.

During its long history of 76 years, the Chemosvit Group a.s. experienced several economic and political changes such as was the Velvet Revolution in 1989 and division of the Republic of Czechoslovakia in 1993. The company was engaged also in a privatization process which was accomplished on 1st April, 1994. With this privatization most of the employees became the company `s own shareholders and the majority of this shares were owned by the management. Since 1994, Chemosvit Group a.s. has undergone extensive restructuring and modernization of basic production, manufacturing facilities and technologies. The company has improved the level of technology, machinery, product quality, labor productivity, management and educational level. Currently, the company exports over 75% of its production to multinational companies representing the majority of its customers[40].

Chemosvit Group a.s. has been transformed into a customer oriented company. The management quality systems are a prerequisite for various certifications that comply with International Standards ISO 9001, the working environment of safety, health controls and the environment.

5.2. **Energy Operations of Chemosvit Energochem a.s.**

The company principal line of business is production, distribution and sales of electricity and heat, treatment, distribution and sales of technological water and natural gas distribution. The company operations are allocated within the area of Chemosvit Group a.s. The Figure 5.3 shows the main technological centers of Chemosvit Energochem a.s. in the next objects:

Obj 94b	The input distribution plant
Obj 54,54 a,b, 55, a, b	Cooling towers and technological water treatment
Obj 31, 31a	Boilers K8, K9, K10 and thermo water treatment station.

[40] Brzica D. (2000) "*Privatization In Slovakia: The Role Of Employee And Management Participation, 1996-2001*", International Labor Organization (ILO).

Figure 5.3: Technological Centers of Chemosvit Energochem a.s.

Source: Chemosvit Energochem a.s., Internal Resources.

5.2.1. ***Supply of Power to the Customers***

All energy forms necessary for technological processes and production of Chemosvit are supplied from Chemosvit Energochem a.s.. Electric power is sold to the parent company and its subsidiaries. Heat is sold through distribution networks to the company and to the city of Svit. Power consumption by the individual company production divisions form a substantial part of consumption compared to external customers. Chemosvit Energochem a.s. provides the following activities and operations:

- Production and distribution of heat in form of steam and hot water.
- Own electricity generation, internal distribution of generated and purchased electric energy.
- Technological water supplies, thermal and chemical water treatment.

5.2.2. ***Power Production Technology and Main Technological Units***

The main technological units of Chemosvit Energochem a.s. include the following:

- Technical water.
- Production and distribution of heat
- Gas installations
- Production and distribution of electric energy

5.2.2.1.Technical water

Technical water (filtered, softened, demineralized) is treated from water from river, which is consequently used in technological processes. The water is extracted from the Poprad River, which is clapped surged so that a part of water could flow to the intake channel through which it is supplied by a dosing object and measuring devices to the settling tanks. A coagulant binding non-soluble parts contained in water which settle on the tanks bottom is dosed in water. Consequently, water is drawn by a pump (securing the requested water pressure) to sand filters in which mechanical impurities are removed. From the sand filters water is distributed by pipelines to final operations for various technological uses. A part of technical water is softened (it gets rid of positive ions) in the softening filters from where it flushes to the supply distributions.

A part of filtered water is further treated in the dematerializing stations for production needs where it gets rid of all water contained ions. An independent circle is the chilling circle for steam turbines condensates and basic line in the cast films production cooling. Water circulating in the circle gets cooled in the cooling towers. The drop of water in the circle is replenished with filtered water.

5.2.2.2.Production and Distribution of Heat

Heat energy in form of overheated steam is used as a drive of generators for electric power production, technological steam in production processes, hear-carrying medium for heating as well as a primary medium for heating water in the hot water circuit. Heat energy is produced by combustion of natural gas in the steam boilers (K8, K9, K10). Natural gas is taken from the high pressure distribution and in reducing stations it is modified to the request pressure. Treated water, a mixture of reversible condensates, and dematerialized water is fed into the boiler, which evaporates by action of heat generated by burning natural gas and following it is reheated to the requested temperature. From the boiler it is distributed through high-pressure pipelines to steam turbines and individual technological units. Steam in the turbine outlet reaches pressure of 0.4 MPa and temperature of 240˚C. This is used for heating, air/conditioning, heating of hot service water and technological purposes. A part of steam condensates in the steam turbines condensates.

5.2.2.3.Production and Distribution of Electric Power

Electric power supplies are provided by two independent sources: a public of 110 KV, which distributes electric system with the proper source and 3 turbine generators with total apparent power of 23.4 MVA. Interconnection of proper and superior electric system is provided for the VHP distribution plant (110 KV) in Lopušná Dolina (Lopusna Valley) and the inlet distribution plant (Obj. 94b) in the company area. A part of electric energy is distributed under 6.3 KV voltages to production units situated close to the inlet distribution plant and the second part is transformed onto 5.25 KV voltages. Voltage systems of 5.25 and 6.3 KB are ergo not directly connectable. Almost all HP distribution plants are supplied through the main and back-up inlets. The Quality Management System is guided by respective organizational directives, valid technological documentation of production departments and applicable legislation.

5.3. **Geographical Position of the Town Svit**

In the south-western part of the Poprad basin, 8 km from the city of Poprad, there is the town Svit. The natural environment of Svit and its vicinity fall as a part of the Carpathian Mountains flora in to the altitude of up to 735 – 1100 m over the sea level and appertain to the border zones of another natural parks protected by law: the Slovak Paradise and the Low Tatras. On the northern side, there is a border of the protected natural area of the Tatra National Park (TANAP). About 500 species of plants grow in this guarded zone; many of them are protected by law, as well as some animal species. The location of Chemosvit Group a.s. in the region is shown in the Figure 5.4.

Figure 5.4: Geographical Position of Chemosvit Group a.s. in Slovakia

Source: www.chemosvit.sk

5.4. **Market and the Customers**

The main customer of Chemosvit Energochem a.s. is the town Svit and the Group Chemosvit a.s. The town history dates back to 1934, when Bata Company bought grounds from the Veľká municipality to build here a plant for chemical fibers production. The first name was Veľká- Svit settlement, later on Batizovce. In 1937 the settlement got its current name, Svit. From 1946, Svit has been an autonomous township and in 1963 it was proclaimed a town. Nowadays, the town Svit has 7,500 inhabitants.

From the beginning of its existence, Chemosvit Group a.s. has been generating necessary energies by its own capacities. The power plant was established on a co-generation basis involving overheating of steam in the steam boilers and the successive production of electricity in the steam turbines driven generators. The primal steam boilers combusted bituminous coal solely. Gradually, as the plant was expanding, pipeline bridges, single medium pipeline distributions and cable distributions of power supplies to the whole area of Chemosvit and a part of the Svit town were built.

Launching of the K-7 steam boiler and the TG-3 back-pressure steam turbine in 1960s, started principle modernization of power economy connected with gradual switching-over to heating oil combustion. Construction of other oil-gas boilers, K-8 (1978), K-9 (1981) and the gas boiler K-10 (1992), made the stage of modernization and ecological operation of power economy accomplished. Since 1995, solely natural gas (NG) has been used as fuel. The process of modernization was completed by installation of up-to-date digital systems for particular technological units' control (1996) and establishment of modern thermal feed water degassing station (1998).

5.5. **Technology Challenges of Chemosvit Energochem a.s.: Changing the Structure of Electricity Industry**

Market liberalization in the Slovak electric sector will inevitably lead to retail price increases, creating opportunities for independent power producers (IPPS) such as Chemosvit Energochem a.s. to place competitive pressure on existing suppliers, as private industry investment plans are established to adapt to new markets, economic cogeneration opportunities should be fully exploited. In this process, carbon externalities should be properly valid to have an impact on investment decisions. This Project of Green energy could be the first project in Slovakia to openly address this issue.

One of the main reasons in favor of investing in green energy is that the local production of energy enables a company to become more competitive against the option of purchasing electricity from the grid. This Project will take the maximum advantage of the economies associated with the available heat load. In fact, the Project will mainly cover internal heat and electric needs of Chemosvit Group a.s. and only provide small deliveries (about 10 GWh) to the grid in winter time, when the plan generates surplus power. In summer, Chemosvit Group a.s. will have to buy roughly the same amount of electricity from the grid.

The Chemosvit Energochem a.s. project of green energy provides as a host facility a plant with deep Slovak roots, a strong reputation for environmental commitment, and a well-established record of successful cogeneration. Its product line is now heavily concentrated on one of the fastest growing markets in the region. Chemosvit a.s. is a 100% privately owned joint stock company with majority stockholders being from the management and the employees of the company. As such, the company is an attractive pioneer in securing the kinds of gas contracts and electricity agreements with grid representatives that are needed for this kind of projects. The recognition of common interest between regional electric distributors, regional gas distributors, and private industry with large heat and electric demands and local district heating companies is an important precedent for implementation of greener production processes.

5.6. **Summary**

The energy system of Chemosvit Group a.s, the largest Slovakian producer of foil packaging materials and synthetic fibers, was designed primarily to meet the demand of company plants due steam and hot water. On-site cogeneration by Chemosvit Group a.s. daughter`s company Chemosvit Energochem a.s. meets approximately half of Chemosvit Group a.s. electric needs. The rest of demand for electricity is met by purchases from the public grid.

In line with its global objective to decrease the emissions of greenhouse gases (GHG), the project will introduce investments necessary to modernize Chemosvit Energochem a.s. electric production capacity in a way that will ensure maximum efficiency and environmental benefits. Without such modernization, the plant would most likely lose its physically obsolete steam turbine capacity and deteriorate in to a heat-only boiler plant, with all its electricity purchased from the public grid.

VI. ANALYSIS OF THE ALTERNATIVES FOR GENERATION OF ELECTRICITY AND HEAT

In recent years Chemosvit Group a.s. invested heavily to modernize its production equipment and energy policy. The main reasons for a new energy policy adopted by the company are presented below.

- Ensuring long-term stability and security of energy supply.
- Permanent guarantee of high economic efficiency of production and energy distribution.
- Long term decreasing trend of energy consumption.
- Physical and moral deteriorated machinery.
- Inadequacy of source dimension by present and expected energy consumption.
- Change the structure supporting media thermal energy (steam, hot water).
- Inadequacy of the current dimensions of distribution networks and the expected heat energy.
- Current high proportion of own energy consumption

6.1. Overview of Present Situation of Chemosvit Energochem a.s.

The maximum consumption of heat by the Chemosvit Group a.s. is around 12.2 MW and its maximum consumption of electric energy is 12.2 MW with a total production of electric power of 17.0 MW and a maximum heat production of 135 MW. Chemosvit Energochem a.s supplies heat mainly to 8 customers as presented in Figure 6.1.

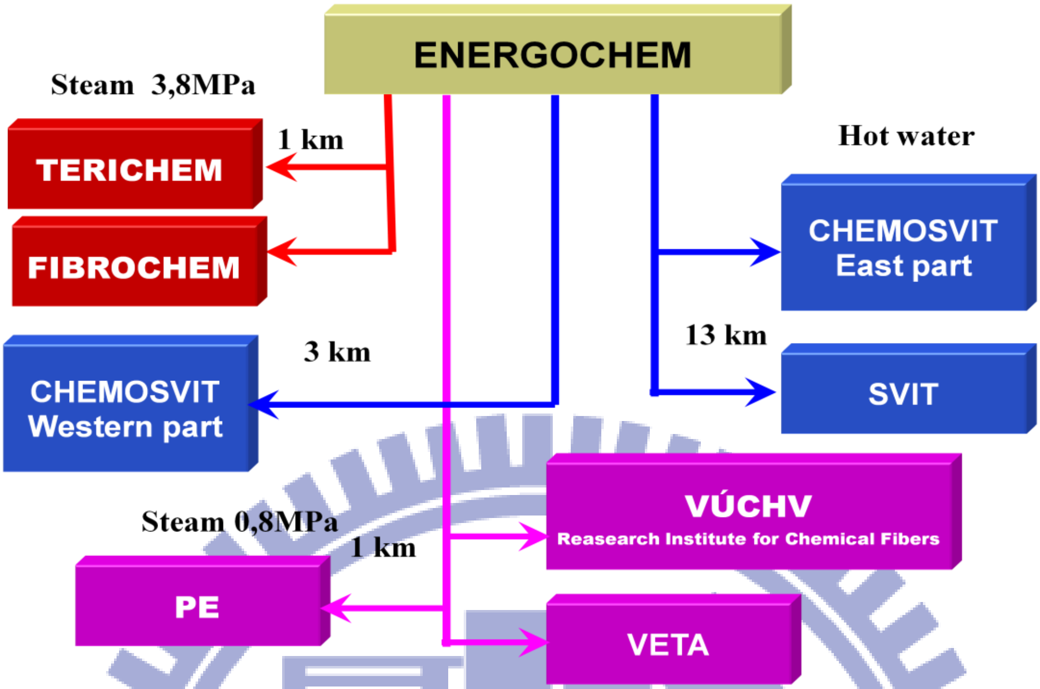


Figure 6.1.: Heat Supply by Customer

Source: Chemosvit Energochem a.s. Memorandum 2009.

6.1.1. ***Overview of Customers of Chemosvit Energochem a.s***

As we can see in the Figure 6.1, Terichem a.s. is one of the most closely located customers of Chemosvit Energochem a.s. "*Terichem Group a.s. is a group of BOPP film manufacturers engaged in the production of packaging films with production sites in Svit, Slovakia and Lutsk, the Ukraine. Terichem and Terichem Lutsk are BOPP film suppliers for printing houses, food companies and tobacco concerns*"[41]. Terichem a.s. as a part of Tervakoski Films Group are suppliers of capacitors which were used in works such as the world's largest hydroelectric power plant Itaipu, and TGV trains.

Chemosvit Fibrochem a.s is the second nearest located customer of Chemosvit Energochem a.s. Chemosvit Fibrochem a.s. is one of the biggest companies of Chemosvit Group a.s. and

[41] www.terichem.eu

produces polypropylene multifilament yarns with various applications, socks and stockings. The company employs around 300 people. One of the largest customers is represented by Chemosvit Folie, which is engaged in producing, converting and sales of packaging materials[42]. The other customers of Chemosvit Energochem are: Chemosvit Group a.s. West part and East part, the town Svit, VUCHV (Research Institute of Chemical fibers), PE and VETA. In the Figures 6.2 and 6.3 the customers of Chemosvit Energochem a.s. in the West and West part of Chemosvit Group a.s. are depicted in detail.

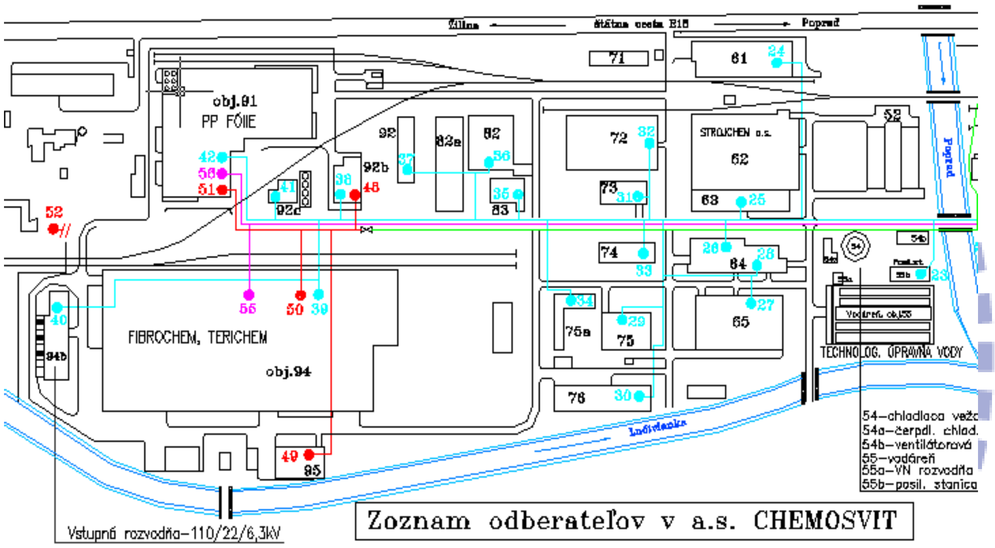


Figure 6.2.: Distributions of Heat – The Western Part

Source: Chemosvit Energochem a.s. Memorandum 2009.

42 http://www.chemosvit.sk/en/ChemosvitFolie/index.html.

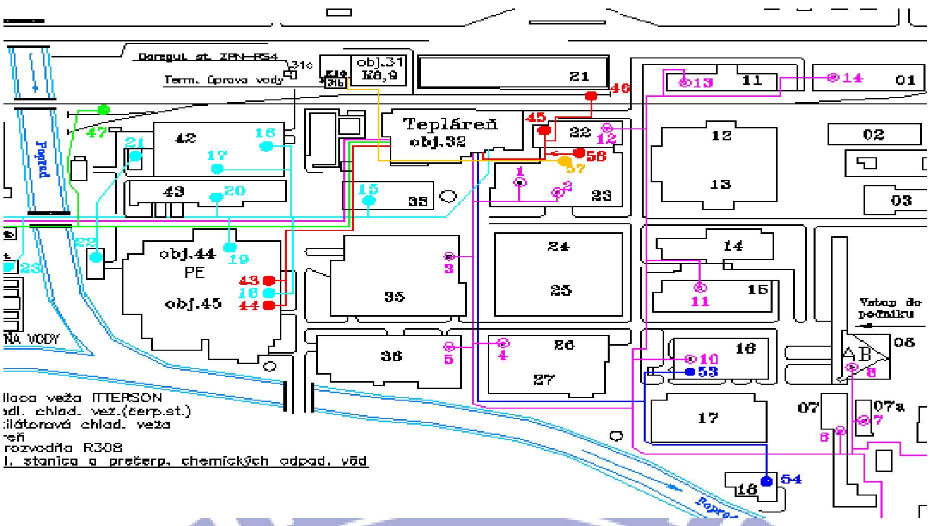


Figure 6.3: Heat Distribution - Eastern Part of Chemosvit Group a.s.

Source: Chemosvit Energochem a.s. Memorandum 2009.

The Figure 6.3 presents graphically the town Svit, which is one of the most important customer of Chemosvit Energochem a.s. The town Svit is one of the youngest towns in Slovakia. Besides the residential areas, two kindergartens, three primary schools, one high school and university department are located in Svit. Nowadays, Svit town has slightly more than 7,400 people. With an area of (4.5 km2) it is one of the smallest towns in Slovakia.

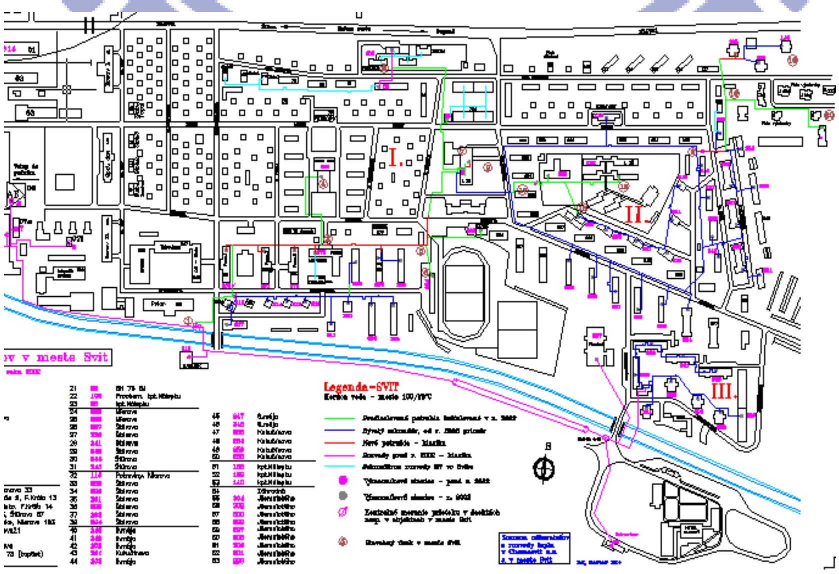


Figure 6.4: Distributions of Heat - The Town Svit

Source: Chemosvit Energochem a.s. Memorandum 2009.

6.1.2. *Historical Overview of Energy Consumption in Chemosvit Energochem a.s.*

The Figure 6.5 shows the historical development of fuel and power installed heat in Chemosvit Energochem a.s., and it as well depicts the tendency of the company to decrease the level of consumption of fuel oil and brown coal since 90`s.

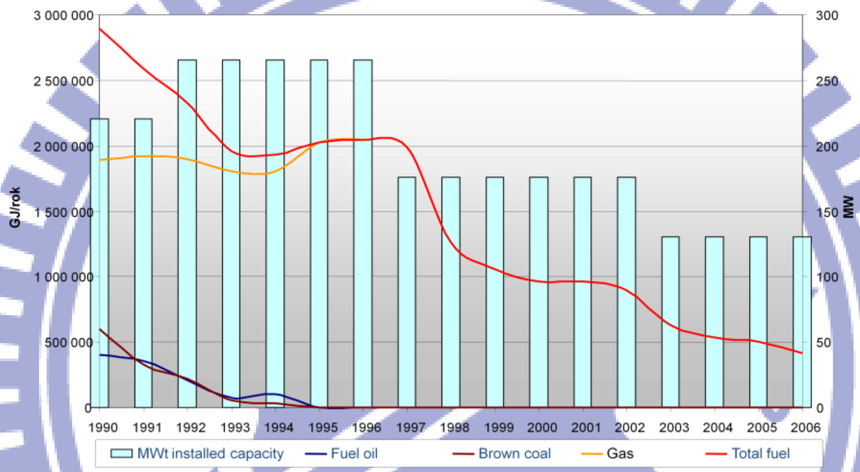


Figure 6.5: Historical Development of Fuel and Power Installed Heat

Source: Chemosvit Energochem a.s. Memorandum 2009.

The next Figures 6.6, 6.7, 6.8 show the trends of Chemosvit Energochem a.s to improve the efficiency in the usage of energy. It is remarkable that since 1996 the production of heat and electricity is facilitated only through the gas usage.

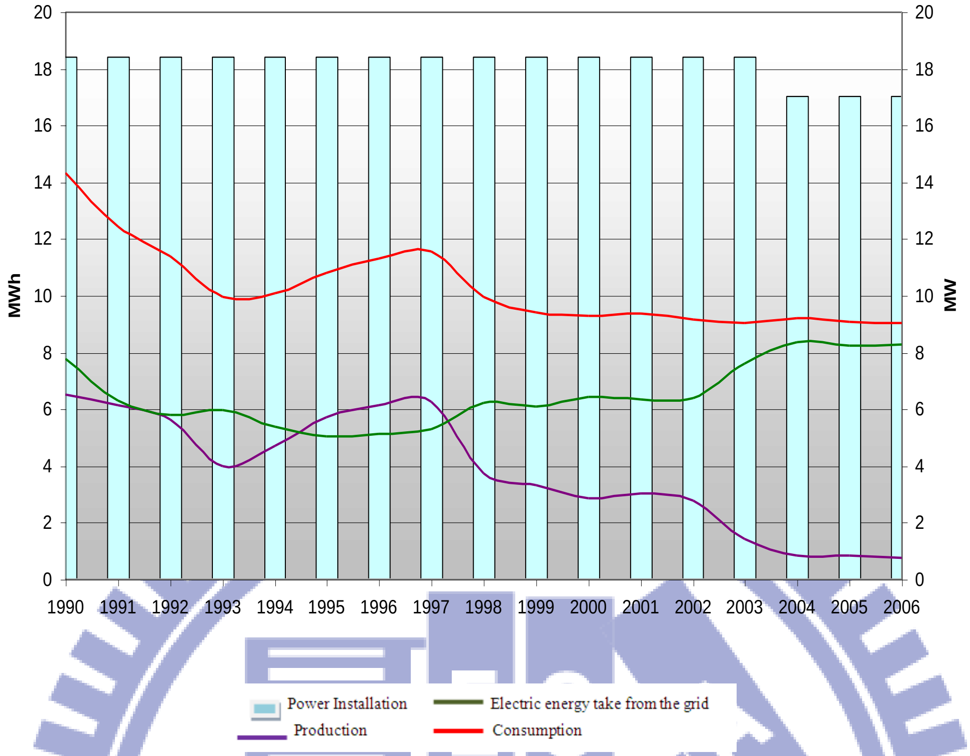


Figure 6.6: Historical Development of Electric Power Energy and Installed Capacity of Electric Production Plant

Source: Chemosvit a.s. Memorandum 2009.

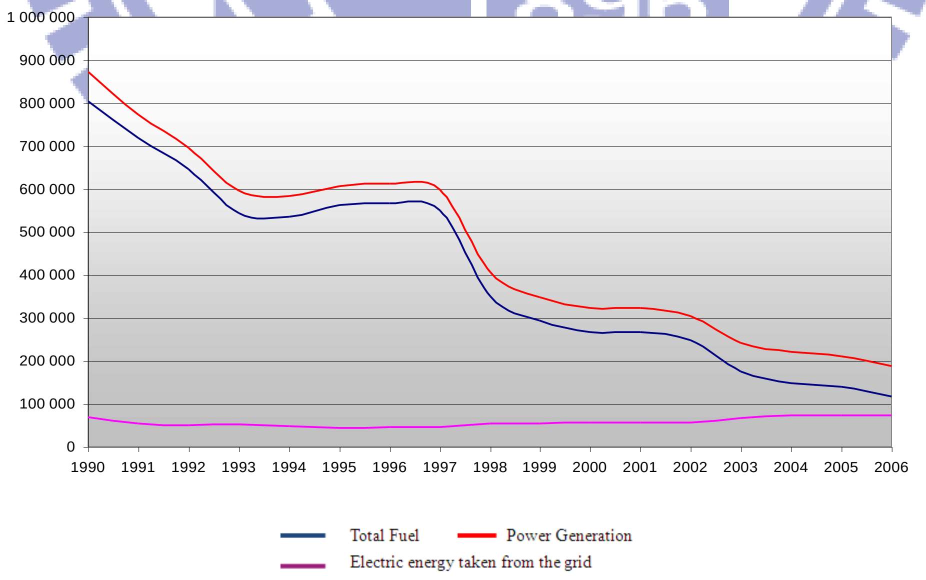


Figure 6.7: The Course of Energy Consumption for the Years 1990-2006 in MWh / Year

Source: Chemosvit Energochem a.s. Memorandum 2009.

6.2. **Alternatives for Electricity and Heat Production**

As mentioned before, the purpose of this thesis is to evaluate the chosen alternatives of generation of energy production at the subsidiary of Chemosvit Energochem, a.s. and review a possible investment decision considering the best option in a cost-effective and reasonably low risk manner. The alternatives were selected in the year 2007 and are presented below:

7. Only Boilers.
8. Boilers + Boilers for Biomass.
9. Boilers + Geothermal source.
10. Boilers + Solar Energy.
11. Cogeneration with Gas Motors.
    a. 2 x 1 MW = 2 MW (Two motos of 1 MW)
    b. 2 + 1 MW = 3 MW (1 motor of 2 MW and 1 motor of 1 MW)
    c. 2 x 2 MW = 4 MW (2 motors of 2 MW)
    d. 2 x 2 + 1 MW = 5 MW (2 motors of 2MW and 1 of 1 MW)
    e. 3 x 2 MW = 6 MW (3 motors of 2 MW)
    f. 5 x 2 MW = 10 MW (5 motors of 2 MW)
12. Cogeneration with gas turbine.

Remark: All alternatives assume installation of steam generators. Also as a baseline in all scenarios the alternative 0 is taken in to consideration because it represents the minimum investment for maintenance, which is required to keep on the operations. Furthermore, all alternatives comply with the assumptions and methodology described in the Chapter 3 of this thesis. The results and calculations were conducted in SKK to avoid any discrepancy, which can prohibit the comparison and evaluation.

6.2.1. *Alternative N.0: Present Infrastructure of Chemosvit Energochem a.s., Investment to Maintenance*

As described in Chapter 3, for all of the alternatives a figure of the nominal value of power plan was elaborated. Figure 6.8 shows the capacity which is currently installed in Chemosvit Energochem a.s.

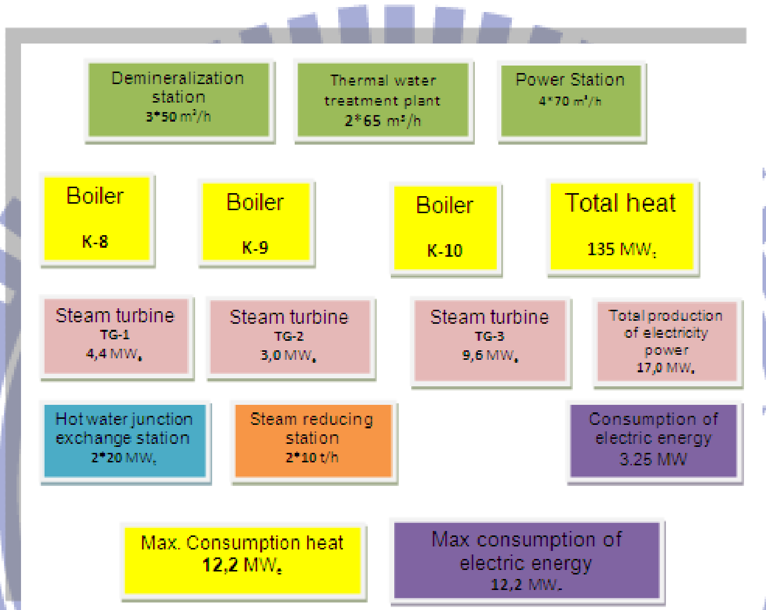


Figure 6.8: Nominal Value of Power Plan: Alternative N.0

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Subsequently, a table of investment breakdown for this alternative was created, in which the required investment to the equipment and facilities are described in detail. Such detailed analysis enables to explicitly distinguish between the alternatives and investment decision. The results of the investment breakdown analysis for alternative N.0 are presented in the Table 6.1, which assumes only the necessary investments into infrastructure maintenance.

Table 6.1.: Breakdown of Necessary Investments in Alternative N.0

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
1	Steam Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ∘ C	3,710,000	371,000	4,081,000
2	Steam Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ∘ C	1,710,000	171,000	1,881,000
3	Steam Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ∘ C	800,000	80,000	880,000
Steam Generators Total					6,220,000	622,000	6,842,000

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
7	Gas Boilers	Obj.32	Energochem	5W	2,600,000	260,000	2,860,000
9	Condensator Switching	Obj. 32	Energochem		800,000	80,000	880,000
10	Exchange station Steam/ Water	Obj. 31	Energochem	2*12 MW	5,500,000	550,000	6,050,000
11	Additional building	Obj. 31	Energochem		500,000	50,000	550,000
12	Pipe bridge	Obj 32.	Energochem		200,000	20,000	220,000
13	Pipe bridge	Obj. 31-34	Energochem		0	0	0
14	Demistation	Obj. 31.	Energochem	10 m^3/h	5,000,000	500,000	5,500,000
15	Steam turbine	Obj 31.	Energochem	2 MW	0	0	0
16	Electro Devices	Obj 31.	Energochem		4,000,000	400,000	4,400,000
18	Regulation System (Control)				1,000,000	100,000	1,100,000
Other Devices Total					19,600,000	1,960,000	21,560,000
Investment Together					25,820,000	2,582,000	28,402,000
Total Investment with 10% of reserve							31,242,200

**All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

In order to maintain the competitiveness of Chemosvit Energochem a.s., an investment of 31,242,200 SKK is needed, which should be used mostly to develop pipelines, pipe bridges, condensates switching, electric devices, etc.

To proceed further with the analysis, a table of cost and revenues was elaborated. The assumptions and methodology for this table is described in Chapter 3 in more detail. The results of cost and revenues analysis, as well as the cash flow analysis for consecutive 8-year period are presented in Table 6.2.

Table 6.2.: Costs, Revenues and Cash Flow for Alternative N. 0

Present	Unit	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year
Investment Expenses	Thousand SKK	31,242							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	134,063	138,085	142,228	146,495	150,890	155,416	160,079	164,881
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**385,165**	**396,718**	**408,620**	**420,878**	**433,505**	**446,510**	**459,905**	**473,702**
Operating Expenses									
Operating expenses for heat production	Thousand SKK/year	17,958	18,497	19,052	19,624	20,212	20,819	21,443	22,086
Operating Expenses for Electric Energy production	Thousand SKK/year	24,985	25,735	26,507	27,302	28,121	28,965	29,834	30,729
Fuel Expenses	Thousand SKK/year	110,050	113,351	116,752	120,254	123,862	127,578	131,405	135,347
Cost for Electric Energy Purchase	Thousand SKK/year	198,510	204,465	210,599	216,917	223,425	230,127	237,031	244,142
Operational Cost Total	Thousand SKK/year	351,503	362,049	372,910	384,097	395,620	407,489	419,713	432,305
Depreciation	Thousand SSK/year	10,442	10,350	10,258	10,206	10,186	8,165	7,259	7,034
Operational Total Cost	Thousand SKK/year	361,946	372,398	383,168	394,304	405,806	415,654	426,973	439,339
Profit Loss before Taxation	Thousand SKK/year	9,218	8,758	10,890	12,575	13,699	16,856	18,932	20,364
Taxation	Thousand SKK/year	1,751	1,664	2,069	2,389	2,603	3,203	3,597	3,869
Accumulated retained	Thousand SKK/year	7,466	14,560	23,381	33,567	44,663	58,316	73,651	90,146
Cash Flow									
Revenues Total	Thousand SKK/year	385,163	396,718	408,620	420,878	433,505	446,510	459,905	473,702
Expenses without depreciation and Interest	Thousand SKK/year	351,503	362,049	372,910	384,097	395,620	407,489	419,713	432,305
Interest	Thousand SKK/year	0	1,562	562	0	0	0	0	0
Payment	Thousand SKK/year	0	20,000	11,242	0	0	0	0	0
Income tax	Thousand SKK/year	1,751	1,664	2,069	2,389	2,603	3,203	3,597	3,869
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	17,909	-2556	7,836	20,392	21,282	21,819	22,595	23,528
	year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cummulative Balance of Accounting Period	**Thousand SKK/year**	**17,909**	**15,352**	**23,189**	**43,581**	**64,863**	**86,681**	**109,276**	**132,804**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**17,056**	**13,925**	**20,032**	**35,854**	**50,822**	**64,683**	**77,660**	**89,887**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

*6.2.2. **Alternative N.1: Hot Water Boilers***

The alternative N.1 is the first and the simplest alternative that was taken into consideration, and requires only the installation of hot water boilers. Similarly to the analysis of alternative N.0, a figure depicting the nominal value of power plan for the configuration of the alternative N.1 was elaborated, which is shown as Figure 6.9.

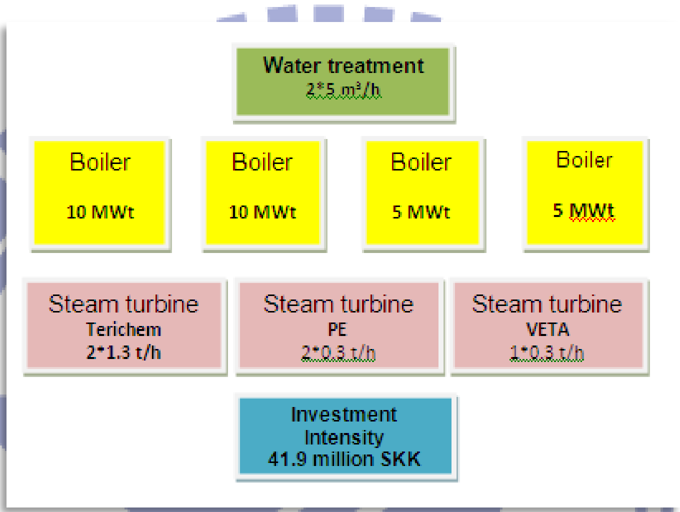


Figure 6.9: The Nominal Value of Power Plan: Alternative N.1

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The implementation of the alternative N.1 requires an investment of 41.9 million SKK. The disposition of the hot boilers water needed to be installed in the area of 24m x 36m. According to the plans of area of Chemosvit Group a.s., the place for installation of hot water boilers can be selected as is shown in the Figure 6.10 and 6.11.

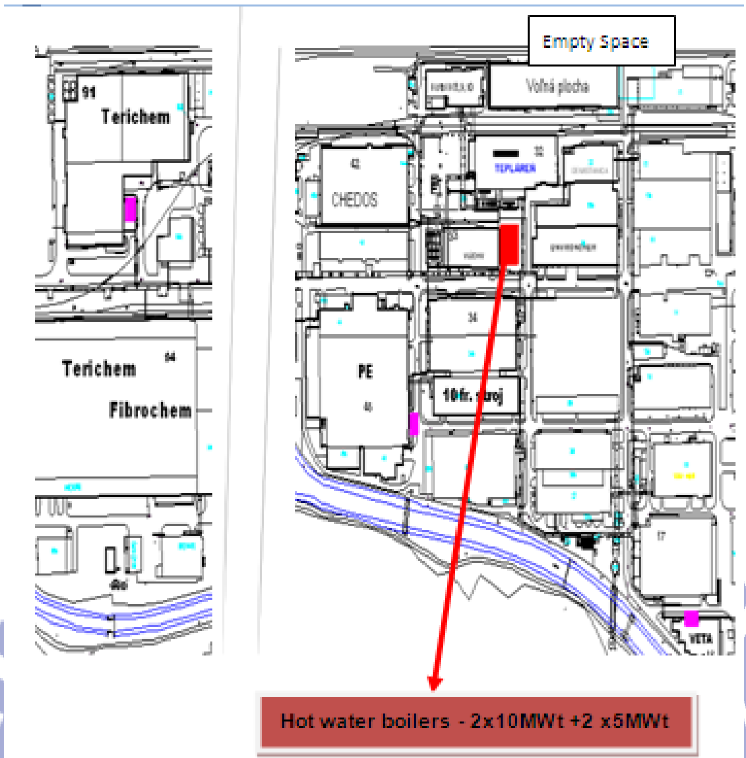


Figure 6.10: Alternative N.1 - The Disposition of Hot Water Boilers

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

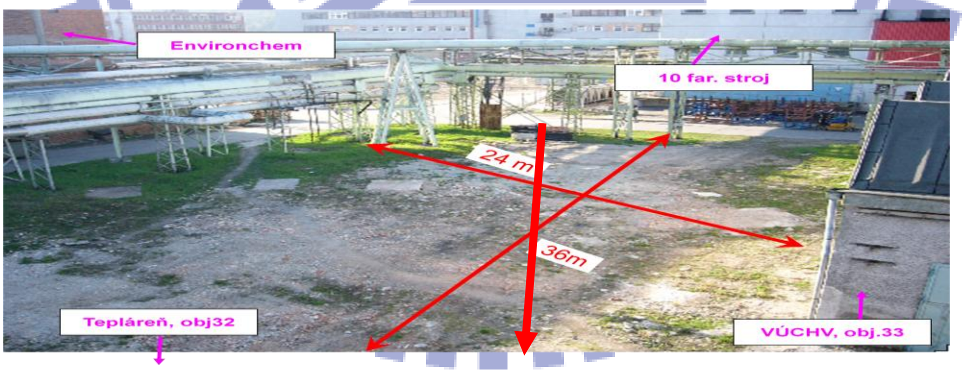


Figure 6.11: Empty Area of 24m x 36m

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The breakdown of the required investment intensity for alternative N.1 is shown in the Table 6.3.

Table 6.3.: Breakdown of Necessary Investments for Alternative N.1

	Device Name	Property	Company	Technical	Facilities	Other	Total
1	Stem Generator, gas, pipeline,	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa. 210 ∘ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline,	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa. 180 ∘ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline,	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ∘ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	pipeline	Obj. *32*	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	Gas Boilers	Obj 32.	Energochem	5 MW	2,600,000	260,000	2,860,000
9	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Condensator Switching	Obj. 32	Energochem		800,000	80,000	880,000
10	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
11	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
18	Regulation System (Control)				5,000,000	500,000	5,500,000
Other Devices Total					28,300,000	2,830,000	31,130,000
Investment Together					34,620,000	3,462,000	38,082,000
Total Investment with 10% of reserve							**41,890,200**

**All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Similarly to alternative N.0, the alternative N.1 also requires an investment of 6,842,000 SKK, mostly in the steam generators, pipeline and constructing, which is a prerequisite of maintaining current infrastructure. The investment change is caused due to the gas boilers. Table 6.4 depicts the costs, revenues and cash flow analysis for the period of 8 years considering the assumptions stated in the Chapter 3 of this thesis.

Table 6.4: Costs, Revenues and Cash Flow for Alternative N.1

Only Boilers	Unit	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year
Investment Expenses	Thousand SKK	41,890							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	126,885	130,691	134,612	138,651	142,810	147,094	151,507	156,052
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**377,985**	**389,324**	**401,004**	**413,034**	**425,425**	**438,188**	**451,334**	**464,874**

Operating Expenses									
Operating expenses for heat production	Thousand SKK/year	19,958	20,557	21,174	22,809	23,463	23,137	23,831	24,546
Operating Expenses for Electric Energy production	Thousand SKK/year	24,385	25,117	25,870	26,647	27,446	28,269	29,117	29,991
Fuel Expenses	Thousand SKK/year	84,232	86,759	89,362	92,043	94,804	97,648	100,578	103,595
Cost for Electric Energy	Thousand SKK/year	210,202	216,508	223,004	229,694	236,584	243,682	250,992	258,522
Operational Expense Total	Thousand SKK/year	338,778	348,941	359,410	370,192	381,298	392,737	404,519	416,654
Depreciation	Thousand SKK/year	11,773	11,681	11,589	11,537	11,517	9,496	8,590	8,865
Operational Total Cost	Thousand SKK/year	350,551	360,622	370,999	381,729	392,814	402,233	413,109	425,019
Profit Loss before	Thousand SKK/year	13,434	12,608	14,911	17,305	18,611	21,955	21,224	25,854
Taxation	Thousand SKK/year	2,552	2,395	2,833	3,288	3,536	4,171	4,603	4,912
Accumulated retained	Thousand SKK/year	10,881	21,093	33,171	47,188	62,263	80,047	99,668	120,610

Cash Flow									
Revenues Total	Thousand SKK/year	377,985	389,324	401,004	413,034	425,425	438,188	451,334	464,874
Expenses without depreciation and Interest	Thousand SKK/year	338,778	348,941	359,410	370,192	381,298	392,737	404,519	416,654
Interest	Thousand SKK/year	0	2,095	1,095	0	0	0	0	0
Payment	Thousand SKK/year	0	20,000	21,890	0	0	0	0	0
Income tax	Thousand SKK/year	2,552	2,395	2,833	3,288	3,536	4,171	4,603	4,912
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	**22,654**	**1,893**	**1,777**	**25,554**	**26,591**	**27,280**	**28,212**	**29,307**
	year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative Balance of Accounting Period	**Thousand SKK/year**	**22,654**	**24,547**	**26,324**	**51,878**	**78,470**	**150,750**	**133,962**	**163,269**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**21,575**	**22,265**	**22,740**	**42,680**	**61,483**	**112,492**	**95,204**	**110,507**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

After comparison of the calculations of cumulative balance of accounting period for the alternative N.0 and alternative N.1., it is observable that the alternative N.1 allocates more cash flow in the 8-year period. Before have any conclusions, further comparison among the alternatives was done, which consisted of deeper analysis of the pros and contras of the alternative N.1, and is summarized below.

Advantages

- It is a simple solution because it only requires the purchase of the boilers.

- Lowest investment intensity.
- Small space requirement - the possibility of building on Greenfield.
- Without the need for upgrading facilities for the consumption of heat.
- Shortest execution time.

Disadvantages

- Without any benefits accruing from the combined production.
- Without the possibility to regulate the electric energy consumption.

6.2.3. ***Alternative N. 2: Hot Water Boilers and Biomass Boiler***

The alternative N.2 is very similar to the alternative N.1; however, it presumes an installation of the hot water boilers and a biomass boiler. The Figure 6.12 depicts the configuration of nominal value of power plan.

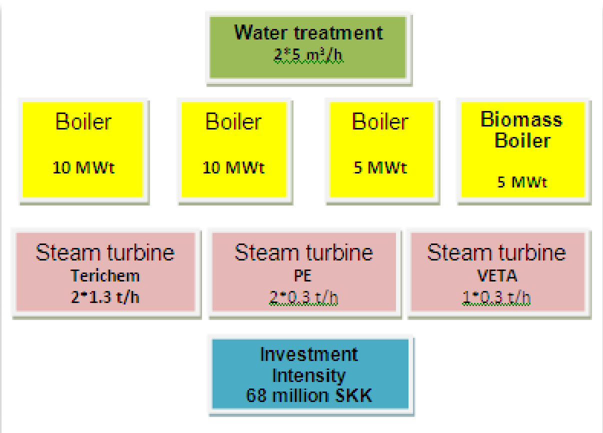


Figure 6.12: The Nominal Value of Power Plan: Alternative N.2

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The investment intensity needed for this alternative is 68 million SKK, which represents the amount higher by 26.1 million SKK against the investment required in the alternative N.1.

This is mostly due to the high cost of the biomass boiler. The configuration for the installation of these boilers is presented the Figure 6.13.

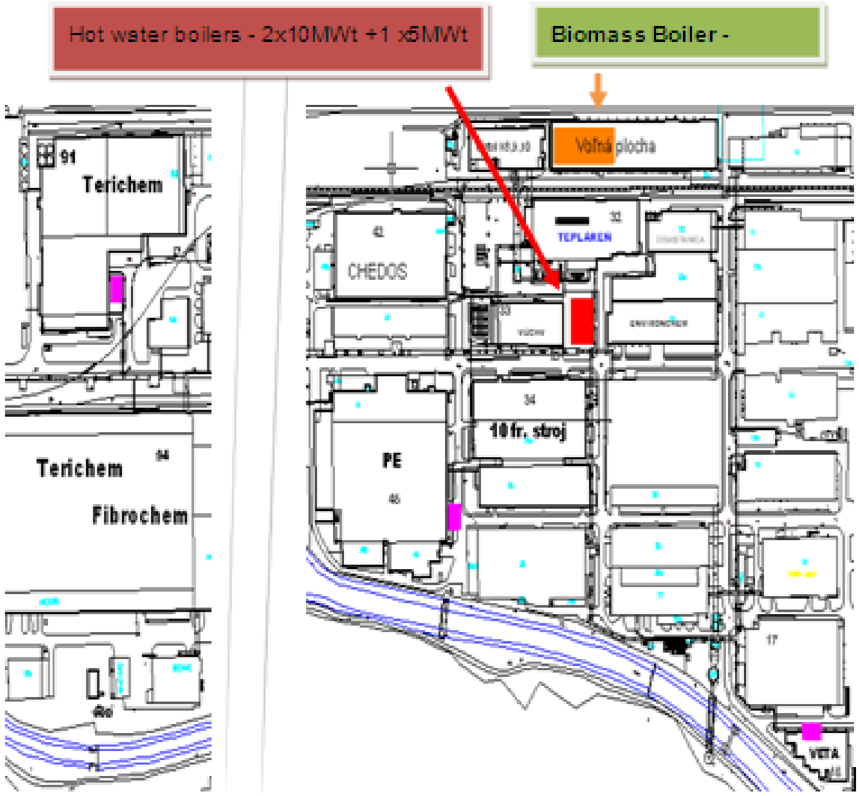


Figure 6.13: Configuration for the Installation of the Hot Water Boilers and Biomass Boiler

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The Figure 6.13 shows that the distribution of the boilers varies from the Alternative N.1. The following Table 6.5 shows the breakdown of the cost for the Alternative N.2, moreover, it is followed by the Table 6.6 depicting the cost, revenues and cash flow respectively.

Table 6.5.: Breakdown of Necessary Investments for Alternative N. 2

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Biomass Boiler	Obj 32	Energochem	5 MW	19,800,000	1,980,000	21,780,000
12	Split fuel wood loader	Obj 32.	Energochem		2,500,000	250,000	2,750,000
13	Split fuel wood stick	Obj 32	Energochem		2,000,000	200,000	2,200,000
18	Regulation System (Control)				5,000,000	500,000	5,500,000
Other Devices Total					50,000,000	5,000,000	55,000,000
Investment Together					56,220,000	5,622,000	61,842,000
Total Investment with 10% of reserve							**68,026,200**

**All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.6.: The Costs, Revenues and Cash Flow: Alternative N.2

Boilers + Biomass Boilers	Unit	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year
Investment Expenses	Thousand SKK	68,026							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	118,908	122,475	126,150	129,934	133,832	137,847	141,983	146,242
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**370,008**	**381,108**	**392,542**	**404,318**	**416,447**	**428,941**	**441,809**	**455,063**

Operating Expenses									
Operating expenses for heat	Thousand SKK/year	17,958	18,497	19,052	19,624	20,212	20,819	21,443	22,086
Operating Expenses for Electric Energy production	Thousand SKK/year	22,385	23,057	23,749	24,461	25,195	25,951	26,729	27,531
Fuel Expenses	Thousand SKK/year	74,923	80,126	82,212	84,507	87,031	89,252	91,650	94,241
Cost for Electric Energy Purchase	Thousand SKK/year	210,202	216,508	223,004	229,694	236,584	243,682	250,992	258,522
Operational Expense Total	Thousand SKK/year	325,469	338,188	348,016	358,285	369,022	379,703	390,815	402,381
Depreciation	Thousand SKK/year	15,040	14,948	14,856	14,804	14,784	12,763	11,857	11,632
Operational Total Cost	Thousand SKK/year	340,509	353,136	362,872	373,089	383,806	392,466	402,673	414,013
Profit Loss before Taxation	Thousand SKK/year	15,499	10,571	13,268	15,827	18,240	22,475	25,136	27,051
Taxation	Thousand SKK/year	2,945	2,008	2,521	3,007	3,466	4,270	4,776	5,140
Accumulated retained earnings	Thousand SKK/year	12,554	21,116	31,864	44,864	59,458	77,663	98,023	119,934

Cash Flow									
Revenues Total	Thousand SKK/year	370,008	381,108	392,542	404,318	416,447	428,941	441,809	455,063
Expenses without depreciation and Interest	Thousand SKK/year	325,469	338,188	348,016	358,285	369,022	379,703	390,815	402,381
Interest	Thousand SKK/year	0	3,401	2,401	1,401	401	0	0	0
Payment	Thousand SKK/year	0	20,000	20,000	20,000	8,026	0	0	0
Income tax	Thousand SKK/year	2,945	2,008	2,521	3,007	3,466	4,270	4,776	5,140
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	**28,594**	**3,510**	**5,603**	**7,625**	**21,532**	**30,968**	**32,218**	**33,543**
Cumulative Balance of Accounting Period	**Thousand SKK/year**	**27,594**	**31,104**	**36,708**	**44,332**	**65,864**	**96,864**	**129,050**	**162,593**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**26,280**	**28,212**	**31,710**	**36,472**	**51,606**	**72,281**	**91,713**	**110,049**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

As we can perceive from the above tables, the initial cumulative balance for the year 1 to 4 are better than the results of the Alternative N.1, but in the long run, mainly because of the instability of the price of the biomass, it is a little less than the Alternative N.1. After the analysis the pros and contras of the Alternative N.2 are summarized as follow:

Advantages

- Relatively lower fuel costs in the short run.
- Without requirement of the reconstruction on the side of heat consumption.

Disadvantages

- Without any benefits accruing from the combined production.
- Without the possibility to regulate the electric energy consumption.
- Need of buying extra accessories - the landfill, biomass, biomass loader, access roads.
- No guarantee of price increases and availability of biomass.

*6.2.4. **Alternative N. 3: Hot Water Boilers and Geothermal Source***

The alternative N.3 looks a little different than alternative N.1 and N.2, which is mainly due to the usage of a geothermal source. The main proposal for the alternative N.3 is the hot water boilers + geothermal resource. The main argument for the proposal of the geothermal source is that the Chemosvit Group a.s is spread over big geothermal source of water, which was proven by several geothermal drills, as well as various thermal water parks built in the region. Moreover, this proposal is supported by a detailed geological study supplied to the author by the company; however, it is not suited to be published due to the confidentiality. The configuration for the Alternative N.3 is presented in the Figure 6.14.

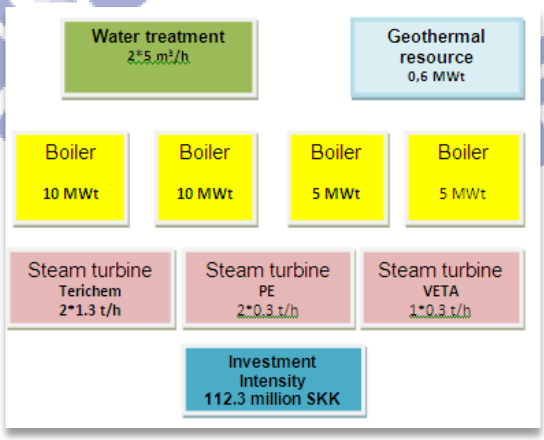


Figure 6.14: The Nominal Value of Power Plan: Alternative N.3

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

From the configuration of this alternative it is observable that the investment intensity is much higher than in the previous alternatives. The main reason for this big difference in price is the high investment into drilling in order to extract the geothermal source. The Figure 6.15 shows the installation of this alternative inside the area of the Chemosvit Group a.s.

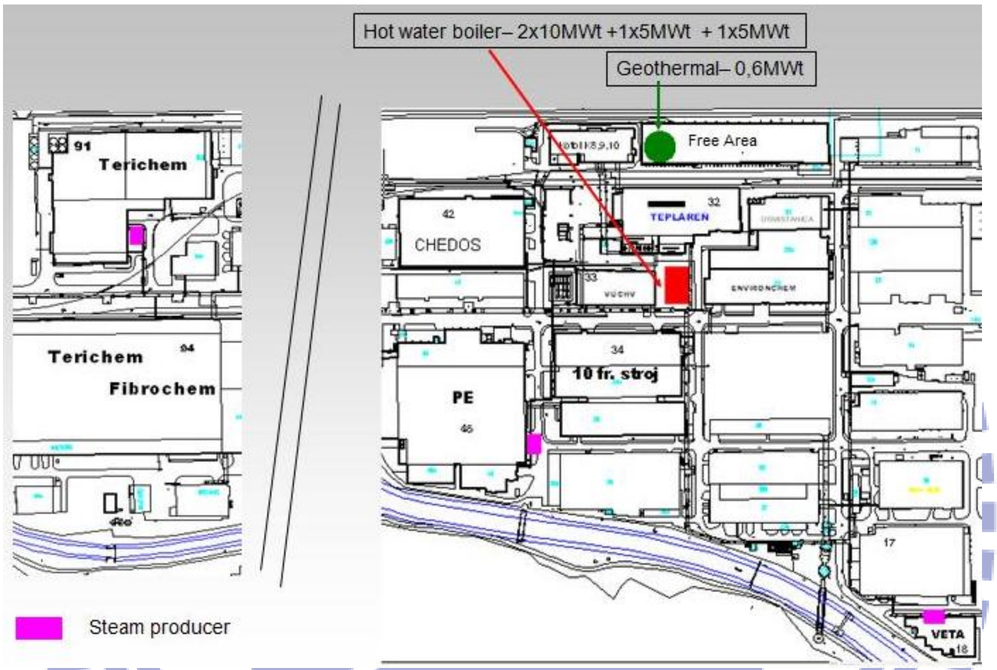


Figure 6.15: Configuration for the Installation of the Hot Water Boilers and Geothermal Source

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

One of the first questions that should be asked under such intense investment requirements is what are the cost of every single part for implementing this project, as well as the overview of cumulative balance for 8 years. The answer can be found in the Tables 6.7 and 6.8.

Table 6.7: Breakdown of Necessary Investment for Alternative N. 3

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operati	Total
1	Stem Generator, gas, pipeline, construction	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Propert y**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	Gas Boilers	Obj.32	Energochem	5 MW	2,400,000	240,000	2,640,000
9	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Geo Drill hole	Obj. 32	Energochem		500,000	50,000	550,000
13	Exchange Station			1 MW	1,500,000	150,000	1,650,000
14	Pumps, chemicals,				2,000,000	200,000	2,200,000
15	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					86,600,000	8,660,000	95,260,000
Investment Together					92,820,000	9,282,000	102,102,000
Total Investment with 10% of reserve							**112,312,200**

**All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.8.: The Costs, Revenues and Cash Flow of Alternative N. 3

Boilers + Geothermal Source	Unit	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year
Investment Expenses	Thousand SKK	112,312							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	130,088	133,990	138,010	142,150	146,415	150,807	155,331	159,991
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**381,188**	**392,623**	**404,402**	**416,534**	**429,030**	**441,901**	**455,158**	**468,813**

Operating Expenses									
Operating expenses for heat production	Thousand SKK/year	17,958	18,497	19,052	19,624	20,212	20,819	21,443	22,086
Operating Expenses for Electric Energy production	Thousand SKK/year	22,385	23,057	23,749	24,461	25,195	25,951	26,729	27,531
Fuel Expenses	Thousand SKK/year	80,658	83,078	85,570	88,138	90,782	93,505	96,310	99,200
Cost for Electric Energy	Thousand SKK/year	210,202	216,508	223,004	229,694	236,584	243,682	250,992	258,522
Operational Expense Total	Thousand SKK/year	331,204	341,140	351,375	361,916	372,773	383,956	395,475	407,339
Depreciation	Thousand SKK/year	20,576	20,484	20,392	20,340	20,310	18,299	17,393	17,168
Operational Total Cost	Thousand SKK/year	351,780	361,624	371,766	382,256	393,093	402,255	412,868	424,507
Profit Loss before Taxation	Thousand SKK/year	15,407	11,384	14,020	16,662	19,322	24,030	27,674	30,306
Taxation	Thousand SKK/year	2,927	2,163	2,664	3,166	3,671	4,566	5,258	5,758
Accumulated retained	Thousand SKK/year	12,480	21,701	33,057	46,553	62,204	81,668	104,084	128,632

Cash Flow									
Revenues Total	Thousand SKK/year	381,188	392,623	404,402	416,534	429,030	441,901	455,158	468,813
Expenses without depreciation and Interest	Thousand SKK/year	331,204	341,140	351,375	361,916	372,773	383,956	395,475	407,339
Interest	Thousand SKK/year	0	5,616	4,616	3,616	2,616	1,616	616	0
Payment	Thousand SKK/year	0	20,000	20,000	20,000	20,000	20,000	12,312	0
Income tax	Thousand SKK/year	2,927	2,163	2,664	3,166	3,671	4,566	5,258	5,758
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	**33,056**	**9,704**	**11,748**	**13,837**	**15,570**	**17,763**	**27,497**	**41,715**
	year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative Balance of Accounting Period	**Thousand SKK/year**	**33,056**	**42,760**	**54,508**	**68,345**	**84,315**	**102,078**	**129,575**	**171,290**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**31,482**	**38,785**	**47,086**	**56,228**	**66,063**	**76,172**	**92,087**	**115,936**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Surprisingly the cumulative balance of cash flow for the period of 8 years is better in the short and long run comparing to the balance of alternatives N.0, N.1 and N.2. The main reason for this is that after the high investment of drilling, other investments in fuel for the geothermal source are not needed, thus, the investment in the fuel for the boilers is still required. After the extensive analysis of the alternative N.3, the advantages and disadvantages are summarized as follows.

Advantages

- The geothermal energy is a simple solution.
- It requires a small space - the possibility of building on Greenfield.
- Energy from geo-source "free".

Disadvantages

- Without any benefits accruing from the combined production.
- Without the possibility to regulate the electric energy consumption.
- Low-potential heat- necessarily to reconstruct devices and facilities on the side of heat consumption.
- High investment intensity without guarantee of source sustainability and temperature.

*6.2.5. **Alternative N. 4: Hot Water Boilers and Solar Energy***

The alternative N.4 incorporates the hot water boiler and solar energy. The main argument for proposing the solar energy is that it is a renewable source of energy and as stated before the solar radiation reaching the earth's surface can be converted directly into electricity or heat. The heat can be used directly as heat or it can produce steam and generate electricity. The configuration of the alternative N.4 is presented in the Figure 6.16.

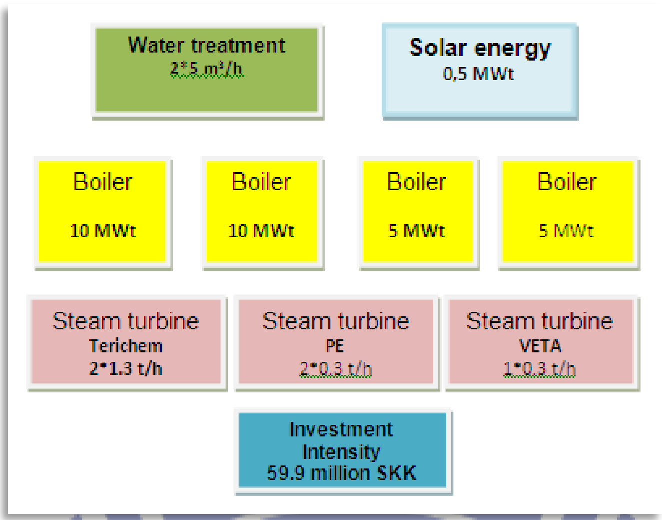


Figure 6.16: The Nominal Value of Power Plan: Alternative N.4

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

As can be seen from the above Figure 6.16, the intensity of investment is less than any other alternative and apparently, it looks like a good solution, which is because the source of the sun is for free and the initial investment is not significantly high. The next Figure 6.17 shows how the solar panels may be installed inside the area of Chemosvit Group a.s.

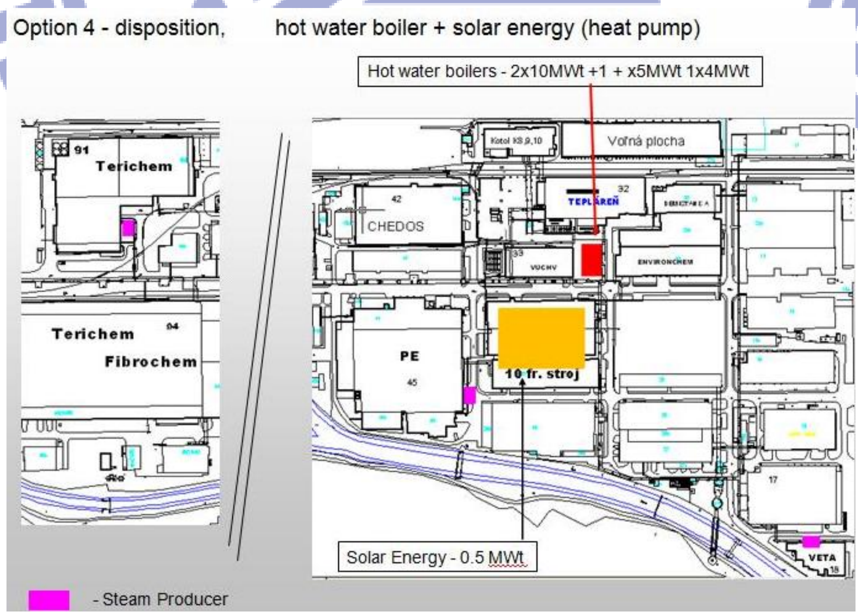


Figure 6.17: Configuration for the Installation of the Hot Water Boilers and Solar Energy Source

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

According to the scenario of alternative N.4, the solar panels propose the installation on the roof of one of the production halls. The analysis of breakdown of investment required for alternative N.4 and the costs, revenues and cash flow analysis are shown in the Tables 6.9 and 6.10.

Table 6.9.: Breakdown of Necessary Investment for Alternative N. 4

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	Gas Boilers	Obj.32	Energochem	5 MW	2,400,000	240,000	2,640,000
9	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
10	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
11	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
12	Solar Panels	Obj 32.	Energochem		12,000,000	1,200,000	13,200,000
13	Accesories				3,000,000	300,000	3,300,000
14	Regulation System (Control)				5,000,000	500,000	5,500,000
Other Devices Total					43,300,000	4,330,000	47,630,000
Investment Together					49,520,000	4,952,000	54,472,000
Total Investment with 10% of reserve							**59,919,200**

**All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.10.: The Costs, Revenues and Cash Flow of Alternative N. 4

Boilers + Solar Source	**Unit**	**1 year**	**2 year**	**3 year**	**4 year**	**5 year**	**6 year**	**7 year**	**8 year**
Investment Expenses	Thousand SKK	59,919							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	124,601	128,339	132,190	136,155	140,240	144,447	148,781	153,244
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**375,701**	**386,972**	**398,582**	**410,539**	**422,855**	**435,541**	**448,607**	**462,065**

Operating Expenses									
Operating expenses for heat production	Thousand SKK/year	17,958	18,497	19,052	19,624	20,212	20,819	21,443	22,086
Operating Expenses for Electric Energy production	Thousand SKK/year	22,385	23,057	23,749	24,461	25,195	25,951	26,729	27,531
Fuel Expenses	Thousand SKK/year	81,676	84,127	86,651	89,250	91,928	94,685	97,526	100,452
Cost for Electric Energy Purchase	Thousand SKK/year	210,202	216,508	223,004	229,694	236,584	243,682	250,992	258,522
Operational Expense Total	Thousand SKK/year	332,222	342,189	352,455	363,028	373,919	385,137	396,691	408,592
Depreciation	Thousand SKK/year	14,027	13,935	13,843	13,791	13,770	11,750	10,844	10,619
Operational Total Cost	Thousand SKK/year	346,249	356,124	366,297	376,819	387,689	396,887	407,535	419,210
Profit Loss before Taxation	Thousand SKK/year	15,452	13,853	16,288	18,724	21,166	24,654	27,072	28,855
Taxation	Thousand SKK/year	2,936	2,632	3,095	3,557	4,021	4,684	5,144	5,482
Accumulated retained earnings	Thousand SKK/year	12,516	23,737	36,931	52,097	69,241	89,211	111,139	134,512

Cash Flow									
Revenues Total	Thousand SKK/year	375,701	386,972	398,582	410,539	422,855	435,541	448,607	462,065
Expenses without depreciation and Interest	Thousand SKK/year	332,222	342,189	352,455	363,028	373,919	385,137	396,691	408,592
Interest	Thousand SKK/year	0	2,996	1,996	996	0	0	0	0
Payment	Thousand SKK/year	0	20,000	20,000	19,919	0	0	0	0
Income tax	Thousand SKK/year	2,936	2,632	3,095	3,557	4,021	4,684	5,144	5,482
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	26,543	5,155	7,036	9,038	30,915	31,720	32,773	33,991
	year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative Balance of Accounting Period	**Thousand SKK/year**	**26,543**	**31,698**	**38,735**	**47,773**	**78,687**	**110,407**	**143,179**	**177,171**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**25,279**	**28,751**	**33,461**	**39,303**	**61,653**	**82,387**	**101,755**	**119,916**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The solar panels may be regarded as a good proposal but the investment to the solar panels is relatively high; however, low when compared with the other alternatives. The main problem with the solar panels is the high volatility of these devices. The advantages and disadvantages are summarized below.

Advantages

- Energy from the sun "for free".

Disadvantages

- Without any benefits accruing from the combined production.
- Without the possibility to regulate the electric energy consumption.
- Low-potential heat- necessarily to reconstruct devices and facilities on the side of heat consumption.
- High investment intensity without guarantee of source sustainability and temperature.
- Source of volatility, the differing performance in the summer and winter (the length of sunlight, the angle of incidence of sunlight, clouds).

*6.2.6. **Alternative N. 5: Cogeneration with Gas Engines***

The alternative N.5 includes the cogeneration with gas engines. The argument for this proposal is that the cogeneration is a technique used for maximizing the energy efficiency. The energy efficiency is the set of techniques that are applied to improve the performance of any industrial facility. The use of gas engines for the purpose of the cogeneration is the level of convenience within a range of fuels. The least polluting and allowing generation systems are the most modern and efficient. It also ensures the viability of the operations to be a very clean.

In this arrangement a compressor of high pressure air fed to a combustion chamber where fuel is injected, and so generates gases when burned at high temperature and pressure. Subsequently, the gases in turn fed to the turbine where they expand generating mechanical energy, which is transformed into electricity through a generator coupled to the turbine shaft.

The configuration for the arrangement of the cogeneration inside of Chemosvit Group a.s. is explained in the next Figure 6.18.

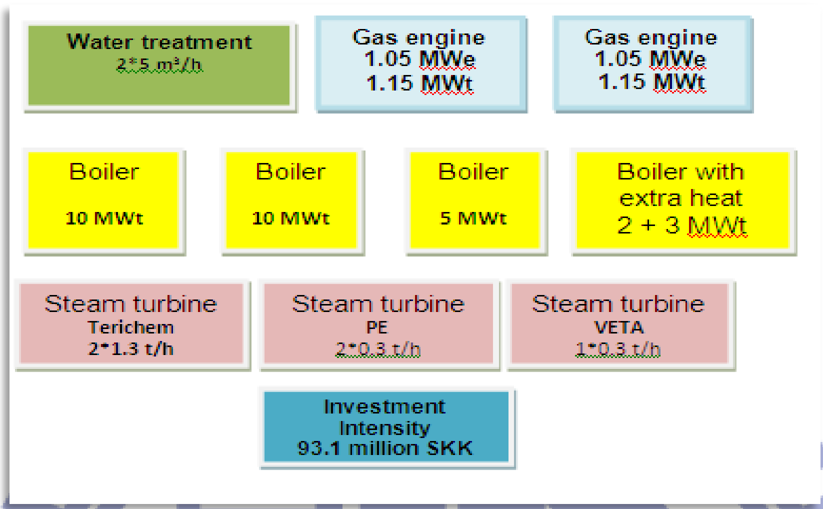


Figure 6.18: The Nominal Value of Power Plan: Alternative N.5

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The level of investment intensity is 93.1 million SKK, but presumably the system will improve the efficiency of the generation of heat for the Chemosvit Group a.s. The following Figure 6.19 shows the layout of the cogeneration with gas engines, meanwhile in the next Figure 6.20 the layout of the configuration of the motors and boilers is depicted in detail.

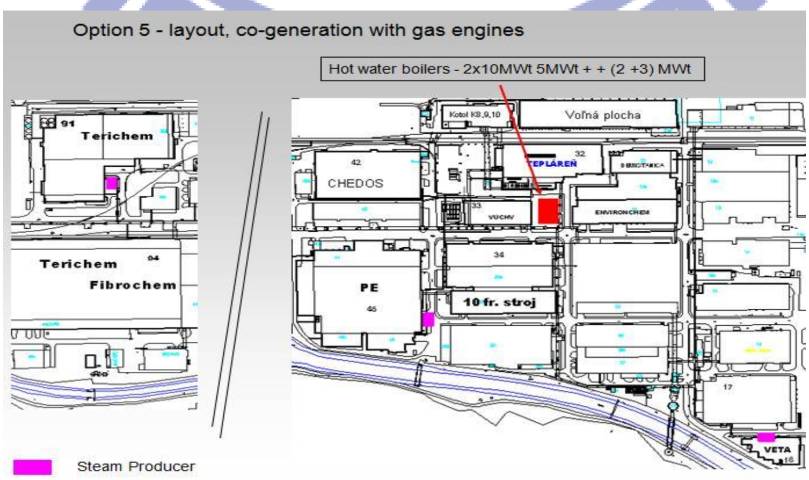


Figure 6.19: Configuration for the Installation of the Cogeneration with Gas Engines

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

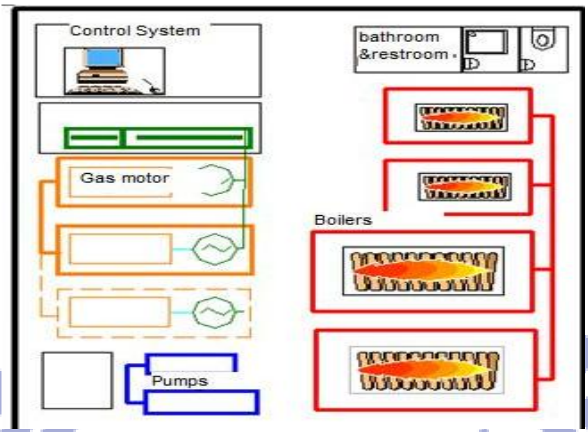


Figure 6.20:. Detailed Layout of the Cogeneration with Gas Engines

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The central heat and power cogeneration can achieve an energy efficiency of around 90%. The procedure is more environmentally friendly, as during the combustion of natural gas less carbon dioxide (CO2) and nitrogen oxide (NOx), after that oil or coal is released. The breakdown of the investment and the cost, revenues and cash flow analysis are shown in next Tables 6.11 and 6.12.

Table 6.11.: Breakdown of Necessary Investment for Alternative N. 5

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ∘C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ∘C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ∘C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	2X1 MW	42,000,000	4,200,000	46,200,000
12	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
13	Chimney				1,000,000	100,000	1,100,000
14	Other accessories &				5,000,000	500,000	5,500,000
15	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					70,700,000	7,070,000	77,770,000
Investment Together					76,920,000	7,692,000	84,612,000
Total Investment with 10% of reserve							**93,073,200**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.12.: The Costs, Revenues and Cash Flow of Alternative N. 5

Cogeneration Gas motors	**Unit**	**1 year**	**2 year**	**3 year**	**4 year**	**5 year**	**6 year**	**7 year**	**8 year**
Investment Expenses	Thousand SKK	93,073							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	125,985	129,765	133,658	137,667	141,797	146,051	150,433	154,946
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**377,085**	**388,398**	**400,050**	**412,051**	**424,413**	**437,145**	**450,259**	**463,767**

Operating Expenses									
Operating expenses for heat production	Thousand SKK/year	19,958	20,557	21,174	21,809	22,463	23,137	23,831	24,546
Operating Expenses for Electric Energy production	Thousand SKK/year	26,985	27,795	28,629	29,488	30,372	31,283	32,222	33,189
Fuel Expenses	Thousand SKK/year	104,353	107,484	110,708	114,029	117,450	120,974	124,603	128,341
Cost for Electric Energy	Thousand SKK/year	166,683	171,684	176,835	182,140	187,604	193,232	199,029	205,000
Operational Expense Total	Thousand SKK/year	317,980	327,520	337,345	347,465	357,889	368,626	379,685	391,075
Depreciation	Thousand SKK/year	18,171	18,079	17,987	17,935	17,915	15,894	14,988	14,763
Operational Total Cost	Thousand SKK/year	336,151	345,598	355,332	365,401	375,804	384,520	394,673	405,838
Profit Loss before Taxation	Thousand SKK/year	26,934	24,146	27,064	29,997	32,955	37,971	41,586	43,929
Taxation	Thousand SKK/year	5,117	4,588	5,142	5,699	6,261	7,215	7,901	8,347
Accumulated retained	Thousand SKK/year	21,817	41,375	63,296	87,594	114,287	145,044	178,729	214,311

Cash Flow									
Revenues Total	Thousand SKK/year	377,085	388,398	400,050	412,051	424.413	437,145	450,259	463,767
Expenses without depreciation and	Thousand SKK/year	317,980	327,520	337,345	347,465	357,889	368,626	379,685	391,075
Interest	Thousand SKK/year	0	4,654	3,654	2,654	1,654	654	0	0
Payment	Thousand SKK/year	0	20,000	20,000	20,000	20,000	13,073	0	0
Income tax	Thousand SKK/year	5,117	4,588	5,142	5,699	6,261	7,215	7,901	8,347
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	39,988	17,637	19,909	2,223	24,608	33,578	48,673	50,345
	year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative Balance of Accounting Period	**Thousand SKK/year**	**39,988**	**57,624**	**77,533**	**99,766**	**124,374**	**157,951**	**206,624**	**256,970**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**38,084**	**52,267**	**66,976**	**82,078**	**97,450**	**117,865**	**146,844**	**173,927**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The alternative N.5 shows that the required investment significantly large, but in the long run the cumulative balance is more efficient than the balance of all the previous alternatives. The efficiency of the cogeneration depends mainly in the configuration of the cogeneration. After analyzing the pros and contras of the alternatives N.5, it was found that the only disadvantage is the high investment intensity, which is diminished by the long-run profitability. The advantages and disadvantages are summarized below.

Advantages

- Own electric energy production.
- Partial dependence.
- Effective energy production in cogeneration.
- Small space requirement - the possibility of building on Greenfield.
- Without the need for upgrading facilities for the consumption of heat.

Disadvantages

- Investment intensity.

*6.2.7. **Alternative N. 6: Cogeneration with Steam Turbine***

As stated before, the cogeneration looks like a good option for the needs of the company, not only because of the increase in the efficiency of the energy, but also it does not need a big upgrade of the installations of Chemosvit Group a.s. On the basis of this the last alternative proposed is the cogeneration with steam turbine.

In this configuration the mechanical energy is produced in a turbine coupled to an electric generator, through the expansion of high pressure steam generated in a conventional boiler. In this system the overall efficiency is around 85% to 90% and the power of 20% to 25%. The configuration of this proposal is shown in the next Figure 6.21.

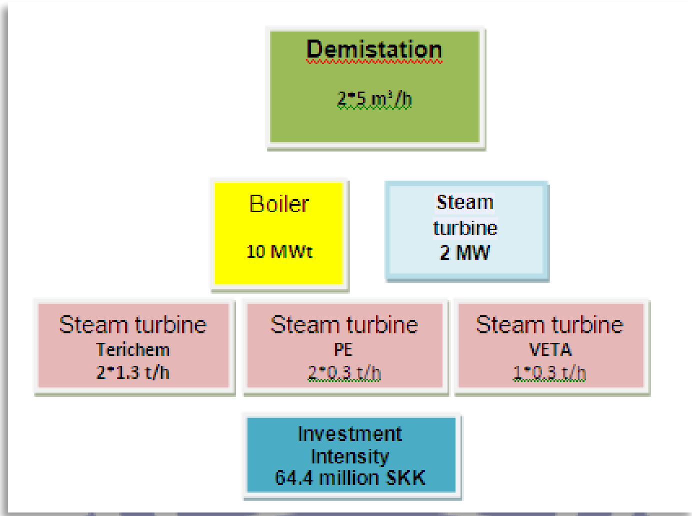


Figure 6.21: The Nominal Value of Power Plan: Alternative N.6

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The investment intensity for this kind of cogeneration is 64.4 million SKK, which is 28.7 million SKK less than the cogeneration with gas engines. The main reason for this is that less boilers are used and those are replaced by a steam turbine. As can be seen in the next Figure 6.22, (which shows the disposition for the installation of this alternative) a big place for the installation of the turbine is not required. This also makes this alternative greatly attractive.

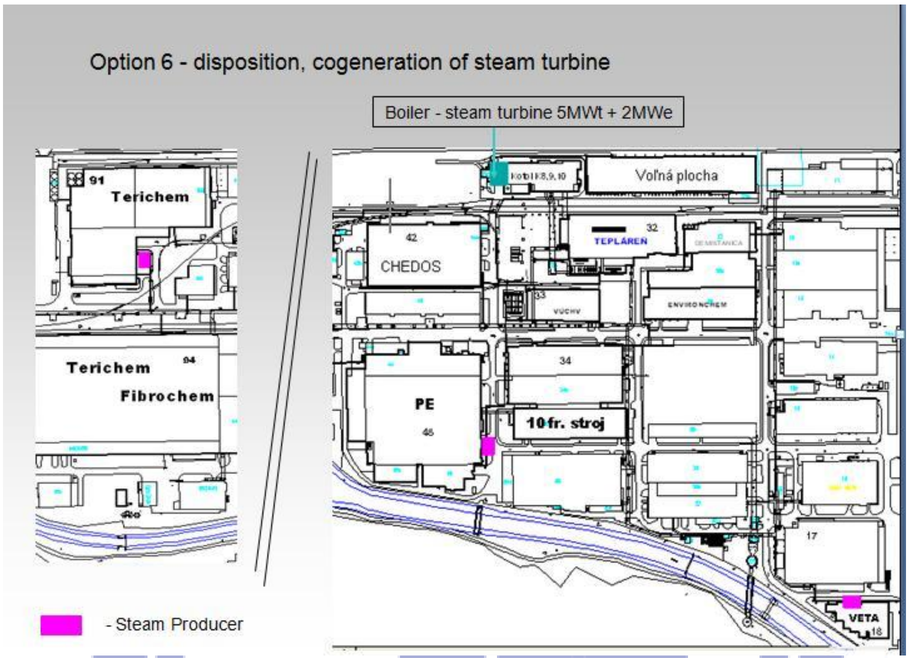


Figure 6.22: Configuration for the Installation of the Cogeneration with Steam Turbine

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Following Tables 6.13 and 6.14 show the analysis of the breakdown of investment and costs, revenues and cash flow analysis for alternative N.6 respectively.

Table 6.13.: Breakdown of Necessary Investment for Alternative N. 6

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
9	Distributors switcher	Obj 32.	Energochem		800,000	80,000	880,000
10	Exchange station	Obj 31.	Energochem	2*12 MW+	5,500,000	550,000	6,050,000
11	Extention building	Obj 31.	Energochem		2,000,000	200,000	2,200,000
12	Pipeline bridge	Obj 32.	Energochem		2,800,000	280,000	3,080,000
13	Pipeline bridge 130 ◦ C water	Obj 31-34	Energochem		300,000	30,000	330,000
14	Demistation	Obj 31.	Energochem	10 m^3/h	5,000,000	500,000	5,500,000
15	Steam turbine	Obj 31.	Energochem	2 MW	20,000,000	2,000,000	22,000,000
16	Electro devices	Obj 31	Energochem		5,000,000	500,000	5,500,000
15	Regulation System (Control)				3,000,000	300,000	3,300,000
Other Devices Total					47,000,000	4,700,000	51,700,000
Investment Together					53,220,000	5,322,000	58,542,000
Total Investment with 10% of reserve							**64,396,200**

**All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.14.: The Costs, Revenues and Cash Flow of Alternative N. 6

Cogeneration Steam turbine	**Unit**	**1 year**	**2 year**	**3 year**	**4 year**	**5 year**	**6 year**	**7 year**	**8 year**
Investment Expenses	Thousand SKK	64,396							
Operational Revenue									
Revenue from heat production	Thousand SKK/year	136,792	140,895	145,122	149,476	153,960	158,579	163,336	168.236
Revenue from Electric Energy production	Thousand SKK/year	251,100	258,633	266,392	274,384	282,615	291,094	299,827	308,821
Operational Profit Total	**Thousand SKK/year**	**387,892**	**399,528**	**411,514**	**423,860**	**436,575**	**449,673**	**463,163**	**477,058**
Operating Expenses									
Operating expenses for heat	Thousand SKK/year	17,958	18,497	19,052	19,624	20,212	20,819	21,443	22,086
Operating Expenses for Electric Energy	Thousand SKK/year	24,985	25,735	26,507	27,302	28,121	28,965	29,834	30,729
Fuel Expenses	Thousand SKK/year	105,347	108,508	111,763	115,116	118,569	122,126	125,790	129,564
Cost for Electric Energy Purchase	Thousand SKK/year	195,075	200,927	206,955	213,164	219,559	226,145	232,930	239,918
Operational Expense Total	Thousand SKK/year	343,366	353,667	364,277	375,205	386,461	398,055	409,997	422,297
Depreciation	Thousand SKK/year	14,586	14,494	14,402	14,351	14,330	12,309	11,404	11,178
Operational Total Cost	Thousand SKK/year	357,952	368,161	378,679	389,556	400,791	410,365	421,401	433,475
Profit Loss before Taxation	Thousand SKK/year	15,939	14,147	16,615	19,084	21,564	25,308	27,762	29,583
Taxation	Thousand SKK/year	3,028	2,688	3,157	3,626	4,097	4,809	5,275	5,621
Accumulated retained earnings	Thousand SKK/year	12,911	24,370	37,829	53,286	70,754	91,253	113,740	137,702
Cash Flow									
Revenues Total	Thousand SKK/year	387,892	399,528	411,514	423,860	436,575	449,673	463,163	477,058
Expenses without depreciation and Interest	Thousand SKK/year	343,366	353,667	364,277	375,205	386,461	398,055	409,997	422,297
Interest	Thousand SKK/year	0	3,220	2,220	1,220	220	0	0	0
Payment	Thousand SKK/year	0	20,000	20,000	20,000	4,396			
Income tax	Thousand SKK/year	3,028	2,688	3,157	3,626	4,097	4,809	5,275	5,621
Commercial lease	Thousand SKK/year	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Balance for cash flow	Thousand SKK/year	**27,497**	**5,954**	**7,861**	**9,809**	**27,401**	**32,809**	**33,891**	**35,140**
	year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative Balance of Accounting Period	**Thousand SKK/year**	**28,497**	**33,451**	**41,311**	**51,120**	**78,521**	**111,330**	**125,221**	**180,361**
Cummulative Balance of Discounted Cash Flow	**Thousand SKK/year**	**27,140**	**30,341**	**35,686**	**42,057**	**61,523**	**83,076**	**88,992**	**122,075**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

After analyzing the cumulative balance and the table of cost and revenues, this option may be significantly attractive for the investment decision. Thus, the other kind of cogeneration seems to be even better. The advantages and disadvantages of this alternative are summarized as below.

Advantages

- Producing energy creates certain independence.
- The production of energy by cogeneration is really efficient.
- Use of existing facilities and buildings.
- Without the need for upgrading facilities for the consumption of heat.

Disadvantages

- Higher investment intensity
- High own consumption of heat in the production of superheated steam

6.3. **Selecting the Alternative**

The process for selecting the best alternative of the 6 options proposed above was based on the analysis of the cumulative balance of cash flow for 8-year period calculated individually for each alternative. This analysis, as shown in the next Figure 6.23, revealed the results that in the long run the alternative of cogeneration with gas motors is much more profitable than the other five options.

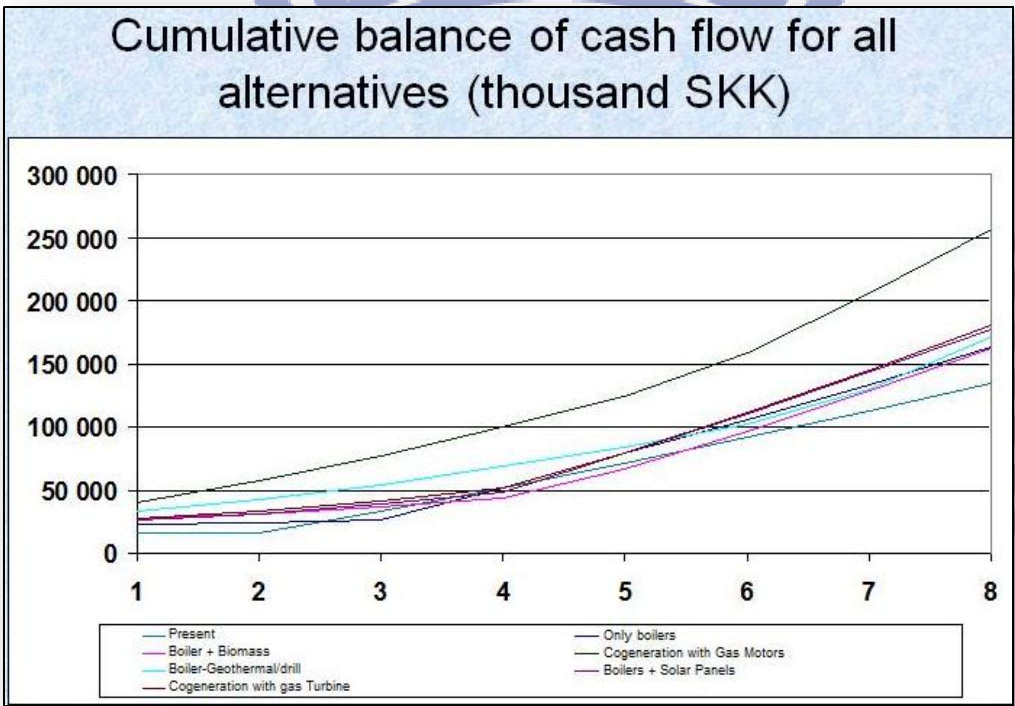


Figure 6.23: Cumulative Balance of Cash Flow for All Alternatives

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

To support the results of this cumulative balance of cash flow for all alternatives, an analysis of the payback period was also conducted. The literature review of this thesis describes in more detail the requirement for another measurement indicator to avoid any inaccuracy in selection of the alternative for the investment decision. In the practice, the payback method is often used to support the decision-makers. This measurement was selected as complementary source of information for conducting the choice of alternative, mostly due to the personal requirements of the Chairman of the Board of Directors of Chemosvit Energochem a.s., Ing. Vladimir Balog, which would like to obtain more viable information about the alternatives prior to taking the decision in winter 2010. The internal analysists use various other measurement to evaluate the alternatives such as net present value or internal rate of return, which is the reason these measurements are not conducted in the thesis to avoid the duplicity of information supplied to the management of Chemosvit Energochem a.s. The payback periods were calculated for all alternatives described in previous section and are presented in the Table 6.15.

Table 6.15.: Payback Period for All Alternatives

Alternative	Return on Investment
Present	*Years*
Only Boilers	4
Boilers+Biomass	6
Boilers+Geothermal drill	8
Boilers+Solar Energy	5
Cogeneration with gas motors 2X1 MW	5
Cogeneration with Gas turbine	5

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

From the results of payback method and the cumulative balances of cash flow for all alternatives, the best alternative was chosen taking into consideration the long run of 8-year period. Even if the payback method does not suggest the best alternative to be cogeneration with gas motors, it seems to be the most preferable for longer period of time. The payback method is often criticized in the literature that it ignores the cash flows from investment beyond the payback period. The payback period of cogeneration with gas motors is indeed longer than the first alternative presented in the Table 6.15, thus, even if the 4 years of payback look attractive at the first sight, in the long run they are actually less profitable and more pollutant.

The cogeneration with gas engines is the alternative, which may be the most preferable for the energy production in Chemosvit Energochem a.s. However, this alternative has various modifications and within such cogeneration exist several types of configuration that should be considered. For example, the cogeneration with two gas engines of 1 MW, or two gas engines (1 of 2 MW and another with 1MW). In the next section of this chapter, 6.4, I propose complementary 6 configurations of cogeneration with gas engines, in which the every single proposal is analyzed as in the text above.

6.4. **Six Different Configurations of Cogeneration with Gas Engines**

The cogeneration is the process that simultaneously produces electricity (or mechanical energy) and thermal energy from fuel. The cogeneration systems vary among each other, and so it is required to compare various types of configuration with gas motors. Consequently, the best configuration is chosen.

The proposed modifications of the cogeneration with gas engines are as follows:

- 2 x 1 MW = 2 MW (Two motos of 1 MW)
- 2 + 1 MW = 3 MW (1 motor of 2 MW and 1 motor of 1 MW)
- 2 x 2 MW = 4 MW (2 motors of 2 MW)
- 2 x 2 + 1 MW = 5 MW (2 motors of 2MW and 1 of 1 MW)
- 3 x 2 MW = 6 MW (3 motors of 2 MW)
- 5 x 2 MW = 10 MW (5 motors of 2 MW)

For analyzing purposes the cost of the investment for these 6 options were calculated similarly to the calculations conducted for all other alternatives. In the following 6 Tables 6.16 – 6.21 the calculations of the breakdown of investment for every single configuration are depicted.

Table 6.16: The Configuration C.5.1 - 2 x 1 MW

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operation	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ∘ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ∘ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ∘ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	2X1 MW	42,000,000	4,200,000	46,200,000
12	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
13	Chimney				1,000,000	100,000	1,100,000
14	Other accessories &				1,000,000	100,000	1,100,000
15	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					70,700,000	7,070,000	77,770,000
Investment Together					76,920,000	7,692,000	84,612,000
Total Investment with 10% of reserve							**93,073,200**

******All prices are in SKK (Slovak Crown)*

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.17: The Configuration C.5.2 – 2 + 1 MW

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operations	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ∘ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ∘ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ∘ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	2 MW	37,200,000	3,720,000	40,920,000
12	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	1 MW	21,000,000	2,100,000	23,100,000
13	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
14	Chimney				1,000,000	100,000	1,100,000
15	Other accessories &				1,000,000	100,000	1,100,000
16	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					86,900,000	8,690,000	95,590,000
Investment Together					93,120,000	9,312,000	102,432,000
Total Investment with 10% of reserve							**112,675,200**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.18.: The Configuration C.5.3 – 2 x 2 MW

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operation	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	2 x 2 MW	75,600,000	7,560,000	83,160,000
12	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
13	Chimney				1,000,000	100,000	1,100,000
14	Other accessories &				1,000,000	100,000	1,100,000
15	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					104,300,000	10,430,000	114,730,000
Investment Together					110,520,000	11,052,000	121,572,000
Total Investment with 10% of reserve							**133,729,200**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.19: The Configuration C.5.4 – 2 x 2 + 1 MW

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operation	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	2 x 2 + 1 MW	93,100,000	9,310,000	102,410,000
12	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
13	Chimney				1,000,000	100,000	1,100,000
14	Other accessories &				1,000,000	100,000	1,100,000
15	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					121,800,000	12,180,000	133,980,000
Investment Together					128,020,000	12,802,000	140,822,000
Total Investment with 10% of reserve							**154,904,200**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.20: The Configuration C.5.5 – 3 x 2 MW

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operation	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	3 x 2 MW	111,600,000	11,160,000	122,760,000
12	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
13	Chimney				1,000,000	100,000	1,100,000
14	Other accessories &				1,000,000	100,000	1,100,000
15	Regulation System				5,000,000	500,000	5,500,000
Other Devices Total					140,300,000	14,030,000	154,330,000
Investment Together					146,520,000	14,652,000	161,172,000
Total Investment with 10% of reserve							**177,289,200**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.21: The Configuration C.5.6 – 5 x 2 MW

	Device Name	Property	Company	Technical Parameters	Facilities	Other Operation	Total
1	Stem Generator, gas, pipeline, construction part	Obj 91	Terichem	2X1. 3 t/h, 2 Mpa, 210 ◦ C	3,710,000	371,000	4,081,000
2	Stem Generator, gas, pipeline, construction part	Obj. 45	PE	2X0. 3 t/h, 0.9 Mpa, 180 ◦ C	1,710,000	171,000	1,881,000
3	Stem Generator, gas, pipeline, construction part	Obj 18.	VETA	1X0.3 t/h, 0.4 Mpa 140 ◦ C	800,000	80,000	880,000
Steam Generators Total					**6,220,000**	**622,000**	**6,842,000**
	Device Name	**Property**	**Company**	**Technical Parameters**	**Facilities**	**Other Operations**	**Total**
4	Pipeline	Obj. 32	Energochem	K HV Boiler	600,000	60,000	660,000
5	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
6	Gas Boilers	Obj 32.	Energochem	10 MW	5,000,000	500,000	5,500,000
7	Gas Boilers	Obj.32	Energochem	5 MW	2,600,000	260,000	2,860,000
8	New Device	Obj. 32.	Energochem		2,000,000	200,000	2,200,000
9	Pump Displacement	Obj 32.	Energochem		500,000	50,000	550,000
10	Electro Devices	Obj 32	Energochem		5,000,000	500,000	5,500,000
11	Gas Motor+ Generator + Combustion Engine	Obj 32.	Energochem	5 x 2 MW	186,000,000	18,600,000	204,600,000
12	Burner to combustion			3 MW	1,000,000	100,000	1,100,000
13	Chimney				1,000,000	100,000	1,100,000
14	Other accessories &				1,000,000	100,000	1,100,000
15	Regulation System				7,000,000	700,000	7,700,000
Other Devices Total					216,700,000	21,670,000	238,370,000
Investment Together					222,920,000	22,292,000	245,212,000
Total Investment with 10% of reserve							**269,744,200**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Summary of the investment intensity for the configurations 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 of cogeneration with gas engines are presented below.

Investment performance

1. ***2 x 1 MW - 93,1 million SSK***
2. 2 + 1 MW - 112,7 million SSK
3. 2 x 2 MW - 133,7 million SSK
4. 2 x 2+ 1 MW - 154,9 million SSK
5. 3 x 2 MW - 177,3 million SSK
6. 5 x 2 MW – 269,7 million SSK

From the results obtained in the cost breakdown analysis for each configuration, it can be seen that the lowest investment requirement possesses the cogeneration with 2 motors with 1 MW each. However, the amount of investment does not supply enough information to proceed with the decision about the choice of alternative, which is the main reason to conduct further analysis and develop the cumulative balance of cash flow for all six configuration presented in the Table 6.22 below. It is assumed that the selling price of MWh remains constant of 3100 SKK/ MWh and the electricity price will grow by 3 % in the first year.

Table 6.22: Comparison of the Cumulative Balance of Discounted Cash Flow for 8-Year Period with the Amount of Investment and the Return on Investment for All Configurations of Alternative N. 5

	1	2	3	4	5	6	7	8	Investment	Return on Investment
Cogeneration with gas motors 2X1 MW	37,699	46,989	57,435	68,847	86,479	117,219	145,886	172,678	93,073	6
Cogeneration with gas motors 2+1 MW	44,047	58,529	73,824	89,759	106,179	131,850	165,412	196,751	112,675	6
Cogeneration with gas motors 2X2 MW	49,714	68,698	88,200	108,061	128,139	148,019	179,338	214,889	**133,729**	**6**
Cogeneration with gas motors 2X2+1 MW	55,221	78,553	102,117	125,769	149,382	172,552	195,366	231,404	154,904	6
Cogeneration with gas motors 3X2 MW	59,811	86,591	113,379	140,041	166,462	192,250	217,498	240,503	177,289	6
Cogeneration with gas motors 5X2 MW	76,047	100,919	126,864	153,622	180,955	208,365	235,847	270,090	269,73	8

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

After conducting the calculations and presenting the results, it can be observed that the cogeneration with 2 motors of 2 MW each is the best alternative among the 6 configurations of cogeneration with gas engines. The result is concluded on the basis of comparison of the amount of investment with the long run cumulative balance of cash flow at the 8th year of operations.

Finally, the basic indicators for all the alternatives are analyzed, assuming the same selling price of electric energy (3,100 SKK/MWh) and an increase of electric energy per year by 3%. The parameters will be varied because of the volatility of the electric market. Therefore, the price increase of electric energy varies from 3% to 10%. The analysis takes into consideration further factors: investment cost, amount of natural gas used, price of natural gas, amount of heat from alternative source, share of heat from alternative heat, amount of heat sold, price of the heat sold, amount of produced electric energy, share from total amount, price of produced electric energy, amount of energy, price of purchased electric energy, price of produced and purchased energy, total amount of electric energy, price of electric energy sold, depreciation and the calculated cumulative balance of cash flow for 8-year period. All of these indicators are shown in the following Tables 6.23 and 6.24 incorporating all of the alternatives with the variation of electric energy price increase during the first year by 3% and 10%.

Table 6.23.: Overview of Basic Indicators for All Alternatives with 3% of Price Increase

1 year	Alternatives	0	1	2	3	4	5.1 2X1MW	5.2 2+1MW	5.3 2X2MW	5.4 2X2+1MW	5.5 3X2MW	5.6 5X2MW	6
Investment Cost	Thousand SSK	31,242	41,890	68,026	112,312	59,919	93,073	112,675	**113,729**	154,904	177,289	269,733	64,396
Amount of Natural Gas	m^3	12,564,626	9,419,952	6,298,473	8,998,316	9,099,773	11,799,472	12,537,058	**13,166,609**	13,818,017	14,327,331	16,184,486	11,973,437
Price of Natural Gas	Sk/m^3	8.76	8.94	9.14	8.96	8.98	8.8	8.78	**8.77**	8.76	8.75	8.75	8.8
Amount of heat from Alternative	GJ	0	0	115,884	18,792	15,660	0	0	**0**	0	0	0	0
Share of heat from Alternative heat	GJ	0	0	48.3	7.8	6.5	0	0	**0**	0	0	0	0
Amount of heat sold	GJ	240,000	240,000	240,000	240,000	240,000	240,000	240,000	**240,000**	240,000	240,000	240,000	240,000
Price of heat sold	Sk/GJ	559	529	495	542	519	525	525	**525**	525	525	525	570
Amount of produced electric energy	MWh	6,000	0	0	0	0	16,965	22,770	**27,793**	32,825	36,856	51,357	7,500
Share from total amount	%	7.1	0	0	0	0	20.5	27.5	**33.5**	39.6	44.4	61.9	8.9
Price of produces Electric Energy	Sk/MWh	1,532	0	0	0	0	1,176	1,114	**1,083**	1,099	1,081	1,086	1,155
Amount of Energy	MWh	78,000	82,920	82,920	82,920	82,920	65,955	60,150	**55,127**	50,095	46,064	31,563	76,500
Price of purchased Electric Energy	Sk/MWh	2,545	5,535	5,535	5,535	5,535	5,542	2,540	**2,534**	2,528	2,517	2,453	2,550
Price of produced and purchased energy	Sk/Mwh	2,473	2,535	2,535	2,535	2,535	2,263	2,148	**2,048**	1,962	1,879	1,607	2,425
Total Amount of El. Energy	MWh	84,000	82,920	82,920	82,920	82,920	82,920	82,920	**82,920**	82,920	82,920	82,920	84,000
Price of El. Energy sold	Sk/MWh	3,100	3,100	3,100	3,100	3,100	3,100	3,100	**3,100**	3,100	3,100	3,100	3,100
Depreciation	Thousand SKK	10,442	11,773	15,040	20,576	14,027	18,171	20,621	**23,253**	25,900	28,698	40,254	14,586
Cumulative Balanace of Cash Flow for 8 years	Thousand SKK	79,027	157,367	209,890	144,029	186,498	255,124	290,691	**317,489**	341,889	355,333	399,046	108,389

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Table 6.24.: Overview of Basic Indicators for All Alternatives with 10% of Price Increase

1 year	Alternatives	0	1	2	3	4	5.1	5.2	5.3	5.4	5.5	5.6	6
							2X1MW	2+1MW	2X2MW	2X2+1MW	3X2MW	5X2MW	
Investment Cost	Thousand SSK	31,242	41,890	68,026	11,312	59,919	93,073	112,675	**133,729**	154,904	177,289	269,733	64,396
Amount of Natural Gas	m^3	12,564,626	9,419,952	6,298,473	8,998,316	9,099,773	11,799,472	12,537,058	**13,166,609**	13,818,017	14,327,331	16,184,486	11,973,437
Price of Natural Gas	Sk/m^3	8.76	8.94	9.14	8.96	8.98	8.8	8.78	**8.77**	8.76	8.75	8.75	8.8
Amount of heat from Alternative source	GJ	0	0	115,884	18,792	15,660	0	0	**0**	0	0	0	0
Share of heat from Alternative heat	GJ	0	0	48.3	7.8	6.5	0	0	**0**	0	0	0	0
Amount of heat sold	GJ	240,000	240,000	240,000	240,000	240,000	240,000	240,000	**240,000**	240,000	240,000	240,000	240,000
Price of heat sold	Sk/GJ	559	529	495	542	519	525	525	**525**	525	525	525	570
Amount of produced electric energy	MWh	6,000	0	0	0	0	16,965	22,770	**27,793**	32,825	36,856	51,357	7,500
Share from total amount	%	7.1	0	0	0	0	20.5	27.5	**33.5**	39.6	44.4	61.9	8.9
Price of produces Electric Energy	Sk/MWh	1,532	0	0	0	0	1,176	1,114	**1,083**	1,099	1,081	1,086	1,155
Amount of Energy	MWh	78,000	82,920	82,920	82,920	82,920	65,955	60,150	**55,127**	50,095	46,064	31,563	76,500
Price of purchased Electric Energy	Sk/MWh	2,545	5,535	5,535	5,535	5,535	5,542	2,540	**2,534**	2,528	2,517	2,453	2,550
Price of produced and purchased energy	Sk/Mwh	2,473	2,535	2,535	2,535	2,535	2,263	2,148	**2,048**	1,962	1,879	1,607	2,425
Total Amount of El. Energy	MWh	84,000	82,920	82,920	82,920	82,920	82,920	82,920	**82,920**	82,920	82,920	82,920	84,000
Price of El. Energy sold	Sk/MWh	3,100	3,100	3,100	3,100	3,100	3,100	3,100	**3,100**	3,100	3,100	3,100	3,100
Depreciation	Thousand SKK	10,442	11,773	15,040	20,576	14,027	18,171	20,621	**23,253**	25,900	28,698	40,254	14,586
Cumulative Balanace of Cash Flow for 8 years	ThousandSKK	101,876	175,136	227,658	161,797	204,267	291,377	333,406	**365,892**	395,962	414,053	474,502	132,730

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The final results for the cumulative balance of cash flow of 8 years are presented in the next Figures 6.24 and 6.25. This cumulative balance of cash flow will indicate which alternative is more profitable in the long run. The figures graphically summarize the cash flow for 3% and 10% of electric energy price increase in the first year, respectively.

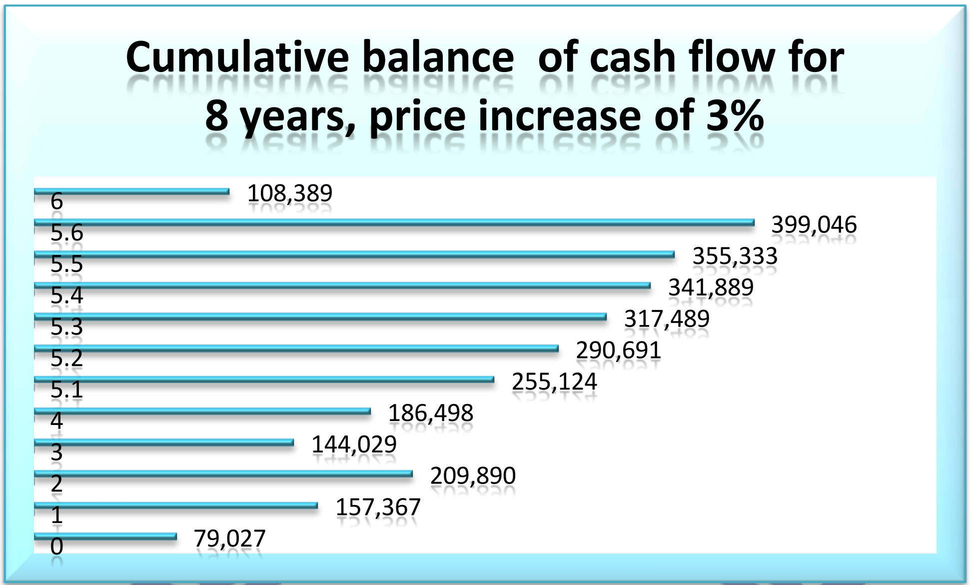


Figure 6.24.: Comparison of the Cumulative Cash Flow for 8 Years for All Alternatives with an Electric Energy Price Increase of 3%

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The above Figure 6.24 shows that in the long run the balance of cash flow is higher under the alternative of cogeneration with gas engines, particularly in the configuration 5.6, which is the cogeneration with 5 motors of gas with 2 MW of capacity each. This scenario assumes of relatively low volatility of the electric price with an increase only of 3% of the energy price per year. The disadvantage 5.6 choice significant investment intensity (269 million SKK) and as the table 6.22 shows the return on investment can be extracted after 8 years. Therefore, under assumption of low price volatility and considering the investment intensity, the most preferable configuration for the generation of the energy is the cogeneration with 2 motors of 2 MW each, or the configuration 5.3. The next Figure 6.25 analyzes the results with a high electric energy price volatility of an increase by 10% per year.

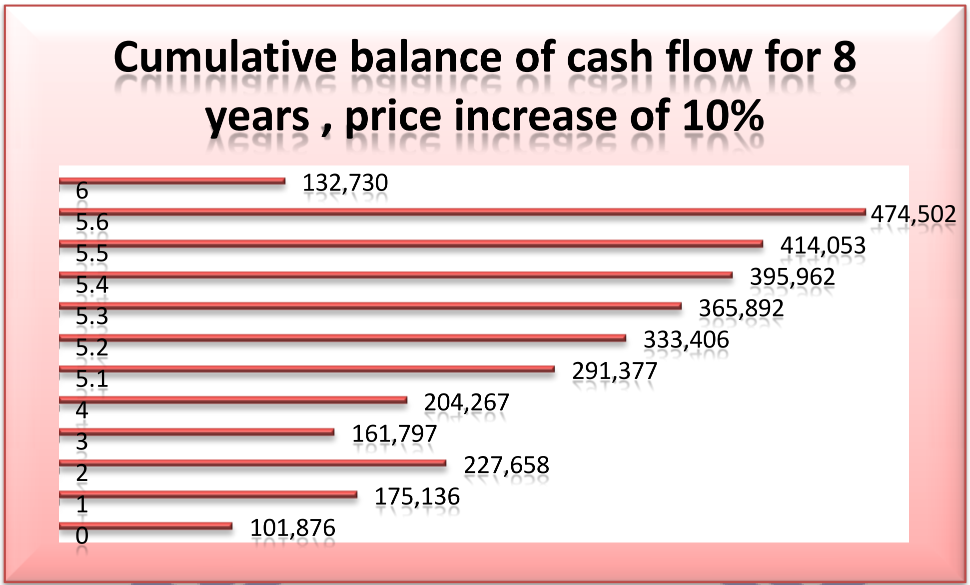


Figure 6.25: Comparison of the Cumulative Balance of Cash Flow for 8-year Period for all Alternatives with an Energy Price Increase of 10%

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The previous figure shows that with a high volatility of electric energy price (10% of increase per year), the configuration 5.6 remains in the long run the best, mostly due to the highest cumulative balance of cash flow. The disadvantage of this configuration is again high investment intensity (269 million SKK) and the longest payback period of 8 years. Consequently, under the assumption of high volatility and considering the investment intensity, the best configuration for the cogeneration of energy is the alternative 5.3, which assumes 2 motors with 2 MW each.

As a conclusion, various methods were used to analyze the investment alternative for cogeneration with gas engines. After comparing the results, the best alternatives to be selected in Chemosvit Energochem a.s. may be the configuration with 2 motors of 2 MW each, which requires the investment of 133.7 million SKK.

Sensitivity Analysis

When making decisions about financial analysis, the sensitivity analysis is a tool in which is analyzed the degree of risk posed by that investment. The sensitivity analysis is a form often used in financial management to visualize immediately the economic advantages and disadvantages of a project.

The main customer for heat and electricity is the Chemosvit Group, buying around 95% of the energy and heat, historically the demand and growth has been steady. For the sensitivity analysis is taken into consideration the following scenarios, taking into account the variation of electricity provided to the town Svit.

Pessimistic:

This is the worst picture of investment, bearing in mind that the town Svit reduces energy consumption.

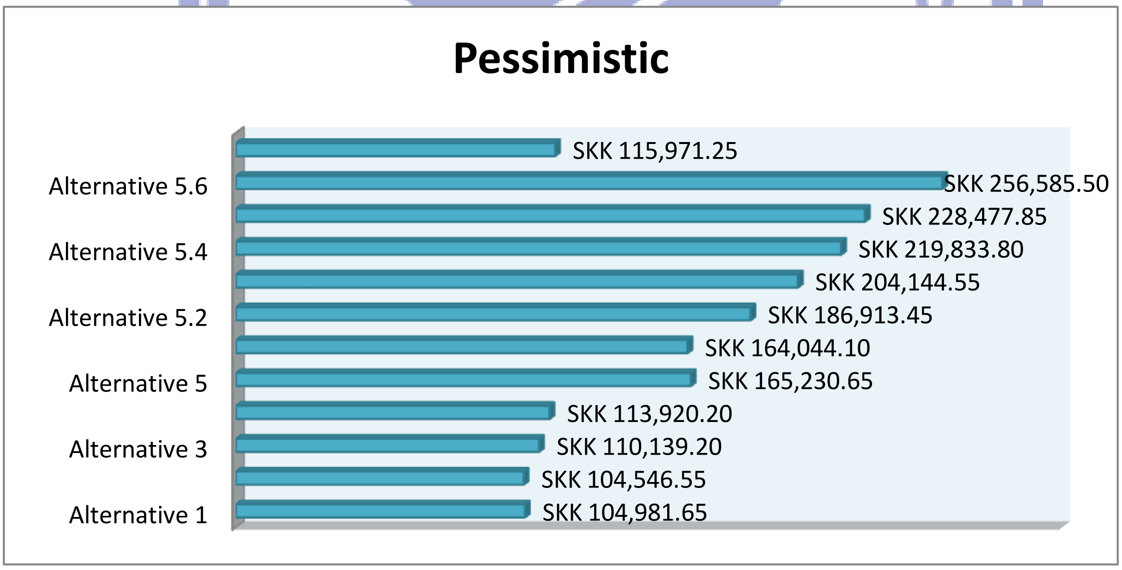


Figure 6.26 Pessimistic scenario of the sensitivity analysis

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Probable:

This would be the most likely would assume the investment analysis which is based on historical data.

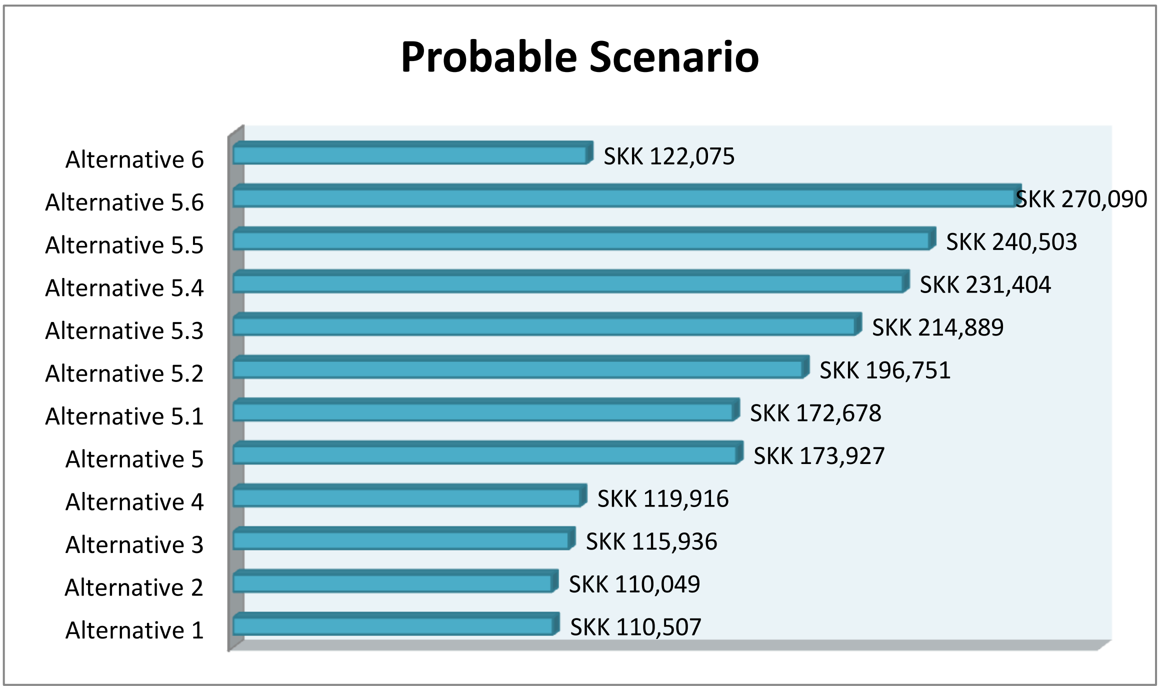


Figure 6.27 Probable scenario of the sensitivity analysis

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Optimistic:

It is possible to achieve more than what we project, taking into account that you can make selling a little more electricity.

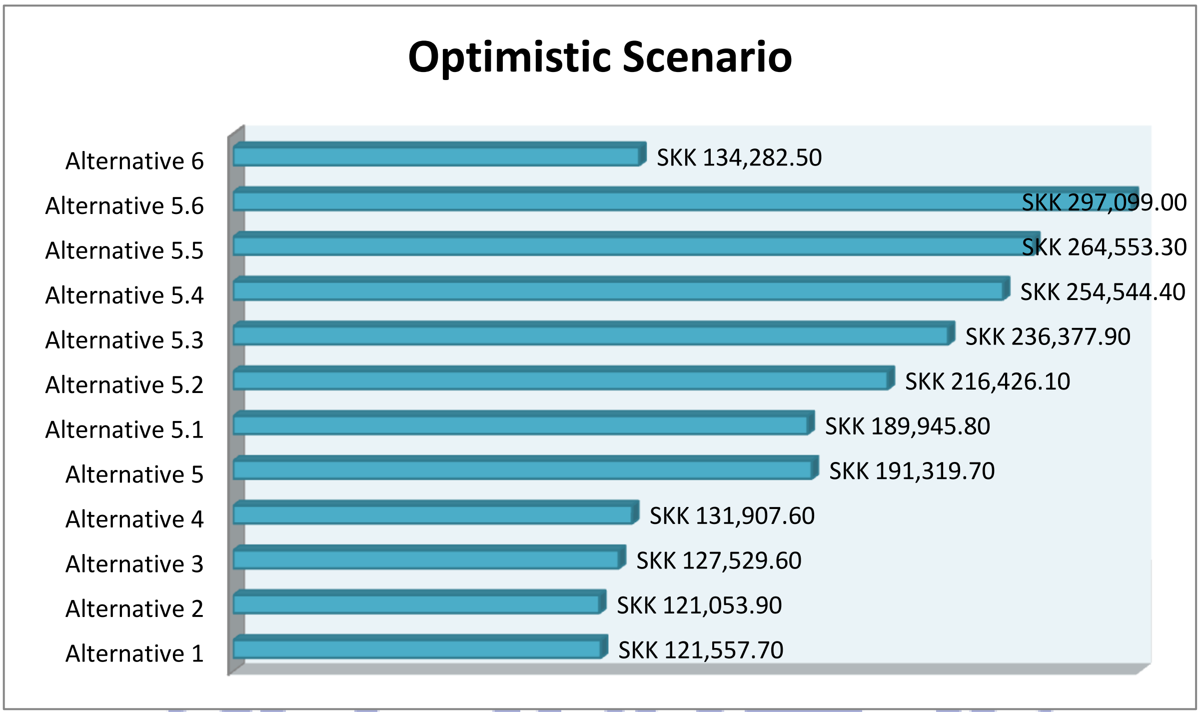


Figure 6.28 Optimistic scenario of the sensitivity analysis

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

CONCLUSIONS

The main purpose of this thesis was to evaluate the selected alternatives of generation of electric energy and heat of *Chemosvit Energochem, a.s.* The study aims to contribute to the investment decision-making process into the new production capacities. The representatives of the firm are determined to choose the most efficient and cost saving alternative in the winter of the year 2010 with consequent investment and realization of the chosen project in the year 2011. The alternatives were selected in the year 2007 considering objectives of sustainable production, environmental protection and the future reduction of emissions. The selected alternatives are as follows:

1 Only Boilers.

2 Boilers + Boilers for Biomass.

3 Boilers + Geothermal Source.

4 Boilers + Solar Energy.

5 Cogeneration with Gas Motors.

5.1 2 x 1 MW = 2 MW (Two motos of 1 MW)

5.2 2 + 1 MW = 3 MW (1 motor of 2 MW and 1 motor of 1 MW)

5.3 2 x 2 MW = 4 MW (2 motors of 2 MW)

5.4 2 x 2 + 1 MW = 5 MW (2 motors of 2MW and 1 of 1 MW)

5.5 3 x 2 MW = 6 MW (3 motors of 2 MW)

5.6 5 x 2 MW = 10 MW (5 motors of 2 MW)

6 Cogeneration with Steam Turbine.

The applied methodology for the evaluation of these alternatives is incorporating several steps preformed for each of the alternatives, starting with the configuration of nominal value of the plan, considering new machinery, installment and equipment requirements, followed by the localization of these facilities inside the area of the enterprise. The information extracted from these outlines enabled calculations of the breakdown of necessary investments. The new establishments, machinery or additional buildings cause a significant variance for the investment intensity of each alternative, which is one of the critical factors for the evaluation. However, to support the analysis of investments required, revenues and expense expected from the projects were further calculated. The initial revenues and expenses were based on the data of *Chemosvit Energochem a.s.* customers in the year 2007, which is the main reason the calculations were performed in the Slovak Crown currency, not in EUR. The tables of revenues and expense were complemented by the cash flow analysis for the consecutive 8-year period, starting with the initial year of investment 2011. To perform such an analysis, assumptions stated in the methodology section and selected by the representatives of Chemosvit Energochem a.s. were taken into consideration.

Thereafter, the cumulative balances of cash flows over the period of 8 years were calculated. To provide more accurate results, further analysis using a payback method was performed and compared with the results from previous cumulative cash flow balances. The initial evaluation of the data revealed apparent results, which were in favor of the alternative incorporating cogeneration with gas engines. This type of cogeneration has, however, variety of configurations and modifications it can be applied to. Consequently, six new configurations were designed incorporating the cogeneration with gas engines. Similarly, the breakdown of investment needs for all six configurations was calculated and compared with the payback period.

To accomplish the final analysis, an overview of the basic indicators for all the alternatives was constructed considering an annual increase of electric energy price by 3% and 10%. The scenario with 3% growth of energy prices represents a low volatility, whereas the scenario with 10% growth represents a high volatility of the energy price. This analysis included various factors influencing the results and an investment decision.

From the cumulative balance of cash flow as stated in the Chapter 6 and shown in the Figures 6.24 and 6.25 it is apparent that in both cases of high and low volatility of the electricity price (3% and 10% of increase per year) the alternative 5.6 was more preferable as the cumulative balance of cash flow allocated the highest amount. Though, there are significant disadvantages of choosing this alternative, such as large investment intensity of 269 million SKK and longest payback period of 4 years evident from payback method analysis. Accordingly, under the conditions of high as well as low volatility considering the investment intensity, the most appropriate alternative to be chosen for the electricity generation is the cogeneration with 2 gas engines with 2 MW each, depicted as alternative 5.3.

As a final conclusion, from 12 alternatives presented in this thesis, the most suitable alternative for *Chemosvit Energochem a.s.* may be the investment decision of 133.7 million SKK into the cogeneration with gas engines, which requires 2 motors with the capacity of 2MW each. The main limitation of this thesis was mainly the lack of time to conduct and accomplish a deeper analysis in each of the proposals and provide so more detailed and relevant results. *Also another limitation was that because of the lack of time the political, environmental were not included in this research,* Several other methods for evaluation of the investment decision can be taken into consideration providing more accurate results. Moreover, the assumptions selected by the company can be subject of further sensitivity analysis. However, the main purpose was to contribute *Chemosvit Energochem a.s.* with evaluation of selected alternatives and so provide them with more information and data prior their final decision. The resulted alternative of cogeneration has potential to support the struggle for the healthier and cleaner environment in the region and sustainability of our planet. The international agreements and environmental treaties are partially effective, however, it is important to develop and implement new greener technologies on the level of individual enterprise and ensure so habitable planet for future generation.

RECOMMENDATIONS

As it has been revised up along the thesis, the best among all alternatives for Chemosvit Group a.s. would be the cogeneration with the 2 gas engines. However, the system can be even more efficient, when the cogeneration combines absorption system and results in trigeneration. The absorption is a process by which cold can be generated from a heat source.

In summer, the heat demand drops considerably, so the heat generated by the cogeneration equipment can be exploited to generate cold for air conditioning necessary at this time. The most commonly used way of cooling is a machine with a compressor plants working with ammonia vapor or other refrigerant. Such a device is an evaporator, compressor, condenser and regulator valve. Basically, it's equivalent of the classic fridge. The cogeneration system can be changed as shown in the Figures 7.1 and 7.2 below.

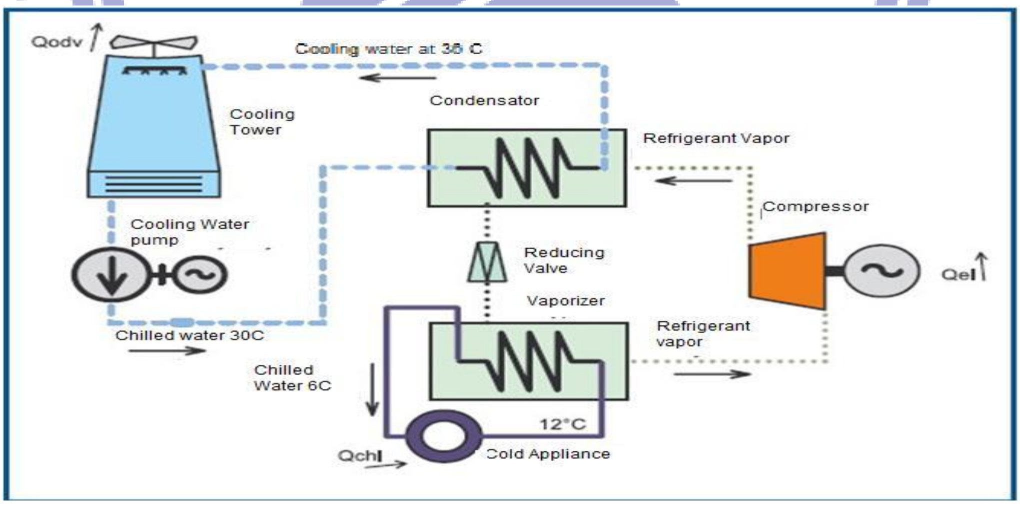


Figure 7.1.: Fundamental Compressor Refrigeration Unit

Source: ASHRAE 2009(American Society of Heating Refrigerating and Air-conditioning Engineers)

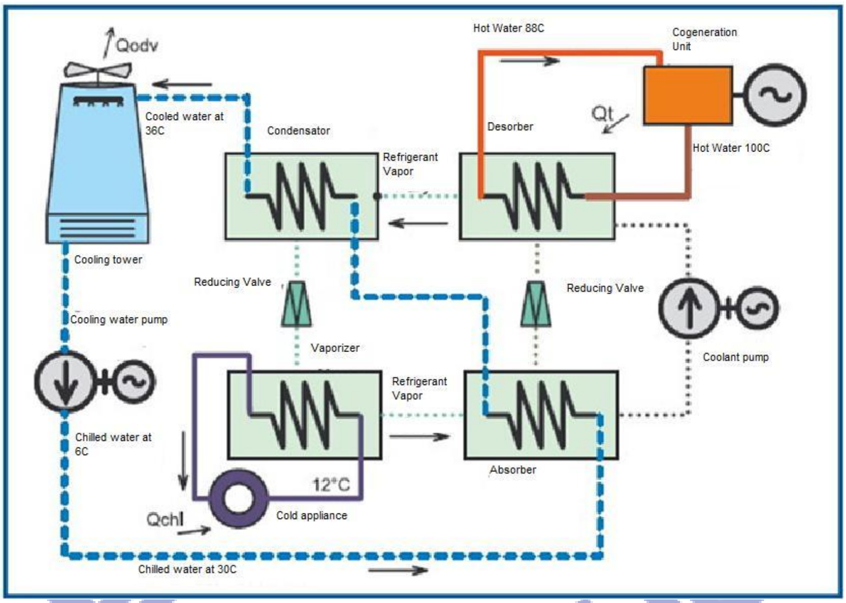


Figure 7.2: Fundamental Refrigeration Absorption Unit

Source: ASHRAE 2009 (American Society of Heating Refrigerating and Air-conditioning Engineers)

Following section is providing the information to justify my recommendation of trigeneration. Currently, Chemosvit Group a.s. needs a technology at various subsidiaries to produce cold. The cogeneration is the combined production of electricity and heat, in our case based on gas engines. Efficient production of electric energy depends on the heat, as well as on climatic conditions and is seasonal in nature. The summer in the region is relatively hot; therefore, the full potential of the proposed installed capacity for the 2 cogeneration gas motors will not be used effectively. The Figures 7.3 and 7.4 show that during the summer months the cogeneration is not used at full capacity, which is the reason why the efficiency of the proposed cogeneration can be improved applying a trigeneration system.

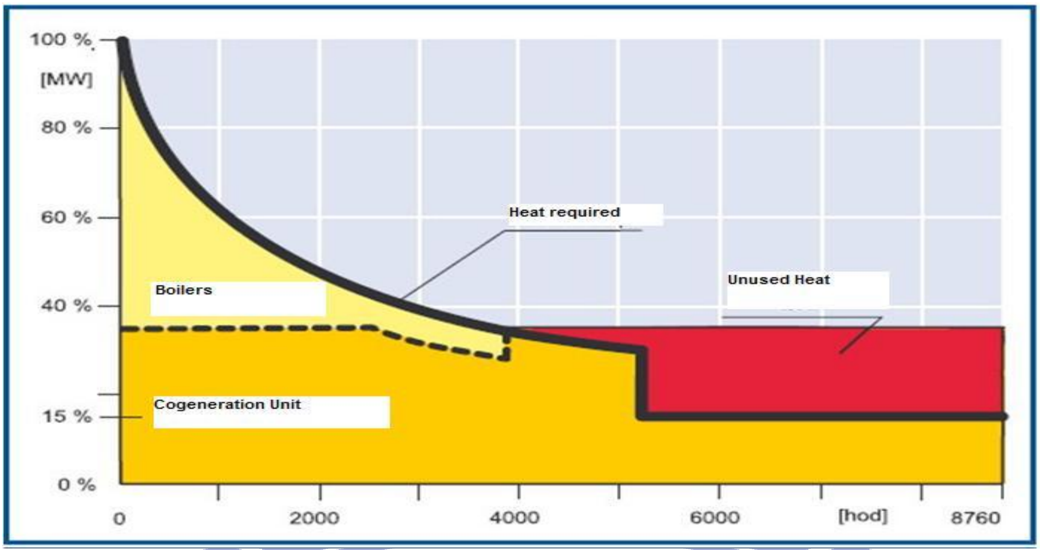
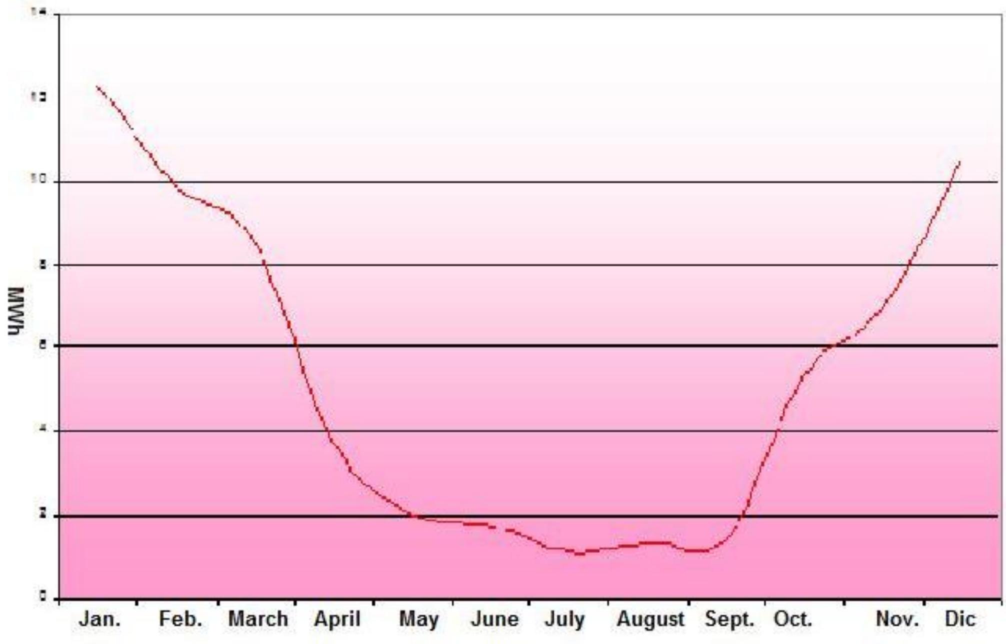


Figure 7.3: Heat Waste Using Cogeneration during the Summer

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

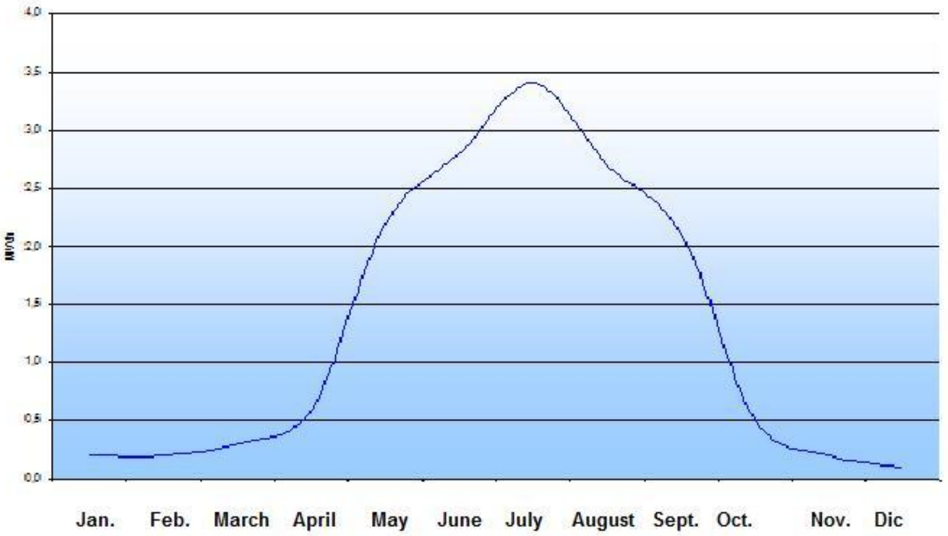


Source:

Figure 7.4: Heat Needed for the Chemosvit Group a.s. During the Year 2009

Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The above Figure 7.4 shows that the average needed heat for the Chemosvit Group a.s. during the year 2009 significantly decreases in the summer months. It is apparent that during these months some of the heat will be wasted as shown in Figure 7.1. Furthermore, the cooling system is required during the hot months to prevent problems with technology and machinery. From the next Figure 7.5 the requirement for cooling system of Chemosvit Group a.s. is evident.



Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Figure 7.5: Cold Need for the Chemosvit Group a.s. During the Year 2009

The previous figures show that the effective production of electricity in the summer is not possible mostly due to the lower requirements on heat. This negative phenomenon can be mitigated with a trigeneration system, which means as explained before the combined production of heat, electricity and cooling. As the need for cooling has the opposite trend as the need for heat, the tri-generation thus becomes much more effective than mere cogeneration. In the Figure 7.6 below it is shown that the unused heat apparent from Figure 7.1 can be use in the way of trigeneration.

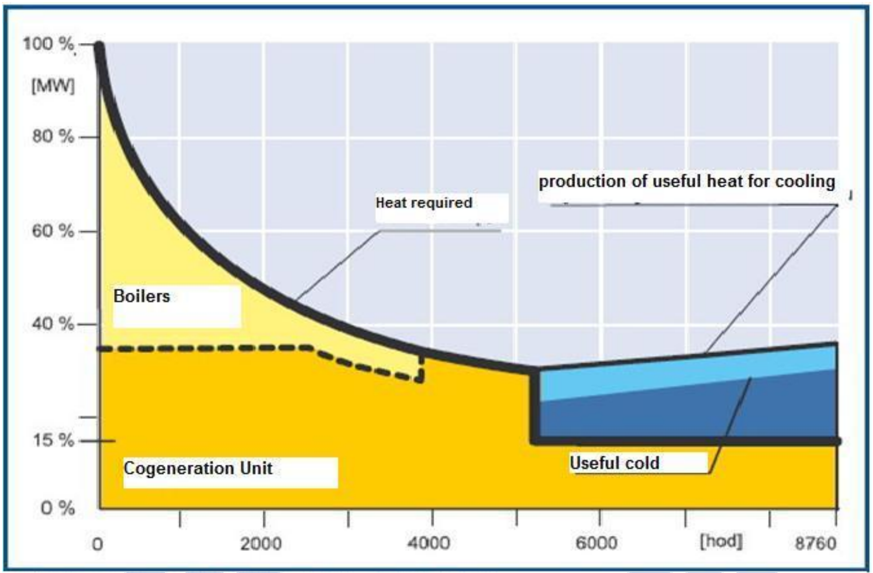
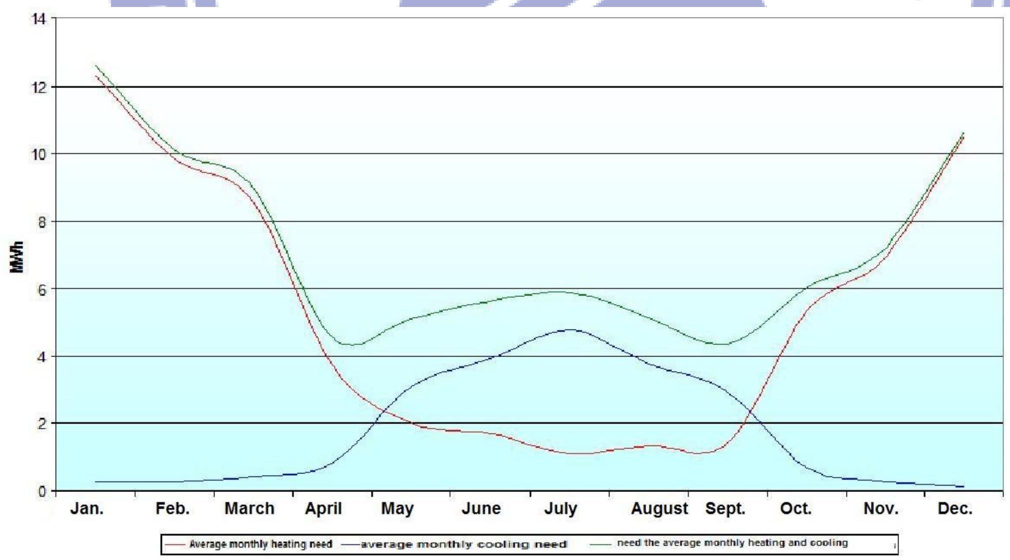


Figure 7.6: Heat in the Production of Cold

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The following Figure 7.7 shows the estimated need for heat to produce cooling (green line) as a product of the trigeneration.



Source:

Figure 7.7: Average Monthly Heating and Cooling

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The main recommendation is to centralize the production in a cold place and invest in new pipes to convey cooling to individual buildings. The production of cold can be placed in the object 55 (to find the obj. please see the Figure 7.8). The main reason to propose the trigeneration is the location of the object in the center of the Chemosvit Group a.s. area, and so the cold can be distributed with more efficiency. Moreover, this area is sufficiently close in proximity to the existing cooling tower that is indispensable to the process of production of cold. My recommendation is to install the two 3 MW units, which may be interconnected in case of failure of one. The proposed pipes installation for Western and Eastern part is shown in the next two Figures 7.8 and 7.9.

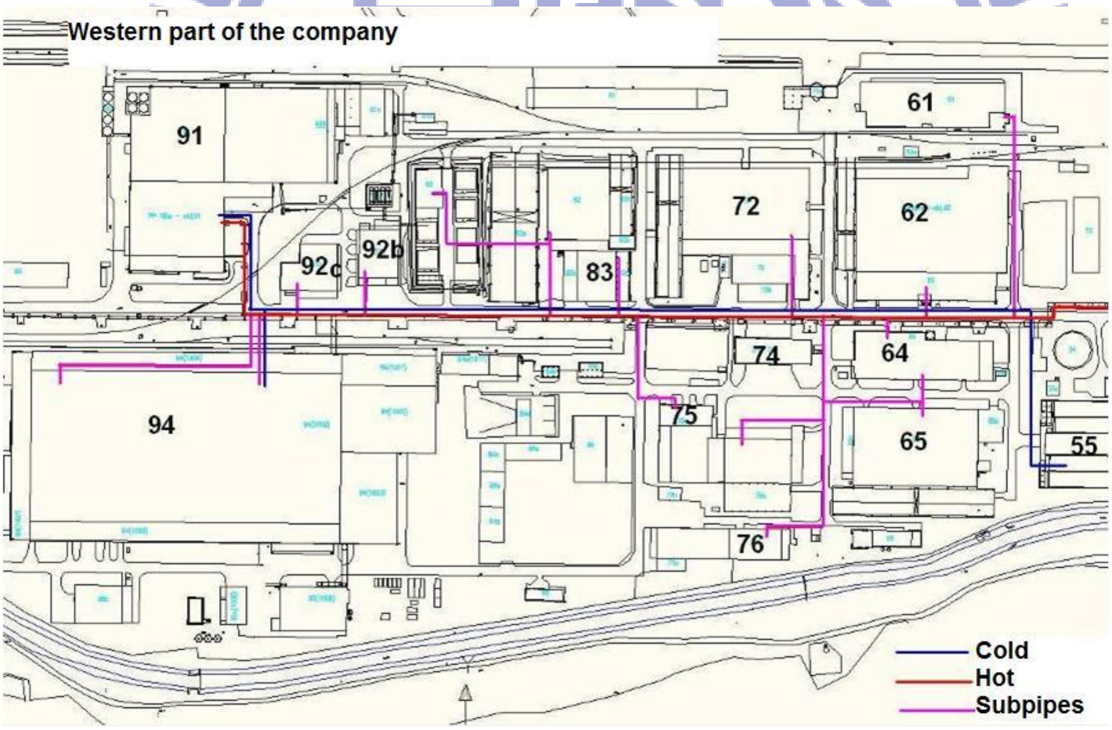


Figure 7.8: Proposed Solution – Western Part

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

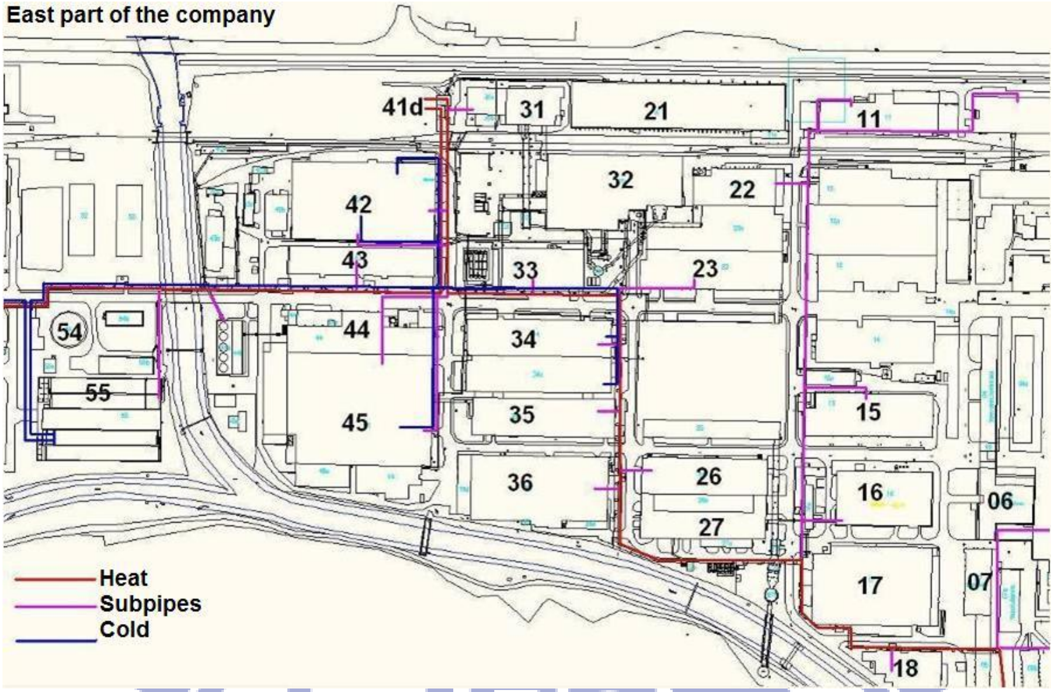


Figure 7.9: Proposed Solution – Eastern Part

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

The recommendation for the investment intensity is presented in following Table 7.1.

Table 7.1: Investment Cost for Cooling System

	Item	Units	# of units	Unit price	Total E	Total SKK
1	Absorption unit 3MW	Pc	2	410,000	820,000	24,703,320
2	Pipe	M	4,340	95	414,320	12,481,804
3	Reductor joint, elbow joint, "T" joint	Pc	20	1,200	24,000	723,024
4	Valves	Pc	20	1,500	30,000	903,780
5	Assembling lines	M	4,340	45	195,300	5,883,608
6	Pressure gauges	Pc	13	3,000	39,000	1,174,914
7	Projects	Pc	1	15,000	15,000	451,890
8	Other Expenses	Pc	1	100,000	100,000	3,012,600
Total					**1,637,620**	**49,334,940**

Source: Elaborated by Author Based on Chemosvit Energochem a.s. Internal Data

Advantages of the Recommended Solution

One advantage of central cooling is the lowest production cost of primary energy for cooling (the price of natural gas is less expensive than the cost of electricity to power compressors and fans). The main benefit of central production of cold is that it avoids the cost of servicing, maintenance and repairing of local cooling resources that had to be financed by subsidiaries.

Calculation of Return of Recommendation

The expected consumption of cooling volume based on historical data of the Chemosvit Group a.s. is of 11 235 MWh per year for all customers (Chemosvit Folie a.s., Terichem as, Chemosvit Fibrochem a.s.) The average number of hours is the value of 2 875 h (these figures are based on historical data). On the basis of this consumption it is only needed 4 MW to produce the necessary amount of cooling.

The sale of the cooling MW hour manufactured assumes a cooling unit price per MWh at the selling price of heat, which as an amount of € 70.417 per MWh. To achieve the required production volume of cooling, it is necessary the heat of 18 290 MWh and electricity of 337 MWh. In addition to direct costs, complementary costs not directly related to the actual production of cold have to be taken into account. They are represented by expenses, depreciation, repairs and maintenance (or services).

Quantification of Benefits of Recommendation

The trigeneration is consequently better than the simple cogeneration, which is mostly because of the zero economic effect, since cold production costs are covered by the returns with almost zero profit. In terms of generated cash flow this result is positive, however, this still is not a desired effect.

The final effect from this investment will be reflected after incorporating the overproduction of electric energy and though realization of additional payment. The overproduction of electricity will be 15 546 MWh per year and so the company can offer a discount on electric energy for every MWh of extracted cold.

The ultimate positive effect is the fact that the price of cold for the customers will be lower reaching almost the level of variable cost, which originated from cold production under the self-production capacities of the customers. This effect will be reached through reduction of investment cost for the customers, operation cost, maintenance and repairing of installments as a part of their overhead. The Chemosvit Group a.s and the town Svit will be the main beneficiaries, if this investment will be taken in to consideration in the future. Meanwhile it can contribute to the reduction of CO_2 emissions and to a sustainable environment.

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AUTOBIOGRAPHY

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2. Educational background:

Educational Institute	Duration	Field of Study	Diploma
● Instituto Tecnológico y de Estudios Superiores de Monterrey	**Aug 2003-June 2007**	Major in Mechanical Electrical Engineer, with studies in manufacture concentration.	Bachelor Studies
● Shanghai Jiao Tong University, Shanghai ,The people's Republic of China.	**Summer 2005**	Complete studies of mechanical manufacture related to the modern manufacturing systems and manufacturing enterprises.	Speciali_ zation Studies
● Technical University of Berlin, Berlin, Germany	**Summer 2005**	Complete studies of mechanical manufacture related to the use of manufacture machinery.	Speciali_ zation Studies

Language skill: English, Spanish, Chinese, Catalan, studies of 3 years of French.

3. Work Experiences:

Name of organization	Position	Duration	Description of activities
• Castmet, SA de CV.	Project director	**April 2005-April 2007**	➢ In charge of the direction of some projects related with Italian and German companies ➢ Linking them with Mexican companies in the area of manufacture services.

4. Autobiography

There are several things I can say about myself:

I come from Mexico City. In the summer semester of 2007 I finished my Undergraduate studies (with the degree of Bachelor) in the field of the Mechanic and Electrical Engineering at the Monterrey Institute of Technology and Higher Education (Instituto Tecnologico y de Estudios Superiores de Monterrey) in Mexico city that is considered to be one of the best universities in Latin America and is also the best-known school in Mexico with highly renowned programs in Engineering and Business. During my Bachelor studies I had an opportunity to enter an international program of exchange studies in Mainland China (Jiao Tong University in Shanghai) and Germany (Berlin University of Technology) in the academic year 2005.

As I consider the higher education a necessary step in my future career, immediately after finishing my Bachelor degree program I applied for the Taiwanese Ministry of Education scholarship program. I was awarded by a scholarship in the period of the years 2007-2012. Presently, I am a student of GMBA at the National Jiao Tong University in Hsinchu, beginning the third second semester and student of mandarin language in National Cheng Chi University in Taipei.

During my Bachelor studies, I started to work for the cross-cultural company established in Mexico City, where I received a valuable opportunity to get in common with different of managerial systems.

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