Project design of an open pit colliery in Terkidag, Turkey

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In this manuscript, first of all, the status of Turkey in terms of energy production and consumption is given and the need to rely on domestic sources, namely lignite deposits, is emphasized rather than importing fuels from abroad. Then, a thorough literature work concerning open pit design and production planning is explained in detail. On this basis, the project design and production planning of Tekirdag-Saray open pit colliery are conducted. According to the selected production technique, machinery-equipment that will be utilized in the coal winning system is determined and in the final part, the investment cost and unit production cost regarding the project are computed and the importance of constructing a power plant in the region operating with domestic fuels is expressed.

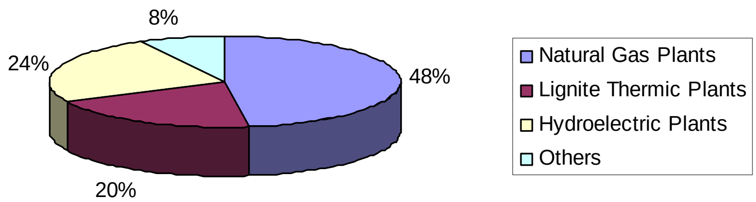
Key words: *Energy, open pit, production planning, optimization, engineering economics.*

Introduction

Turkey is an energy importing country with more than half of its energy requirements met by imported fuels. The Turkish Energy Policy is mainly concentrated on assurance of energy supply; reliably, sufficiently, in time, in economic terms and in a way to support and orientate the targeted growth and social developments. The country's energy strategy is aimed at satisfying demand without hampering economic growth. Diversification of sources and products of energy also play an important role in determining this strategy. (Pamukcu & Konak, 2006).

The increasing use of electric energy, which is the main input of every economic activity, also increases the demand for the electricity energy. With reference to Turkey's most recent numbers related to electricity generation and consumption; electricity generation for the 3rd period of the year 2007 (July-August-September) happened to be equal to **46,361 GWh** by increasing at a rate of 9.21 % when compared to the same period of the year 2006. Electricity generation has increased at a rate of 10.95 % when compared to the previous 2nd period of 2007. In the 1st period of 2007 (January-February-March), electricity generation was achieved as **42,390 GWh** and in the 2nd period of 2007 (April-May-June), the electricity generation was achieved as **41,660 GWh.**

Of the total electricity generated in the 3rd period of 2007; 36,060 GWh was produced by thermic means, 10.255 GWh was produced by hydraulic means and 46.2 GWh was produced by wind energy. According to the same period of 2006, thermic electricity generation has increased by 11.31 % and hydroelectric electricity generation has risen by 2.11 %. In terms of various energy resources, for the same period of 2007, gross electricity generation was obtained through natural gas at a rate of 47.74 %, through hydroelectric plants at a rate of 24.2 % and through lignite-based thermic power plants at a rate of 20.05 %. When compared to the 3rd period of 2006; electricity generation has increased by 9 % at natural gas power plants and by 8.29 % at lignite-based power plants. Figure 1 shows the electricty generation in terms of resources for the 3rd period of 2007.



Figu. 1. Turkey's Electricity Generation in Terms of Resources for the 3rd Period of 2007.

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On the contrary, electricity consumption of Turkey for the 3rd period of 2007 (July-August-September) happened to be **34,306 GWh** by increasing at a rate of 11.62 % when compared with the same period of 2006. Speaking of the total energy consumed; 41.23 % of the electricity generation was consumed in industry whereas 23.81 % was used in residences. If a year is assumed to consist of 4 periods, Turkey's annual electricity production seems to exceed **170,000 GWh** and Turkey's annual electricity consumption seems to be around **140,000 GWh** for the year 2007. (www.tuik.gov.tr). Turkey's gross electricity generation and net electricity consumption are depicted in Table 1 for the past decade.

Tab. 1. Turkey's Gross Electricity Generation and Net Electricity Consumption.

Years	**Gross Production** [GWh]	**Net Consumption** [GWh]
1998	103,296	81,885
1999	111,022	87,705
2000	116,440	91,202
2001	124,921	98,296
2002	122,725	97,070
2003	129,400	102,947
2004	140,581	111,766
2005	150, 698	121,141
2006	161,983	130,600
2007	**~ 170,000**	**~ 140,000**

As seen from the numbers and from the graph in Figure 1, nearly half of Turkey's electricity generation is dependent upon natural gas which means that the country should import more natural gas provided that the increasing trend for electricity demand continues. Turkey imports natural gas from its neighbors, mainly from Russia and Iran and to a less extent from Azerbaijan. Therefore, it is useful to evaluate the domestic resources for electricity generation rather than being dependent upon external sources. In this manuscript, the project design of an open pit coal mine that is located in Thrace region of Turkey will be investigated. Within this scope, the open pit design and optimal production planning of the mentioned coal mine will be conducted. Thrace region of Turkey is of great importance because it accommodates Istanbul, which is the most populated and industrialized city of Turkey. At least, the need for energy in that particular region can be met by domestic fuels (lignite-based power plants) in case these local resources are exploited prudently.

Literature work regarding open pit design and production planning

Open pit mine planning must be correlated to all phases of a mining operation. The factors that must be considered in planning an open pit mine are numerous and must reflect the characteristics and surrounding conditions of a particular orebody. In planning an open pit mine, the pertinent elements that must be included are; assay, geology, tonnage and areal extent of ore reserves, topography, mining equipment, economic factors of operating costs, capital expenditures, profit, types of ore, pit limits, cut-off grade, stripping ratio, rate of production, pit slopes, bench heights, road grades, ore metallurgical characteristics, hydrological conditions, property lines and marketing opportunities. (Pfleider, 1972)

During mine planning stage, specific attention should be devoted to mine life-production rate determinations, push back design and sequencing, as well as providing some general guidance regarding both long and short term planning activities (Hustrulid & Kuchta, 1998). The basic objectives of extraction planning have been well stated by Mathieson (1982):

- To mine the orebody in such a way that for each year the cost to produce a kilogram of metal is a minimum, i.e., a philosophy of mining the "next best" ore in sequence.
- To maintain operation viability within the plan through the incorporation of adequate equipment operating room, haulage access to active bench, etc.
- To incorporate sufficient exposed ore "insurance" so as to counter the possibility of mis-estimation of ore tonnages and grades in the reserve model. This is particulary true in the early years which are so critical to economic success.
- To defer waste stripping requirements as much as possible and yet provide a relatively smooth equipment and manpower build-up.

- To develop a logical and easily achievable start-up schedule with due recognition to manpower training, pioneering activities, equipment deployment, infrastructure and logical support, thus minimizing the risk of delaying the initiation of positive cash flow from the venture.
- To maximize design pit slope angles in response to adequate geotechnical investigations and yet through careful planning minimize the adverse impacts of any slope instability.
- To thoroughly subject the proposed mining strategy, equipment selection, and mine development plan to "what if" contingency planning, before a commitment to proceed is made.

Planning is obviously an ongoing activity throughout the life of the mine. Plans are made which apply to different time spans (Kose et al,.2006). There are 2 kinds of production planning which correspond to different time spans (Couzens, 1979):

- Operational or short-range production is necessary for the function of an operating mine,
- Long-range production planning is usually done for feasibility or budget studies. It supplements pit design and reserve estimation work and is an important element in the decision making process.

The open pit design and scheduling problem is a large-scale optimisation problem that has attracted considerable attention over the last 40 years. The development of the 'know-how' to improve the economics of open pit mining projects through the use of mathematical optimisation techniques goes back to the early 1960s. Unfortunately, until recently, many of these 'optimising algorithms' could not be implemented due to the limited capacity of the computer hardware used in many mining operations. During the last ten years, advancements in the computer hardware technology, along with developments in software technology has allowed open pit mines to have powerful desktop computers that can solve complex optimisation problems on site. (Dagdelen, 2007).

The current practice of planning an open pit mine begins with a geologic block model and involves determination of:

1. whether a given block in the model should be mined or not;
2. if it is to be mined, when it should be mined; and
3. once it is mined, how it should then be processed.

The answers to each of these questions, when incorporated into the whole orebody block model, define the annual progression of the pit surface and the yearly cash flows that will be coming from the mining operations during the life of the mine. There can be many different solutions to the scheduling problem depending on the decisions made for each of the blocks. The decision as to which blocks should be mined in a given year, and how they should be processed (ie waste, run of mine leach,crushed ore leach or mill ore, etc) defines not only the cash flow for that year, but also impacts the future annual schedules. What is decided today has long-term implications for what can be done in the future, and all of these decisions link together to define the overall economics of a given project. The objective of the planning process for an open pit mine is usually to find optimum annual schedules that will give the highest net present value (NPV) while meeting various production, blending, sequencing and pit slope constraints.

Current mine production planning, scheduling, and allocation of resources are based on mathematical programming models. In practice, the optimized solution cannot be attained without examining all possible combinations and permutations of the extraction sequence. Operations research methods have limited applications in large-scale surface mining operations because the number of variables becomes too large. (Askari-Nasab et al, 2008)

Open pit planning and scheduling play a significant role in establishing, maintaining and improving the economics of open pit mining ventures. The development of an open pit plan and schedule involves consideration of the following elements: the market for the mineral, the mineral deposit, the treatment process, the external factors, the mining method, the scale of operations, the open pit design, the open pit schedule, the calculation of economic performance, and the implementation of the open pit plan and schedule. Open pit planning and scheduling is the linkage which enables a mineral deposit amenable to open pit mining to meet a market requirement for the particular mineral. To effect this linkage, the open pit planner should have a good detailed appreciation of both the mineral deposit and the market. Maximisation of the net present value of an open pit project serves as an objective in planning and scheduling. This is achieved by maximising the net present value at each stage of the operational life. Maximisation of net present value means that the capital invested in the project is being used most efficiently. Open pit operations take place in a continually changing environment. Consequently open pit planners must take account not only of current conditions but also conditions that are expected to develop in the future. The implementation of an open pit plan and schedule requires that those responsible for seeing that it is carried out are committed to the plan. In effect they must 'own' the plan. (Crone, J.G., 1992)

Ideally, optimal open pit limits should be determined on the basis of optimizing net present value. However, the problem, as formulated, is intractable. It is not ppossible to assign a net present value to a block until it is known when the block is to be mined but the time at which a block is mined is not known until the pit is designed. The problem could be formulated as a constrained scheduling problem thereby avoiding the circular constraints refered to above. However, such a solution is yet to be formulated and achieved within reasonable computing time. The most common approach to the proble is to design an optimal open pit shell using maximum profit as the criterion and then to schedule the blıocks within this shell in such a way as to maximize net present value (Onur & Dowd, 1993).

The variables in open pit mine production planning interact in a circular fashion, that is, without knowledge of one variable the next variable in the circle cannot be determined. Fixing or assuming the values of one or more variables along this circle will lead to inferior planning. An efficient plan will require simultaneous solution to the variables in the circle. However, such a solution is not easy to obtain due to the complexity and shear size of the problem. During the last three decades, partial solutions have been found using operations research techniques and heuristic algorithms. (Sevim & Lei, 1998).

Sophisticated pit optimisation software has allowed mine planning engineers to generate mining outlines that consider the numerous factors that have a major effect on the success or otherwise of a mine plan. The outlines are generally generated using a range of values for which one can assume a fixed mining cost and a variable revenue. During analysis, the expected costs and revenues are used to investigate the cashflow and sensitivities. Ultimately, the final pit and incremental outlines, or shells, are selected for a given expected price. The life of mine is assumed to be divided into a number of Business Risk Periods (BRPs). The BRP represents the period of time over which the owner is prepared to invest capital. During each BRP, the mine will then operate at a selected investment cost which is generally equal to or greater than the minimum required to meet production targets. In this way, a robust mine plan can be produced which allows the mine to react to change without having to alter the incremental shell limits while maintaining a strategic risk profile. (Seymour, C., 1998).

The quantification of uncertainty and risk has major implications in open pit design and production scheduling. The need to quantify uncertainty in project valuation and decision-making translates to the need to quantify uncertainty and risk in any significant parameter of open pit design and mine planning. Project risk may arise from three main sources: technical; financial; and environmental. The major source of technical risk is the uncertainty of grades, tonnages, geology and geomechanics. For any open pit design, technical risk can be readily modeled and integrated to the optimisation and design process to provide accurate modeling and quantification of uncertainty and risk, eliminating the traditional single estimate assessment. This approach can be used for assessing parameters including project NPV, expected cash flows, gold grams (ounces), and expected production costs. This risk-based approach provides more accurate project valuation, by minimising risk in the selection of a given pit design. (Grieco, N.J., 2001)

In this study, while achieving the project design of a coal mine in Turkey, the afore mentioned premises were taken into consideration.

Description of the study area

Location and Reserve

This manuscript globally deals with the project designing and production plannning of an open pit coal mine in Tekirdag-Saray which is located in the northern Thrace region of Turkey. Tekirdag-Saray lignite basin mainly consists of 3 sectors which are called Edirkoy, Kucukyoncali and Safaalan. The location map of the study area is given in Figure 2. The licence area was permitted back in 1987 with a coverage area of nearly 37,000 hectars.

Tekirdag-Saray lignite basin generally comprises a high stripping ratio due to natural topography. It is a common known fact that one of the most important factors affecting ore production unit cost is the stripping ratio in open pit mines. Within the coal basin, there are totally 15 coal panels in the sectors of Safaalan, Edirkoy and Kucukyoncali and the stripping ratios of these panels range from 5,39 m^3/ton to 40,73 m^3/ton. By discarding the panels which have considerably high stripping ratios, the mineable reserve was found as 65,588,929 tons in the basin for an average stripping ratio of 20,66 m^3/ton.

Fig. 2. Location Map of Tekirdag-Saray Colliery.

Geological Setting

Paleozoic aged gneiss, schist, quarzite, phyllite and granites form the basement of Tekirdag-Saray lignite basin. Eocene limestones represent the undermost level of the Tertiary formations. Eocene limestone are overlain by Oligocene units in the field. At the bottom of the Oligocene, limestones and sandstones are encountered. The bottom part of the Oligocene is overlain by marl layers, on which the sandstone and marl-clay parts of the coal bearing series are seen. The hangingwall and footwall of the lignite seam are composed of clay, sandy clay and schisty sandstones. Lignite is seen in 2 separate seams which have economical value. The thickness of the coal bearing series increases going from north to the south. The average thickness of the coal bearing series in the field is nearly 110 metres. The coal is overlain by Pliocene aged clay, sand, sandstone, conglomerate and limestones. The youngest formation in the field appears to be the alluvial layer. The non-scaled stratigraphic column of the study area is illustrated in Fig. 3.

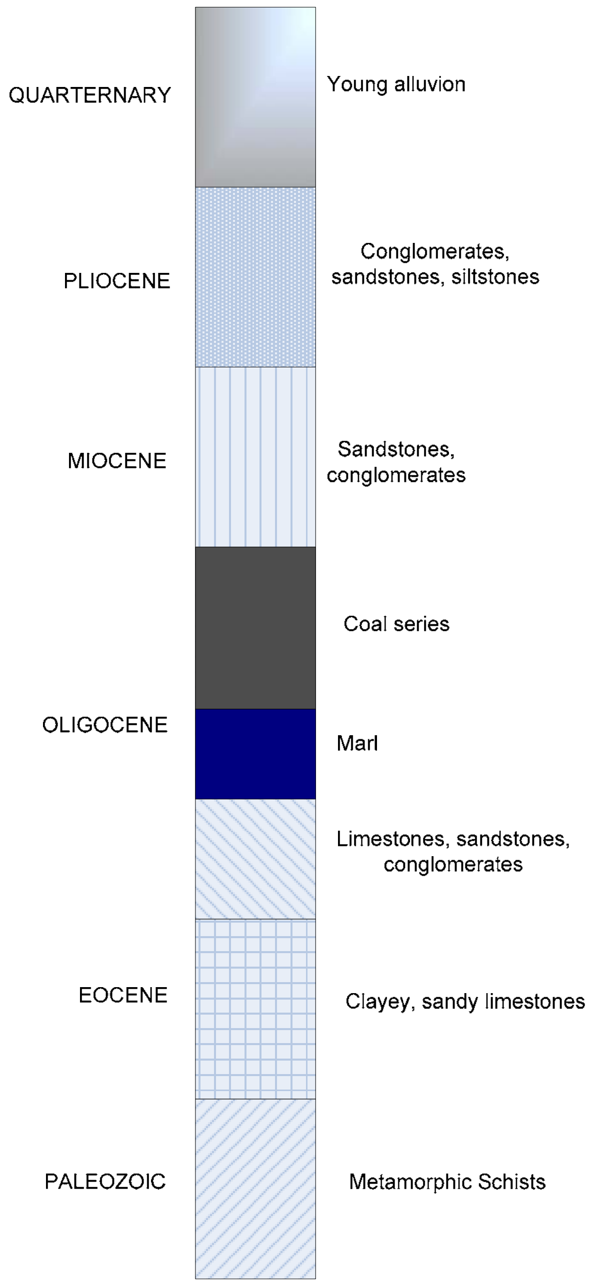


Fig. 3. Lithology of the Study Area.

Production planning and selection of open pit mining method in the region

The mineable coal reserve, total amount of stripping and the properties of the coal are summarized together for 3 different sectors in Table 2.

Tab. 2. General Features of Coal in the Study Area .

Sectors	Mineable Reserve [ton]	Stripping Ratio [m^3/ton]	Moisture Content [%]	Ash Content [%]	Lower Calorific Value [kcal/kg]
Safaalan	**24,078,126**	**20,73**	**43,75**	**24,02**	**1659**
Edirkoy	**18,298,446**	**19,54**	**41,47**	**25,04**	**1782**
Kucukyoncali	**23,212,357**	**21,48**	**39,32**	**21,90**	**1997**

The data in Table 2 indicate that the coal of Tekirdag-Saray basin is a lignite coal with high moisture and ash content. Since the minerals in the coal are disseminated in the form of fine particles, the ash content will not be lowered by ore processing techniques. Besides, such young lignites are not suitable for enrichment by wet coal preparation methods either. On the other hand, the coal in Tekirdag-Saray basin disintigrates and turn into dust during storage and transport processes and thus become an inconvenient fuel for district heating. For all those reasons, Tekirdag-Saray coal is more convenient to be utilized in electricity generation rather than domestic heating. The mineable coal reserve here happens to be sufficient to feed a thermic power plant at a capacity of 2 x 150 MW for 25 years. However, for local district heating and industrial fuel, an amount of 45,000 tons/year are reserved only for the initial 10 years. In the latter 15 years, the fuel need of the local settlements will be met by other coal reserves located in Thrace region.

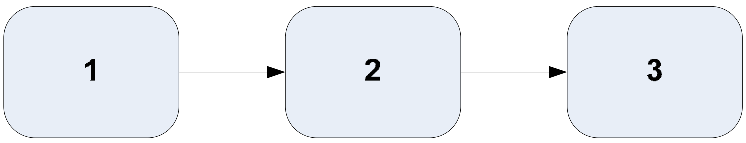
The industrial analysis values of original coal that will be supplied to the power plant will be as follows:
<u>Safaalan + Edirkoy Sectors (first 10 years)</u>
Moisture Content (%) : 42,99
Ash Content (%) : 24,68
Lower Calorific Value (kcal/kg) : 1738

<u>Safaalan + Kucukyoncali Sectors (last 15 years)</u>
Moisture Content (%) : 41,02
Ash Content (%) : 22,71
Lower Calorific Value (kcal/kg) : 1867

The production planning of the field was achieved in the form of 3 different considerations as investigated below:

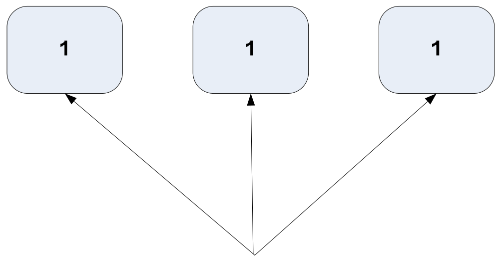
1. <u>Sequential Production:</u> In this plan, the production will begin at Edirkoy sector and will continue with Safaalan and Kucukyoncali sectors, respectively as follows:
   Edirkoy Sector : 2,650,000 tons/year x 6,7 years
   Safaalan Sector : 2,825,000 tons/year x 8,5 years
   Kucukyoncali Sector : 2,368,000 tons/year x 9,8 years
   Total Time : 25 years

   In this case, the production is achieved from 1 sector at a time and when the production of one sector is finished, the production begins at the next sector. The advantages of this type of production planning are good operational concentration and low unit cost. However, the method holds some disadvantages also. The coal reserve of the sectors end up in considerably short time durations as mentioned above. The quality control is difficult and production from single field is risky. When the production is interrupted for any reason, it gets impossible to feed the power plant and besides selective production and proper blending are not possible by this method. For all those reasons, this method was not accepted as the production method.



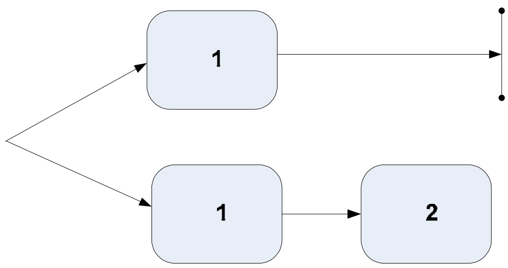
2. <u>Simultaneous Production From 3 Sectors:</u> Simultaneous production from the 3 sectors at the same time were proposed as follows:
   Edirkoy Sector : 710,000 tons/year x 25 years
   Safaalan Sector : 963,000 tons/year x 25 years
   Kucukyoncali Sector : 928,000 tons/year x 25 years
   Total : 2,601,000 tons/year x 25 years

   The advantage of this method is good quality control. When the production is interrupted in one of the fields, the power plant is fed by the other 2 sectors. However, the operational concentration is poor in this method which means that the working machines are too much scattered and work control gets harder. Therefore, the use of this method was also rejected.



3. Simultaneous Production From 2 Sectors: In this case, the production will start simultaneously at the Safaalan Sector and Edirkoy Sector. The production at Safaalan Sector will continue for 25 years and at the same time it will go on for 10 years at Edirkoy Sector. After the reserve at Edirkoy is consumed, the next mine will opened at Kucukyoncali Sector. The breakdown of production plan for this method is as follows:
Safaalan Sector : 936,000 tons/year x 25 years
Edirkoy Sector : 1,775,000 tons/year x 10 years
Kucukyoncali Sector : 1,545,000 tons/year x 15 years

This method was accepted as the main production method on behalf of optimal production planning. The main advantage of this method is good quality control. When the production is interrupted in one of the fields, the power plant is fed by the other sector. Moreover, the operational concentration is better and work control is easier when compared to the simultaneous production from 3 sites.



Mine sequencing and the location of spoiltip areas are shown in Figures 4,5 and 6 for Edirkoy, Safaalan and Kucukyoncali sectors consecutively (DEU Project, 1985).

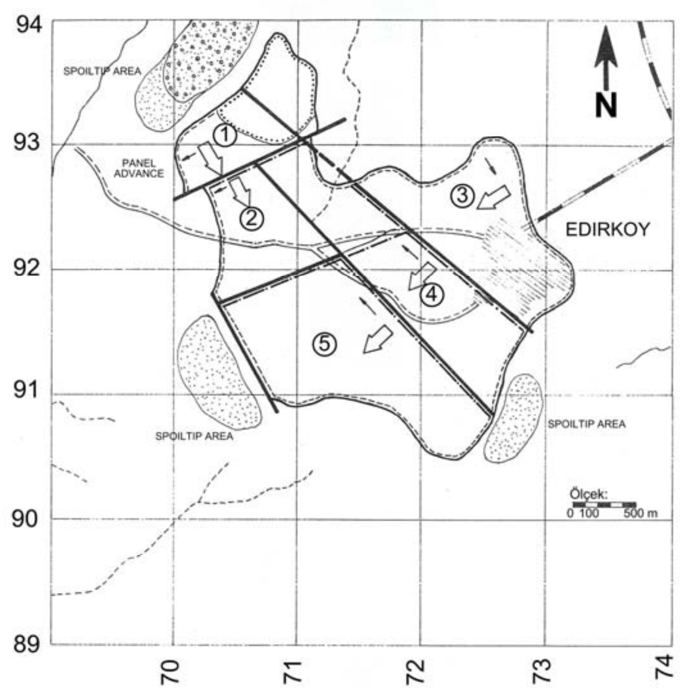


Fig. 4. Mine Sequencing and Location of Spoiltip Areas at Edirkoy Sector.

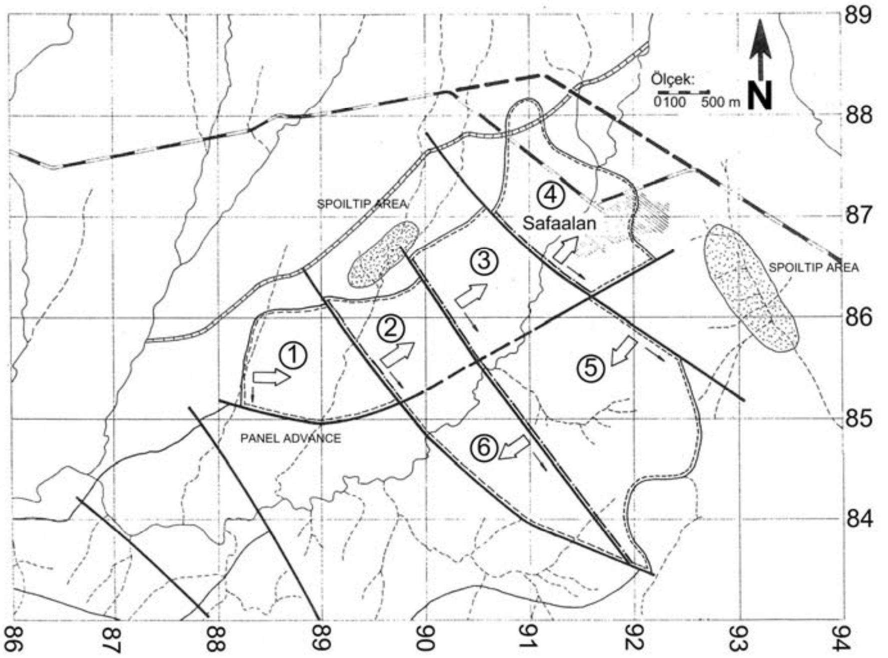


Fig. 5. Mine Sequencing and Location of Spoiltip Areas at Safaalan Sector.

Several stripping and coal winning methods were compared with each other technically and economically in detail. As a result of these comparisons, with reference to stripping operation, the combination of "25yd^3 electrical excavator + mobile crusher + band conveyor" and "20yd^3 electrical excavator + 85 s.tonnes rear dump-truck" method was selected. With respect to coal winning, the method of "10yd^3 hydraulic backhoe excavator + 150 s.tonnes of bottom dump-truck" was selected. Figure 7 schemetically indicates the stripping operation at Tekirdag-Saray colliery.

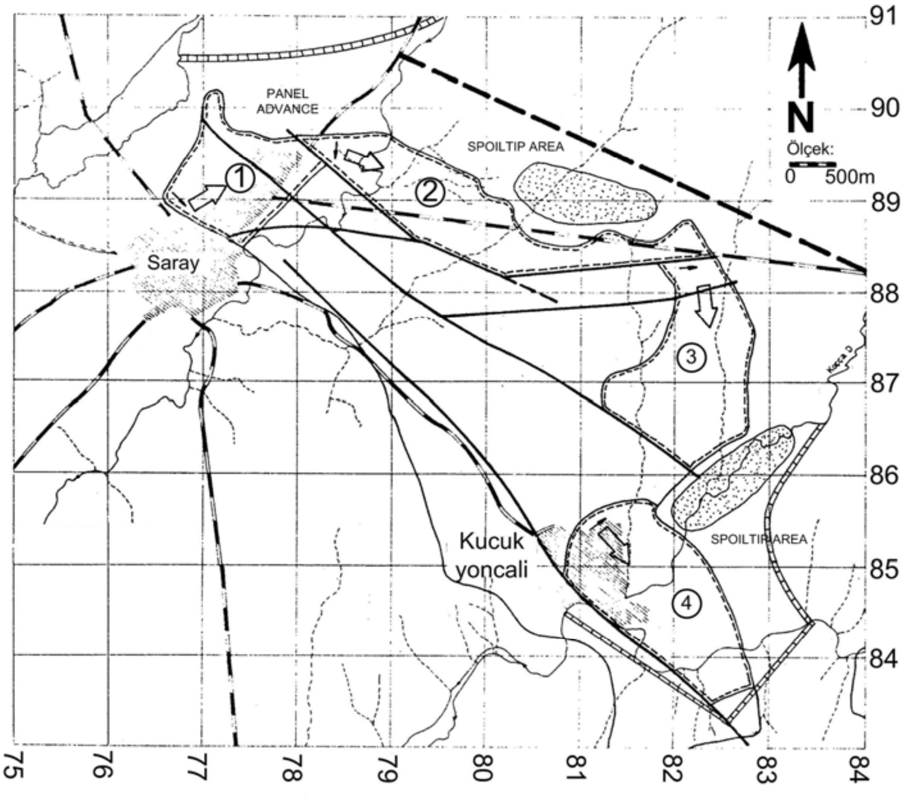


Fig. 6. Mine Sequencing and Location of Spoiltip Areas at Kucukyoncali Sector.

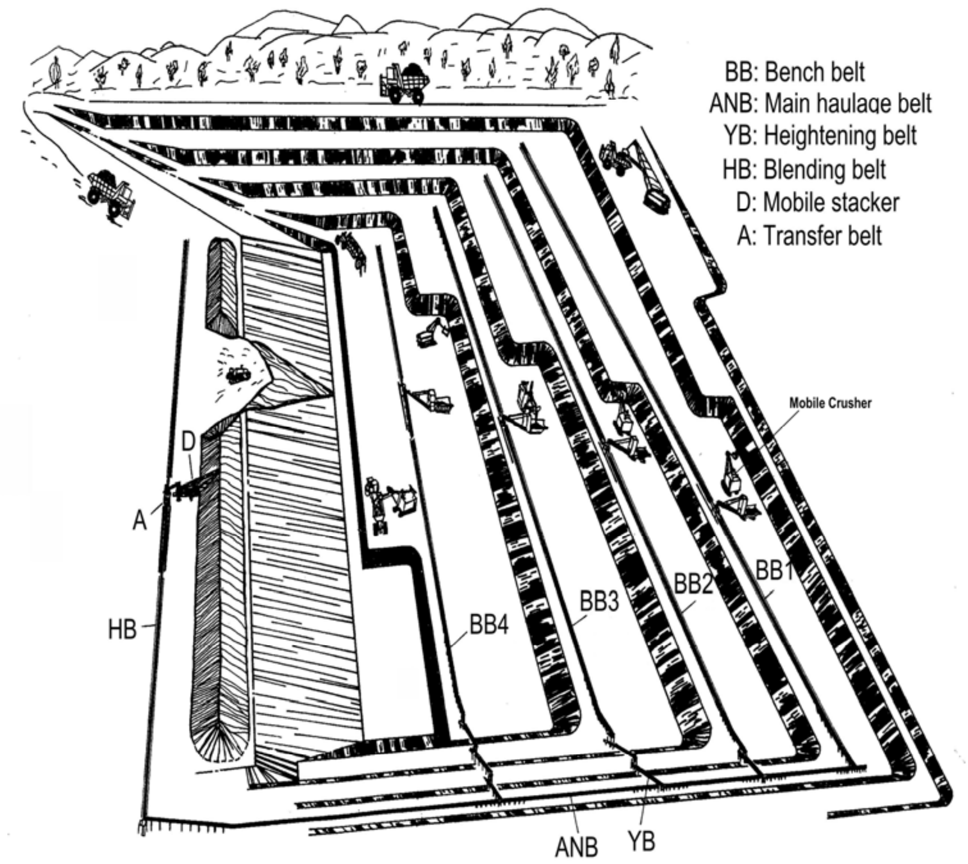


Fig. 7. Schematic View of Stripping Operation at the Colliery.

With respect to economical aspect of the project, the breakdown of both investment and operating costs are given in Tables 3 and 4.

Tab. 3. Investment Costs of the Project.

Investment Period	Years	Amount of Investment (US $) x 10^3	Interest Amount (US $) x 10^3	Operating Capital (US $) x 10^3	TOTAL (US $) x 10^3
Investment Period Investments	1st year 2nd year 3rd year 4th year	470 20,818 65,624 54,209	23 1,088 5,256 11,402	- - - 7,375	493 21,906 70,880 72,986
Subtotal		141,121	17,769	7,375	166,265
Operating Period Continuity Investments	5th year 10th year 15th year 20th year	6,653 2,223 3,382 9,247			6,653 2,223 3,382 9,247
Subtotal		21,505			21,505
Operating Period Renewal Investments	8th year 9th year 10th year 13th year 14th year 15th year 18th year 19th year 20th year	6,510 15,371 16,300 13,155 34,453 16,242 6,510 15,371 16,300			6,510 15,371 16,300 13,155 34,453 16,242 6,510 15,371 16,300
Subtotal		140,212			140,212
OVERALL		302,838	17,769	7,375	327,982

The overall amount of investment seems to be very close to 328 million US $ for this project.

Tab. 4. Annual Operating Costs of the Project

	Operating Expense (US $) x 10^3
1) Auxiliary Material Costs **Explosives** **Tyre** **Rope** **Spare part**	6,835 247 1,357 285 4,946
Energy, Fuel and Lubrication Costs **Electricity** **Fuel** **Lubricant**	14,092 8,206 4,971 915
3) Repair and Maintenance Costs	4,824
Personnel and Labor Costs **Personnel** **Labor**	4,098 562 3,536
General Production and Administration Costs **Rents** **Insurances** **Taxes**	535 64 458 13
6) MTA Study Costs	55
7) Courtesy of State	653
8) Depreciation	15,624
9) Interests	3,073
TOTAL	49,789

The annual production capacity is nearly 2,7 million tons in this study. So, the unit cost of run-of-mine coal will be equal to 49,789,000 US $ / 2,700,000 tons = **18,44 US $.**

This unit cost (18,44 US $) was calculated at an actual interest rate of 10 % and when the payback period is considered as 10 years. In case the payback period is taken 25 years, this time the new unit cost equals 23,60 US $. However, Turkey comprises an unstable economic structure and due to this fact, the economy might sometimes be under high inflationist pressure. Therefore, the unit cost was once more computed by accepting the rate of interest as 35 % (Kose & Kahraman, 2009).

Interest Rate [%]	**Payback Period** [years]	**Unit Cost** [US $/ton]
10	10	18,44
10	25	23,60
35	10	19,75

Conclusions

Although Turkey functions as an "energy corridor" between Asia and European countries, unfortunately almost half of its energy requirements are met by imported fuels. In order to exemplify this situation; Turkey's electricity generation is achieved by natural gas at a rate of 48 % which is imported from its eastern neighbors. According to recent explorations, Turkey possesses 8 billion tons of lignite reserve. Due to the low calorific value (< 2000 kcal/kg) and high moisture content (> 38 %) of this reserve, these lignite basins are rather eligible for electricity production. It is important here to generate electricity through lignite thermic plants as much as possible instead of being dependent upon external sources. For this purpose, the exploitation alternative of the lignite reserve which located in Tekirdag-Saray basin was investigated in this study. The mineable coal reserve in this basin is 65,588,929 tons with an average stripping ratio of 20,66 m^3/ton. The moisture content of the mentioned coal ranges from 39,32 % to 43,75 % and the ash content ranges from 21,90 % to 25,04 % while the lower calorific value is between 1659 and 1997 kcal/kg. In order to generate electricity from this field, it is crucial to accomplish careful production planning and optimization. Among diverse winning alternatives, on behalf of optimal production, the system which proposes simultaneous production from 2 sectors was taken into consideration. In this case, the production is planned to start simultaneously at the Safaalan and Edirkoy sectors. The production at Safaalan sector will linger for 25 years and at the same time it will last for 10 years at Edirkoy sector. After the reserve at Edirkoy is consumed, the production will commence at Kucukyoncali sector and continue for the remaining 15 years. The main advantage of this method is good quality control and blending. When the production is interrupted in one of the fields, the power plant will be fed by the other sector. Moreover, the operational concentration is better and work control is easier when compared to simultaneous production from 3 sites. According to this production planning, this basin is considered to feed during 25 years a power plant at a capacity of 2 x 150 MW. However, for local district heating as an industrial fuel, 45,000 tons/year of coal are reserved only for the first 10 years. In the forthcoming 15 years, the fuel need of the region is bound to be met by other coal reserves in the Thrace region of Turkey. In regards to the economic aspect of the project; the investment cost was found to be nearly 328 million US $ and the unit cost of run-of-mine coal was found as 18,44 US $ at an actual interest rate of 10 % and for a paybeck period of 10 years. When the interest rate is kept constant and payback period is taken as 25 years, this time the unit cost will rise up to 23,60 US $. Owing to the unstable economic structure of Turkey, the unit cost was also computed at an interest rate of 35 % (19,75 US $). It will be highly advisory to implement the construction of such a lignite-based power plant (2 x 150 MW) in Tekirdag-Saray coal basin. Thus, this power plant will contribute to the energy demand of the region which also includes Istanbul, the most civilized metropol of Turkey, in terms of electricity generation and fuel needs.

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