Production of Ferrosilicoaluminum (FSA) in the Town of Rustavi

FEASIBILITY STUDY

Business Plan

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1. PROJECT SUMMARY

The objective of the Project is to attract USD 4.55 million in order to start-up a ferrosilicoaluminum (FSA) ferroalloy plant/production with an output 4,400 t/year.

This alloy is a novel product in metallurgy industry and its production, in addition to financial and economic benefits and introduction of new progressive technologies, includes other positive factors, namely:

- The use of local ore (Madneuli deposit quartzite and currently unused Tkibuli coal dressing waste as a raw material;

- Also, the use of aluminum production slag, large amounts of which have been accumulated from Rustavi Secondary Aluminum Works;

This production will transform cheap waste into high-technology products, improve the ecological situation on the one hand, and drive up revenues from sales of the products made of cheap raw materials on the other hand.

At the same time, it will create new jobs (about 100) and raise the country's budgetary revenues.

Ferroalloys, like precious metals, oil, wheat, etc., are liquid products, whereas ferrosilicoaluminum, as an innovative alloy, is able of substituting both quantitatively and qualitatively more costly ferrosilicium and aluminum.

Sales of the products are guaranteed, because, in addition to supplies to local steelmaking plants, 80% of the output could be exported to the neighboring countries (Armenia, Azerbaijan, Russia, Turkey, and Ukraine).

2. PRODUCTION/PLANT LOCATION

The project implementation is planned within vacated areas of Rustavi Metallurgical Works, which based on the available arranged infrastructure (water natural gas, power supply, railway and motor transport) will facilitate the build-up of production and reduce overall cost of the Project.

A building of industrial designation of 1188 m^2 in area and 18.0 m in height, as well as a water reservoir holding 50 tons, and the area of 2000 m^2 have been allocated for the purpose

The Project implementation period - 2015.

3. COMPANY OVERVIEW

***Imeri* Group of Invention and Management - GIM**

Founders: D. Gogichadze and G. Tabatadze

4. FERROALLOYS APPLICATION TREND

The following ferroalloys and admixtures are being applied for deoxidizing and alloying liquid steel:

1. Manganese-bearing silicomanganese (SiMn) adding the required amount of manganese to steel;

2. Ferrosilicium (FeSi) being applied for removing oxygen and adding silicium to steel.

Chemical composition of ferrosilicium according to GOST 1415-93

Grade	Content, %							
	Silicium Si	Al	Cr	Mn	Ca	C	P	S
		at most						
ФС70	68–74	2,0	0,4	0,4	–	0,1	0,04	0,02
ФС65	63–68	2,5	0,4	0,4	–	0,1	0,05	0,02
ФС50	47–52	1,8	0,5	0,6	–	0,1	0,05	0,02
ФС45	41–47	2,0	0,5	1,0	–	0,2	0,05	0,02
ФС25	23–29	1,0	0,8	1,0	–	0,8	0,06	0,02
ФС20	19–23	1,0	0,8	1,0	–	1,0	0,10	0,02

3. Aluminum (Al) being added to liquid steel after the ferroalloys referred to above and being a stronger deoxidizer.

Chemical composition of aluminum according to GOST 295-98

Grade	Content, %							
	Total Al & Mg, at most	Mg, at most	Admixtures at most, %					
			Cu	Zn	Si	Sn	As	Total
AB97	97,0	0,1	0,1	0,1	1,0	0,1	0,1	3,0
AB91	91,0	3,0	3,0	0,8	3,0	0,3	0,2	9,0
AB87	87,0	3,0	3,8	3,3	5,0	0,3	0,2	13,0

5. OUTPUT - URGENCY

The purpose of the proposed Project is to start-up production of ferrosilicoaluminum (FeSiAl), which will enable steelmaking companies to substitute ferrosilicium (FeSi) and aluminum (Al) with a new complex deoxidizer.

According to the world practice, the consumption of ferrosilicium FeSi45 per ton steel makes 6.4 kg on average, whereas that of metallic aluminum in bars – 1.5 kg. It has been practically established that top quality steel is achievable on supply of 3.0 kg ferrosilicoaluminum per ton, instead of individual supplies of ferrosilicium and aluminum. In this case, the cost-effectiveness is based on the fact that in applying FSA, the consumption of ferrosilicium is decreased by 25%, while that of aluminum by 50-70%.

Its advantage over ferrosilicium and aluminum is obvious. As the studies conducted in companies, such as ThyssenKrupp (Germany), *Nippon Steel* and *Sumitomo MI* (Japan), *ISPAT-Karmet* (Kazakhstan), show, both its economic efficiency and a dramatic improvement of steel quality are on hand, because:

- as a result of steel crystallization, the quantity of non-metallic inclusions was twice less than during traditional deoxidizing;

- at the same time, the mechanical properties of steel have improved.

Production of this ferroalloy (FSA) has been mastered in Kazakhstan and Ukraine and is actively practiced in Russia, Japan, Ukraine and Kazakhstan. A world demand for the product is great and today, according to expert data, makes 2 mln ton/year, whereas its annual output makes only 20,000 tons.

Chemical composition of different grades of produced ferrosilicoaluminum (FeSiAl) is given in the table below:

Grade	Chemical composition, %				
	Si	Al	S	P	Mn
ФС 45 А 15	40-45	12,5-17,5	0,1	0,02	0,31
ФС 45 А 20	40-45	17,5-22,5	0,1	0,02	0,31
ФС 55 А 15	50-55	12,5-17,5	-	-	-
ФС 55 А 20	50-55	17,5-22,5	-	-	-

6. POTENTIAL PLANT OUTPUT

Output of ferrosilicoaluminum makes 4 400 t/year, which is to be achieved by a 10.5MVT ore-thermal furnace.

The process envisages the furnace daily output of 13 tons a day, 370 tons a month.

7. COMPETITORS

Given the above, competition on the world FSA market is actually absent. Quite the contrary, a potentail demand for the product in the world is high and its output is rather scanty.

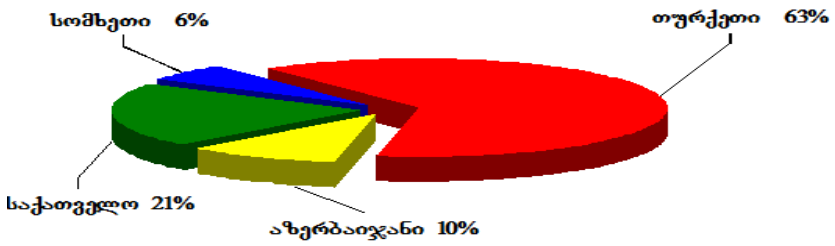
8. SALES

As has been already mentioned, ferroalloys, based on the necessity of their use in steelmaking industry, are distinguished by their high liquidity. The main buyers of the *Imeri* Group products will be the local steelmaking works and customers and those from the neighboring countries.

As regards searching for export markets in the neighbouring regions, a study of the demands of large consumers of ferroalloys, such as Turkey and Russia (producing in total 120 mln tons of steel, or 4 400 t/year under planned production) for such high-grade alloy (FSA) evidences that there will be no problems for realizing the product.

The sales according to countries are expected to be allocated according to the following schedule:

Turkey 63% (2 800 t) Azerbaijan 10% (440 t)
Georgia 21% (920 t) Armenia 6% (260 t)



Because of political instability, exports to the Russian Federation at this stage are not considered. A appropriate market research and risks analysis need to be carried out.

9. INTERNATIONAL MARKET SITUATION

As has been mentioned, optimal consumption of FSA per ton of liquid steel makes 3 kg.

Lately steelmaking in the world has reached 1 200 tons on average and should the steelmakers transfer on mass to this alloy (FSA), the demand potential will make 3 mln tons.

10. PROCESS UNITS AND THEIR LOCATION

A list of the principal engineering units of the future plant's technological process is as follows:

Charge-preparation and measuring units, ore-thermal furnace with a transformer, a set of pouring/casting and slag ladles, casting/pouring, pouring molds (and/or vats), units for fractioning ferroalloys and slag, gas-cleaning system, sprinkler.

The Project defines the following production and auxiliary areas/facilities:

1. Storage of raw materials and preparation area;
2. Batching section;
3. Main building with a 10.5MVA ore-thermal furnace;
4. Finished-products storage area;
5. Slag processing department;
6. Gas-cleaning system module;
7. Chemical laboratory;
8. Sprinkler;
9. Office and utility building;
10. Chemical water-treatment area/section;
11. Outdoor network;
12. Flue

11. PROCESS DESCRIPTION

Quartzite and other components shall be delivered to the plant by railway cars and dump-trucks.

The material shall be unloaded into concrete steel bins arranged with secondary railroad rails.

Materials should be so stored as to prevent their mixing.

To ensure continuous work, a 15- or 30-day stock of raw materials has been fixed in the storage area considering the charge material delivery distance.

The screen-sorted coal, quartzite and coke breeze is supplied by vibrating feeders and the conveyor to the dosing/batching bay.

The batching bay locates daily hoppers. By means of vibrating feeders and belt-conveyor weighers located under the hoppers the charge is being formed. The selection and proper maintenance of these units has a special role in the optimal management of the melting process.

The molding of charge is carried out according to an order coming from the automatic control system with the observance of the weight proportion of the components. The system is controlled by an operator from the

main control desk. The batched charge is supplied by the conveyor located under the hoppers/bins to the bin located above the furnace in the main block.
To ensure normal operation of the furnace, the bin should alsways be filled up by 75%.

A special car movable on segments of a sphere under the hopper ensures feeding of the charge to the furnace hoppers (10), first from one and then from the other side. The charge is being automatically or by an operator fed around the electrodes on the furnace top. The charge run proceeds in accordance with its melting in the tank. The furnace mode of operation is continuous. The steel and charge tapping takes place by means of a special machine ensuring the opening and closing of the furnace hole.

Electrode slip on the furnace is carried out to the values that exclude outlet of the noncoked electrode below the contact clamps. At that, the slip takes place thereafter without stopping the power load. The build-up/plating of electrodes and loading of the anode paste into them takes place on the connected furnace.

The yield of ferroally takes place every 2.6 hours in ladles, of the charge – in raw-material cups.

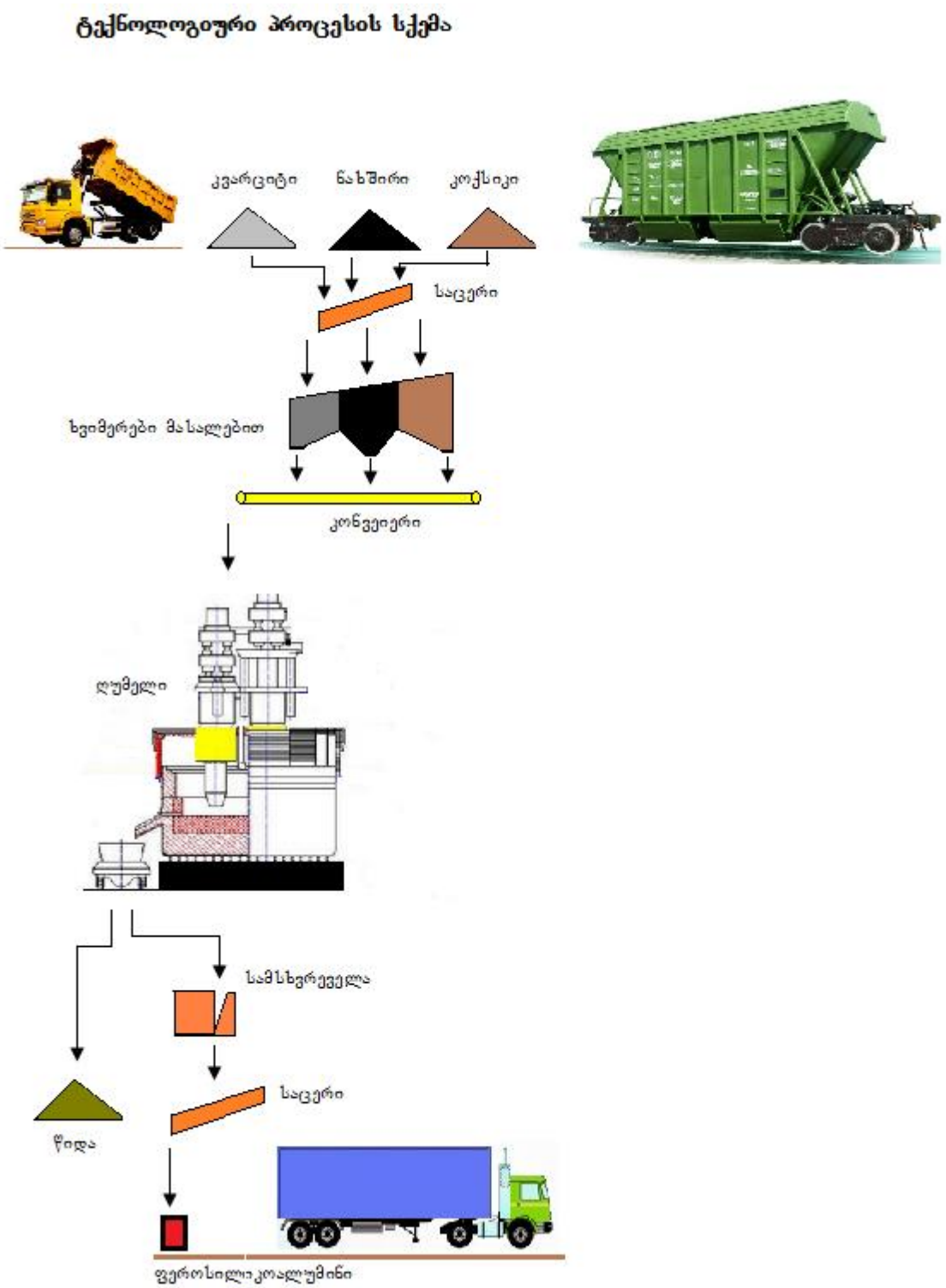
The casting bay is served by a power-driven beam crane, which, after slagging of the slag on the surface of liquid steel, ensures the gradual and portioned teeming of the steel. The ferroalloy, after it has been cooled, is delivered to the crushing and packing department in order that the steel obtain an optimum granulometric composition as requested by the customer.

From the $3m^3$-capacity hopper, the product by means of the vibrating feeder is supplied to the jaw crusher and after seiveing is removed of the pieces with fraction less than 5.0 mm.

The finished ferroalloys are stored in hoppers, from which they are packed into big bags or steel boxes. F finally, the FSA is loaded by means of an autoloader into trucks or railroad cars and delivered to the consumer.

For proper conduct of the silikoaluminum melting process, the process of sintering of self-baking electrodes is of great importance. Particular attention should be given to the anode paste composition and quality.

The proper baking and displacement of the anode paste depend on the electrode casing design and quality the paste loading regularity, and the right welding of the casing sections. All the procedures referred to above should be determined under the relevant technical conditions and the process instructions.



Process flow chart

Quartzite → Coal → Coke breeze → Screen →Hoppers with material → Conveyor → Furnace → Crusher → Slag → Screen → Ferrosilicoaluminum

12. MODE OF OPERATION

The mode of operation of the production complex, based on the process, is continuous, three-shift, four-brigade (in the succession “three work, one rests”).

The number of working days in a year, taking into account the scheduled repair and overhaul, makes 338.

13. PRODUCTION/PLANT DESIGN

As the world and domestic practice show, design of production facilities, due to their complex character and large volume of work, is carried out in two stages:

Stage I – **Predesign**, during which the following is carried out:

- Identifying a source of power supply and obtaining a permit for connection to the system;
- Technological design of workshops;
- Selecting units, installations and handling machinery, making contracts for their supply;
- Developing and designing a complete infrastructure plan;
- Design of electrotechnical, automatic control system, water supply, sewerage, heat supply, gas-cleaning, ventilation facilities and networks;
- Structural design of the project (vertical designing of structures, foundations and building site);
- Drawing up of a master plan ofthe plant;
- Design of a fire-fighting and emergency fire extinguishing system;
- Drawing up a construction schedule;
- Drawing up local and project budgets.

Stage II – **Detailed design**, during which the foolowing is carried out:

- Detailed designing of all the objects, buildings, structures and communications referred to above and drawing up of the project and local budgets.
- Finally, the design examination and commencement of construction are carried out.

14. SOURCE OF RAW MATERIALS FOR FSA PRODUCTION

- Madneuli quartzite SiO2 = 92-94%;
- Tkibuli high-ash coal, ash content - 68,8% (SiO_2-45% Al_2O_3-31%);
- Secondary aluminum production slag, contains Al_2O_3 - 31%.

15. PROCESS CONTROL

Modern ferroalloy production requires permanent control of process parameters and accurate and timely adjustment within the necessary limit. An effective solution of these rasks is possibble only by using an automatic process control system, an interactive system ’production engineer-computer’. Charge forming shall be carried out by the automatic process control system.

The process represents a set of constantly updating systems, including which process operations and an interdirected information network between the ore-thermal furnace, batching unit and the gas-cleaning block.

The entire above system makes it p;ossible to complete a ferroalloy melting passport, an electronic document, containing complete data on ferroalloy melting, from the charge forming to the finished alloy.

16. ENVIRONMENTAL CONTROL

Gas-cleaning system

With the aim to maximally clean the dust-laden gases and respirated dust emitted during melting of FSA and protect the environment it is evisaged to use dry-cleaning bad filters, which ensure the dust content of the filter-extracted air at not more than 10-15 mg/m^3 and which is significantly less than the allowable rates provided for by sanitary standards. The clean air get to the air through the funnel.

For the purpose of providing the furnace, furnace transformer and individual components of the strong smoke suckers of the gas-cleaning unit with cooling water and water saving, a circulating water-supply system with a pump station and water-cooling equipment is envisaged.

Production waste

Waste represents the slag being produced in the ferroalloy melting process, the quantitative factor of which makes – 0.18 – 0.25, meaning that during a year the slag will equal:

$$4\,400 \times 0.18\ (0.25) = 80.2\ (110.0)\ \text{t}$$

According to technology/process, this amount of slag will return to the charge, i.e. production is actually non-waste.

Slag by its composition is non-toxic and does not endanger human health and life. Generally, no toxic raw materials as well as machinery that may become a cause of toxicity are used in production.

Health protection and security measures

The following personnel health protection measures are to be taken in the future undertaking:

- A sanitary zone 70 m in length shall be created in the plant;
- A green zone within a protected area shall be created to reduce the effects of noise. According to the plan, the noise level shall not exceed 55-70 decibels.

- The content of hazardous substances in the air shall not exceed the rate acceptable by sanitary standards.

17. PLANT LOGISTICS

- Power shall be supplied to the plant without interruprions through a substation loacted within Rustavi metallurgical works.

- Water supply of the process equipment and the plant shall be ensured by the water-supply amd sewerage department.

- Products shall be handled and transported from the plant to near customers by motor vehicles, to distanced customers and to the neighboring countries – by the plant railroad through a nearby dead-end-siding.

- The slag waste shall be stored within the plant area for future deleivery to customers interested in inert materials. Transportation shall be carried out in the same manner as in the case of ferroalloys.

18. RISK CONTROL

Sales risks

Imeri Group maintains business contacts and relations with companies which operate in different countries, including Europe, and are consumers of ferroalloy products. In case the new plant is built, an appropriate organization of sales shall be ensured.

As regards the export markets of the neighboring countries, sales of 3,500 tons or 80% of FSA, where imports of ferroalloys amount to 100,000 tons shall not make a problem.

As for the local markets, sales of 21% or 900-1000 tons, where the demand makes 3,000 t, are quite feasible.

With the start-up of production, the process of certification according to the quality management standard ISO 9001:2008 is t o be initiated. Quality management and relatively lower prices, as compared with competitors, will assist the *Imeri* Group in further diversifying sales and enlarging its clientele.

Currency risks

Currency risks occur in the case of local currency deflation, which would increase production costs, specifically the expenditures on wages and power (the expenditures calculated in local currency). These two items of expenses make 16% of the sale price of the finished product. In the last 5 years, the maximum devaluation of the local currency against USD and Euro has made 15%, whereas the rise in value – 16%. Accordingly, such fluctuations will not affect the cost price and the sale price %.

Other components of the cost price are denominated or may be in USD or Euro, which annuls the currency risks in these components.

Construction and development risks

We have marked out the following three risks:

1. The risk concerning selection of a main operational department.
2. The risk concerning qualification of the Project management personnel;
3. The risk concerning the construction schedule meeting.

To insure against the risk of selection of a main operational part, we have selected several world-known suppliers of quality metallurgical equipment.

A contract on equipment supply, installation and acceptance includes the financial and service responsibility of the supplier to ensure an uninterrupted and quality production.

The Project is managed by an experienced and qualified team of managers, which have implemented a sufficient number of projects of similar scale and content.

Control of the risks associated with the violation of schedule and budget over-expenditure generally relates to the construction and erection part of the Project development. Construction of a relatively simple structure is carried out by announcing a tender for a fixed contract after a detailed design has been completed. The only alternating component, which can cause a rise in the cost of construction, includes steel structures and non-standard equipment, the probability of which should be excluded at any stage of the Project implementation by qualified management.

19. PROJECT IMPLEMENTATION PLAN

Planning the construction and start-up of FSA plant:

- Marking out (topography) a building site within the area allocated by Rustavi Metallurgical Works;
- Receiving requirements specifications from the competent authority;
- Drafting a contract on the purchase of main equipment;
- Drafting and making contracts on specialized and motor transport;
- Drafting contracts on main units and transfer of the start-up part of the amount;
- Receiving working drawings of units from the manufacturer and the construction statement;
- Initiating the "design" stage on the bas is of the construction statement;
- Selecting handling facilities, units and equipment and making delivery contracts (receipt of working drawings);
- Preparing environmental impact assessment documents and going through and approving the required procedures;
- Ending the "design" stage and preparing a business plan;
- Selecting personnel for the future plant and drafting training programs for them;
- Detail designing;
- Open warehouse arrangement works;
- Conducting preparatory construction works;
- Arranging administrative office and personnel buildings;
- Dismanling/cleaning the main building;
- Bringing and storing main units and preparing for installation;
- Gas-cleaning system construction and erection works;
- Construction and erection of a water-cooling circulating system;
- Construction and erection of a fennel;
- Construction and erection of a ferroalloys fractioning department;
- Construction and erection of a charge yard;
- Arranging a sprinkler;

- Mounting a fennel;
- Construction and erection of furnaces;
- Mounting a batching system;
- Construction and assembling underground communications;
- Assembling above-land power lines;
- Construction and mounting of inhouse and outdoor lighting network;
- Mounting above-surface mechanisms;
- Construction and erection of raw-materials and materials preparation area;
- Refractory facing of furnaces;
- Mounting an automatc control system;
- Mounting a firefighting system;
- Personnel selection and training;
- Arranging and equipping a chemical-testing laboratory;
- Provision with office and computer facilities;
- Construction of an indoor warehouse;
- Purchase and installation of handling machinery;
- Purchase and storing of raw materials and other stock;
- Construction and erection of a slag-crushing shop;
- Chief assembly and adjustment operations;
- Preparatory plant start-up works;
- Shop area improvement;
- Personnel certification (labor safety, fire safety regulations);
- Plant start-up and commencement of product sales;
- Conduct of certification according to the quality management system‘s standard ISO9001-2008.

The financial plan is based on the following key assumptions:

- The plant productivity and finished product prices shall be stable;
- Production and sales annual level shall be 4,400 tons;
- Fixed components of prime cost will increase by annual 5%.

Chief pricing components

- The chief principal and alternating pricing components in the process of ferroalloys production are electrical energy and carbohydrate-bearing raw material.
- Demand for electrical energy in ore-thermal furnaces in producing FSA varied within 11,500-12,000 kWh/t.
- Consumption of coal per ton makes 2.0 t or more than all individually taken components.

Table 1:Comsumption of charge materials and electricity

#	Material	Unit	Consumption/cost of materials, t.		
			Per 1 t product	Daily	Yearly
1	Madneuli deposit quartzite	T	1,12	15,0	5070
2	Tkibuli coal preparation waste	T	0,97	26,0	8 800
3	Coke breeze	T	0,46	6.0	2028
4	Anode paste	T	0,03	0,39	132
5	Power consumption	kWh/t	12 000	156 000	52,800 mln

Table 2: Production price calculation

#	Material	Unit	Material consumption per 1t/1t product	Price 1t/USD	Consumption 1 t/USD
1	Madneuli deposit quartzite	T	1,1	30	33
2	Tkibuli coal	T	1,0	10	10
3	Coke breeze	T	0,46	285	131
4	Mill scale	T	0,46	233	107
5	Anode paste	T	0,03	600	18
6	Power consumption	kWh/t	12 000	0,055	660
7	Motor power consumption	kWh/t	300	0.055	17
8	Wages	USD			70
9	Depreciation	USD			21
10	Other production costs	USD			20
11	Unforeseen costs	USD			18
Total cost					**1 105**

Table 3: FSA sale price and income

Reported current sale price	USD 1 450/t
Product costs	USD 1 105/t
Income	USD 345/t

Investment repayment period	24 months

Table 4: Project estimated cost

#	Item	Estimated cost, USD	
		Units, equipment	**Note**
	Key development facilities		
1	Main building - ore-thermal furnace - transformer - lining	**2 400 000**	
2	Charge preparation department	**200 000**	
3	Batching department	**100 000**	
4	Finished products storage area	**150 000**	
5	Caking section	**50 000**	
6	Slag department	**50 000**	
	Ancillary buildings and structures		
7	Administrative building	**40 000**	
8	Utility building	**100 000**	
9	Flue	**60 000**	
10	Sprinkler	**15 000**	
11	Chemical water treatment unit	**40 000**	
12	Compressor	**10 000**	
13	Gas cleaning	**400 000**	
14	Underground outdoor power networks	**30 000**	
15	Handing facilities	**50 000**	
16	Bringing units and devices	**200 000**	
17	Design works	**160 000**	
	Total	**4 055 000**	Less VAT

21. FURNACE AND MAIN UNITS/EQUIPMENT SUPPLIERS

The potential manufacturers of high-quality Chinese units: **Sinosteel Jilin Electro-Mechanical Equipment**, **Shoo-In (ITL) Holding Xi'an Equipment Co., Ltd**., and other companies are ready to take part in the process of implementation of this Project.