In the name of God

Pre-Feasibility Studies

Project Title:

LV/MV Switchgears

Project Owner:

Paya Energy Development Co

Advisor of the project:

Dornica Sustainable Development Company

Project Address: No. 4, Ahwaz Industrial Zone, Khuzestan

Preparation Date: February, 2021

Pre-Feasibility Study Summary:

General Information	
Project Title	Manufacturing LV/MV Switchgears
Capacity	
Employment	24 individuals
Business days	300 days
Product consumption	For the field of energy
Market	
Global Price of the Product	10 $
Domestic demand:	70 Milion $
Domestic production	15 Milion $
Import	58 Milion $
Export	6 Milion $
Technical Information	
Land Area	2000
Buildings Area	1470
Core Raw Material	-
How to supply raw materials	Internal/ External
Power Requirement	300 kW
Water Requirement	1 inch
Fuel required	1500
Financial Information	
Fixed Investment	241400 million Rials
Working Capital	40,000 million Rials
Total Investment	381400 million Rails
Annual Sales	452.000 million Rails
Net Present Value	5913 million Rails
Internal Rate of Return	71%
Payback Period	1.4 year
Ratio of investment resources	
Equity 32%	90048
Financing 68%	191352

Introduction:

Electricity is one of the most important industries in the world.

At present, the most employment in the field of electricity is in the power systems field, in which one of the most important jobs in the major countries of the world is panel and power circuit board industry, which has been able to create a good market for people, because all factories and offices and institutions and even large and small buildings need this industry. Today, in large and small cities, there are many workshops and companies that have been able to provide many people with jobs, and this industry is becoming more and more advanced to the point that mechanical control systems in electrical panels are gradually declining. PLC have been able to take over the market and our country is developing in these fields also, but not all factories and companies have been able to implement this new system on their devices and equipment. Because there are not many experts in this field in our country, but several companies and workshops have started to produce this type of intelligent system panels.

Investors in the housing and construction sectors are the most applicants for this type of switchboards.

According to the needs of neighboring countries such as Iraq and according to the geographical location of the Iran, it will be possible to export to these countries.

All the required raw materials can be supplied domestically and part of it can be supplied also from China.

Practical capacity is estimated at 100% of the nominal capacity, given that the company has been in production for the past years.

The time to complete and purchase the equipment is estimated at about 12 months. It is also expected that this amount of product will be produced in 300 working days and an 8-hour shift per day.

In the following report, this production plan will be reviewed in detail.

1-About the Product

Introduction

Electric power industry is among the essential industries, if not the one with the largest share of the global industrial market. Currently, power systems represent the biggest employment market within the electric power industry. An important section of this market around the world is manufacturing switchgears for power and control circuits with a good labor market to meet the demands of factories, plants, offices, organizations, and even big and small buildings. Today, many workshops and companies operate in small and big cities, employing a large number of employees. The industry is an ever-advancing one as the mechanical control systems in

switchgears are being replaced with smart PLC systems. Although Iran has also joined the development process in this area, there are still a number of plants and companies that failed to implement this new system on their machines and equipment since, despite the availability of many experts in Iran, only a small number of plants and companies manufacture this smart switchgears.

The International Electrotechnical Commission developed the IEC-60038 standard for recommended voltage levels. Low voltage (LV) values correspond to 230/400 V with a grounded (earthed) neutral connection. Medium voltage (MV) often refers to values at 3 KV, 6 KV, and 11 KV, although a number of sources classified 11 KV as high-voltage values. As the present discussion focuses on switchgears, further discussion on voltage levels is beyond the scope of this text.

Switchgears and Their Types

(1) Switchgears are boxes made of metal or non-metal materials and used to protect electronic and power devices.
(2) Based on the voltage levels, they are classified into three categories:
    1- Low-voltage (LV)
    2- Medium voltage (MV)
    3- High voltage (HV)

- **What is an LV Switchgear?**

  This section focus on the main topic: low-voltage or LV switchgears.

  LV switchgears are often made in sizes larger than the switchgears installed at houses.

  In addition, many components are used to make LV switchgears as described below.

  Equipments used in HV and MV switchgears are totally different from those used in LV switchgears.

  LV switchgears operate on voltages as low as 1000 V while the range of voltage for MV and HV switchgears is 1000-63000 V and 63000-400000 V, respectively.

LV switchgears are often installed at:

- Power stations
- Converter stations
- Commercial buildings
- Refineries
- Plants and factories, and so on.

An important point to note is that switchgears components are interconnected and failure in one component will lead to malfunctions in other components.

- **Types of LV switchgears**

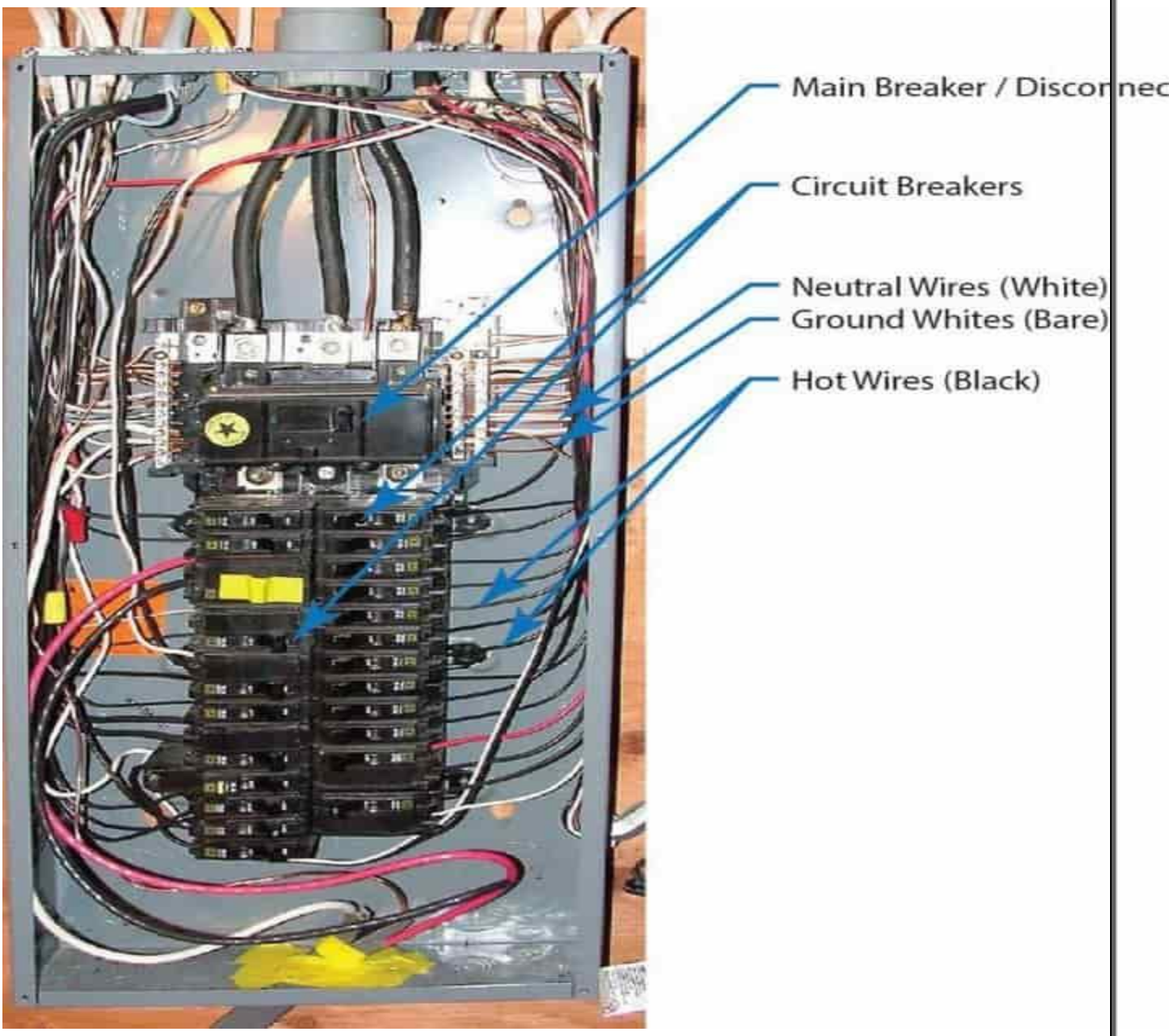
There are different types of LV switchgears.
Based on their structure, LV switchgears are classified into 4 categories:
(1) Free-standing LV switchgears
(2) Rack assembled LV switchgears
(3) Desk type assembly LV switchgears
(4) Wall-mounted LV switchgears

Each type has its own characteristics and applications. For example, free-standing switchgears can be easily accessed from front and wall-mounted type, as its name suggests, is connected to a wall for installation.

Components of LV Switchgears

An LV Switchgear has many components including:

(1) Contactors
(2) Residual current breakers
(3) Transformers
(4) Single- and three-phase bimetal switches
(5) Motor protection circuit breaker (MPCB)
(6) Automatic molded case circuit breaker (MCCB) and miniature circuit breaker (MCB)
(7) Fuses and switches
(8) Voltmeter switch
(9) Rotary and cam switches
(10) Rails
(11) Busbars
(12) Glands and terminals
(13) Insulators
(14) Neutral busbar
(15) Signal lights
(16) Wire lugs and cable lugs



Each component and device is essential for operation of switchgears and an understanding of these components and how they work is required to build good switchgears.

- Connectors
  Connectors are used to remotely open or close control circuits. When receiving a command for breaking a circuit, a connector disconnects all **three-phase** or **single-phase** devices and **electric devices**.
  What is a capacitor connector?
- Fuses

Many of you know what **fuses** do. They disconnect a circuit to protect it against overcurrent conditions. A fuse can be simply defined as a metal string that breaks or melts down under excessive electrical current. Fuses are essential components of all switchgears.

Types of fuses:

Automatic MCB switch: This operates like a fuse, only it disconnects a circuit for overload protection rather than for overcurrent protection. MCB switches are more sensitive and safer than fuses. They also have thermal or thermal-electromagnetic functions.

Three-phase control in LV switchgears

Digital three-phase controllers in LV switchgears protect electric motors.

- Single- and three-phase bimetal switches

  Bimetal switches are among the components of LV switchgears. They are used to protect three-phase electric motors against overload under low voltages.
- What is a bimetal switch?

MPCB switches

Their functions are twofold:

(1) Protection against error (electromagnetic function)

(2) Protection against overload (electronic function)

It is important to note that MPCBs have further applications in other types of switchgears, *i.e.* MV and HV switchgears

- Double push button

  This is used to start and stop a motor.

  This function is available if the switch is of double push type. Single push buttons perform only one of these two functions.
- Limit switch

  As the name suggest, they act as safety locks to control the systems.
- Microswitches

  They are the simplest component of LV switchgears used to connect or disconnect electronic circuits.
- Microswitch

  Timers and time switches set the time between two functions in control circuits.
- Timers and control clocks

These are used to start or shut down devices at specific times.

- Restart timers
  These are used for protection and safety when power goes off and back on.
- Voltage protection
  These protectors direct overvoltage to earth connection when voltage exceeds maximum allowable values.

- Load control
  Load switches are used to disconnect electric motors under overload.
- Electronic floaters
  These switches make sure that motors do not operate under dry conditions and control the level of fluids in equipment.
- Sensors in LV switchgears
  They have three functions including
  (1) Detecting malfunctions
  (2) Detecting failure in devices
  (3) Detecting errors in other parts of the system

LV Switchgears

LV switchgears will be supplied with LV generators or transformers at 230/400V. (The primary voltage of transformers is often set at 6 kV, 11 kV, or 20 kV). These switchgears have equipment for connection/disconnection, control, measurement, protection, and regulation and are mainly designed to control electrical equipment operating with three-phase 400 V or single-phase 230 V inputs.

LV switchgears contain motor drivers, motor control center (MCC), incoming circuit switch, bus coupler, power-consuming components at the output, switches, fuses, and peripherals all designed into a single-line diagram. Input power switches, if more than one, must be closed for normal operation. Bus couplers may be open or close depending on the operational conditions. If open, a couple must automatically close when an input switch is opened. The mechanism of how a couple works must be selected based on the project, approved by the client, and indicated on the single-line diagram and datasheets. A protection schematic, connections, and interlock mechanisms should be devised for incoming switches and couplers and how they are connected to upstream switches. It is important to note that a single-line diagram often depicts only the main components of an LV switchgear. The schematics for

control, protection, measurement, drawings, and relevant tables will be attached to this diagram if needed.

Switchgears usually have metal free-standing housings that can be installed on the floor. They have a multi-casing metal frames often made of steel sheets 2 mm or more in thickness. Depending on the client's instructions and basic project documents, devices will be accessible from the front or back side of the switchgear. All equipment needed for operation must be installed within the switchgear and properly placed in separate partitions. Separators or (metal or non-metal) buckles are used to separate internal components based on IEC-60439-1. Protection grades for switchgear panels are often indicated on project documents based on the environmental conditions of the location where these panels are to be installed or based on client's instruction but IP41 often applies to indoor switchgears while IP55 applies to outdoor ones. LV switchgears are often installed inside substations or properly ventilated areas. As far as environment classification allows, these substations or indoor places are built at safe locations. Switchgear datasheets contain operational information such as temperature of switchgear site, elevation above the sea level, relative humidity, *etc*.

Medium-Voltage Switchgears

MV switchgears with operating at voltages indicated in the introduction section will be supplied with generators or transformers producing an output voltage that can be used by these switchgears. (For a transformer with 6 kV at secondary winding, primary voltage can be 11, 20, and 33 kV.) MV switchgears contain circuit breakers or contactor fuses together with control, measurement, and protection requirements indicated in a single-line diagram. The specifications of switches at incoming circuits and bus couplers for LV switchgears generally apply to MV switchgears as well. MV switchgear panels must be properly ventilated. Regarding the environmental classification and operational conditions, all requirements noted for LV switchgears also apply to MV switchgears. This is also true of protection requirements. The materials used in panels and accessories and installation process must comply with IEC 60298.

Connection/Disconnection Equipment and Circuit Breakers (CB) in LV and MV Switchgears

Incoming connections and bus coupler in switchgears must be connected to circuit breakers. Moreover, some bus bars may be supplied through circuit breakers as indicated in sing-line diagrams. In addition to disconnecting loads, circuit breakers may also disconnect a circuit under short-circuit conditions. These switches come in different types:

- Miniature circuit breakers (MCB)
- Residual current circuit breakers (RCCB)
- MCCB
- Air circuit breakers (ACB)
- Vacuum circuit breakers (VCB)
- SF6

Fuses

Fuses are mainly intended to provide protection against short circuits and often used with contactors in switchgears. In terms of structure and the type of protection they provide, fuses are classified into different groups. Fuses limit energy. IEC-60269 discusses types of fuses operating at different voltages. There are various types of MV/LV fuses. Cut-out fuses are LV fuses used in overhead substations. Bottle (screw-type) fuse is another type of LV fuse. Fuses are also generally divided into two groups based on their location and application: slow blow and fast blow fuses.

Contactors

Contactors can quickly connect/disconnect loads but they cannot disconnect loads during short circuit conditions. Depending on the type of load and maximum starting current, contactors are divided into MV and LV classes. In addition, they can be categorized based on their applications in direct and alternating currents. For example, AC-1 contactors are used for resistive AC loads while AC-3 contactors are used for inductive loads. DC-1 contractors are used to control DC motors with shunt connection and low switching frequencies while DC-3 contactors are used for DC motors with series connection and low switching frequencies.

Various types of switchgears may be used depending on applications, area, and whether the power supply is low or high voltage. Switchgears are sometimes referred to as switchgear and control assembly (SCA).

As you may know, the main function of a switchgear is to receive electricity and distribute in to circuits within a buildings. Switchgears must be designed and manufactures in a way that (1) properly controls the current and (2) provides proper protection. In addition, a switchgear should be able to detect the size and intensity of fault and isolate the faulty section from the whole system within the shortest time possible.

Furthermore, since a considerable part of work is carried out on powered switchgears where blowing is potentially a common thing to occur, switchgears must be properly designed to prevent shocks to operators and staff.

Medium-Voltage Switchgear

Despite their similarities, MV switchgears are different from LV ones in a number of ways. Common properties include distribution of electricity at different voltage levels. It is important to note that MV switchgears can replace LV applications while LV switchgears cannot be used for MV applications.

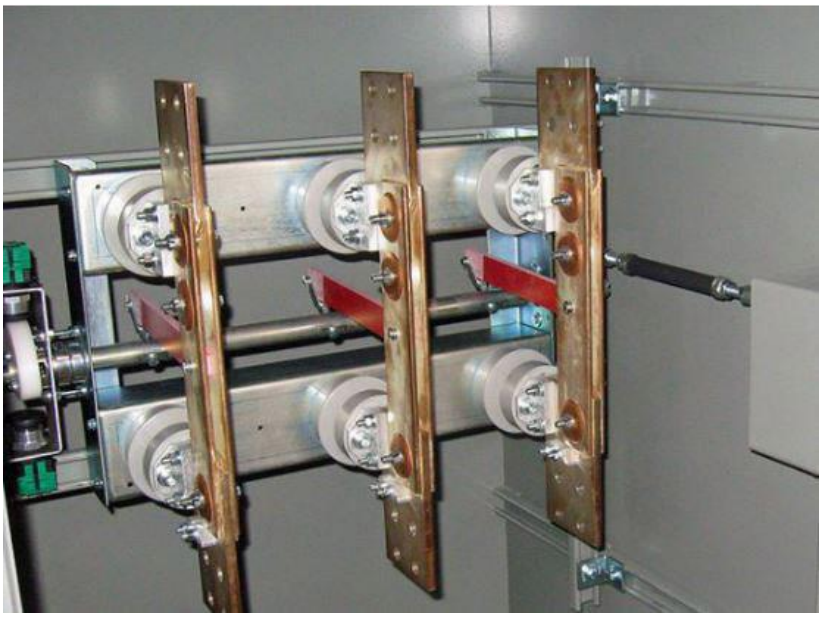
Main components of an MV Switchgear:

- Input cables
- Contactors
- Knife switch
- Load break switch
- Grounding switch
- Circuit breaker
- Fuses
- Relays

Input Cables

These cables can be used for high, medium, and low voltage applications. Traditionally, the high-voltage type was used with oil-impregnated paper. Today, Cross-linked polyethylene (XLPE) or ethylene propylene (ERP) is used for insulation. The common XLPE or ERP insulators are flexible and suitable for high voltage levels. An option preferable to cables is to use busbars which are more expensive but also more reliable.

Knife Switch



Knife switches are used in MV switchgears when isolation is needed to separate certain parts of switchgear for maintenance or other works like grounding. They are operated manually under no-load condition and using motors and compressed air for remote control mode. The size of these switches should also be considered when designing switchgears.

Load break switch

Load break switches are widely used in MV circuits. An important point to note about these switches is their ability to function under load and to properly disconnect a circuit in emergencies.

Two conventional mechanisms are included in these switches:

- In the first one, a compressed is used to direct the movement of the contactors. This mechanism can be used for opening/closing.
- In the second one, two separate springs are used, one for opening and one for closing.

Two types of load break switches, namely knife and slide switches, are generally used both of which can operate with or without fuses.

Grounding switch

This is generally used in switchgears for isolating feeders (at input or output) when carrying out maintenance or other works. It is important to note that this switch must be mechanically interlocked to the circuit breaker to prevent short circuit when closed.

Circuit breaker

As its name suggests, a circuit breaker is mainly intended to close/open circuits when needed or during emergencies. A circuit breaker is a mechanical switch that can interrupt a circuit under load or during short circuit conditions.

Based on the mechanism and insulation used, circuit breakers are classified into the following categories:

- Oil circuit breaker
- Minimum oil circuit breaker
- Air circuit breaker
- Gas (SF6) circuit breaker
- Vacuum circuit breaker
- Air blast circuit breaker

Medium-voltage fuses

Like other fuses, MV fuses in switchgears are needed to provide protection against short circuits. They are typically categorized into expulsion fuses and current-limiting fuses.

They differ from typical fuses in

- Higher breaking capacity
- Higher current rating
- Lower switching frequency
- Longer life

Because of their switching voltage, which is used under electric arcs, these fuses must operate at their nominal voltages.

Protective relays

The main function of protection relays is to disconnect a faulty part of a circuit when a fault is detected. They are used to protect substation equipment including transformers, feeders, capacitors, generators, motors, *etc*.

1-1-**Product Name and Code (ISIC 3)**

The most common type of classification used in economic operations is ISIC. The table below shows ISIC for switchgears.

ISIC	Product
3120512424	LV Switchgear
3120512426	MV switchgear

Source: Ministry of Industries and Mines

1-2-Assessment and Standard Presentation (National or International)

This section presents IEC-approved standards related to environmental conditions for switchgears (standards developed by the International Electrotechnical Commission (IEC) was discussed in details earlier).

IEC 60439-1 covers standards pertaining to environmental conditions for LV switchgears as a combination of on/off switches together with equipments such as instrumentations, protective equipment, control equipment, regulators, and other equipment fully installed and mounted on switchgears.

All equipment referred to above should comply with the standards for LV switchgears as described below.

Standard Ambient Conditions for LV Switchgears:

- Standard ambient temperature for indoor LV switchgears:
  For this type of measurement, average ambient temperature during a day under normal conditions must not exceed 35°C and the allowable temperature range is -5 to 40 °C.
- Standard humidity for indoor LV switchgears:
  For temperatures below 40 °C, relative humidity must not exceed 50% but at lower temperatures humidity is not a problem. For example, a relative humidity of 90% will not cause a problem at 20 °C.
- Standard ambient temperature for outdoor LV switchgears:
  Normally, ambient temperature during a day must not exceed 35 °C with an allowable range of -25 t0 40 °C for temperate climate and a minimum allowable temperature of -50 °C for cold northern climate.
- Standard humidity for outdoor LV switchgears:
  Humidity may reach to100% provided that minimum temperature is 25 °C.
- Standard pollution level for LV switchgears:
  This covers four levels or grades as described below:
  Grade 1: dry pollution or no conductive pollution
  Grade 2: dry pollution which becomes conductive in the presence of humidity

Grade 3: temporary conductive pollution (According to the standard, LV switchgears are used for grade 3).
Grade 4: constant conductive pollution

- Standard elevation above the sea level for LV switchgears:
  According to this standard, switchgears must not be installed at elevations higher than 2 km (2000 m) above the sea level. The reason behind this is two important effects caused by elevation that may affect switchgear performance: reduced heat exchange from electrical facilities given the lower air concentration and reduced air density which leads to lower dielectric constant for air that in turn causes an insulation breakdown.

Standard Ambient Conditions for MV Switchgears

The section above presented some standard ambient conditions for LV switchgears. This section presents these standards for MV switchgears:

- Standard ambient temperature for indoor MV switchgears:
  Average ambient temperature during a day under normal conditions must not exceed 35°C and the allowable temperature range is up to 40 °C. Given that there are three classifications (-5, -15, and -25 °C), the minimum temperature must not fall below -5, -15, and -25 °C, respectively.
- Standard humidity for indoor MV switchgears:
  Humidity must not exceed 95% and over a period of month, it must not exceed 90%.
- Pollution Level:
  In an indoor space, air must not contain dust or corrupting, corrosive, or inflammable substances, but for outdoor installation, air pollution must not exceed level II as defined in IEC 815.
- Standard elevation above the sea level for MV switchgears:
  The elevation must not be higher than 1 km (1000 m).
  In the end, it is important to note that conditions other than those specified above will be considered as special ambient conditions.

1-3-National Standard

Title	Standard Code
Switchgear	IEC

Source: Institute of Standard & Industrial Research of Iran (2019)

1-4-Standard and Permits

Operation license from the Ministry of Industries, Mines, and Trade
Operation license from the Institute of Standards & Industrial Research of Iran

1-5-Applications

Step-down (240 kV-400V) transformers at the delivery end of the power generation and transmission lines act as power supplies to LV switchgears which, in turn, act as an interface connecting the power supply to power consuming devices with a number of important functions:

- Distribute electricity and supply power to devices
- Protect devices and operators' safety
- Optimize and control devices and equipment

Description:

Supply and distribute power: In an industrial or residential area, there are often several sources of power (utility, generators) to supply power to a large number of consumers. Obviously, power should be distributed among all consumers. In fact, a switchgear may have several inputs and outputs. The incoming line is the main input supplying power to the switchgear. Depending on the power-consuming side, the input voltage varies (380, 220, 24 V) at different currents (while, of course, complying with the nominal rating standards).

A busbar is an interface connecting the incoming line to the power consuming side and distributes current at this side. Examples include copper busbars and terminals simply used to distribute load which refers to the amount of consumed power at a system output. In general, power is distributed among consuming units.

Protection: The most essential function of a switchgear is protection. A switchgear must act effectively in protecting humans, provide protection against fire, protect consumers against electric irregularities including excessively high or low levels of voltage, overload, short circuits, and any factor that may cause electrical or mechanical damage to consumers.

Fuses and protective switches are embedded in switchgears to prevent overcurrent at system output lines. These devices react to and disconnect excessive currents. In fact, fuses limit current to protect circuits against overload.

Protective function of switchgear is a challenging topic in power industry and will be widely covered here.

A major issue for switchgear designers and manufacturers to consider is how to provide protection and how to implement this protective function.

Therefore, we need to know what equipment is used by each consumer and what characteristics these protective devices have in order to be able to properly design switchgears.

Proper design is important because in some cases despite anticipating all protective needs of consumers, there are still cases of damages and burns. This can be caused by miscalculation or selecting the wrong protective equipment. Everything must be done to prevent burns or damages in power consuming devices.

Stabilizers can be used to further protects lamps and prevent damaging oscillations in voltage. They stabilize voltage and remove oscillations while providing other advantages as well.

However, stabilizers are arguably expensive and the question is whether it is worth it or not to use stabilizers for such applications. Is it better to change 2 light bulbs a year or pay thousand dollars for a stabilizer? Here is another example. As you may know, electric motors can be started up using speed controllers with several advantages including protection against a disconnected phase, overload protection, speed control, acting as drivers with no initial current, and controllability. The question is given their advantages, why motor speed drivers are not used in just any system. The answer is it is not economical to use them in any circuit. Most circuits still use contactors to drive motors.

Of course, these examples did not mean that the devices noted above are useless because many measures taken and investments made on safety and protection will, in long term, pay off.

In summary, these examples are intended to show that in most cases potential expenses should be taken into consideration when making a design. Protective devices for each project should be artfully selected based on efficiency, sensitivity, and cost considerations. It is important to provide the best possible protection and quality with the lowest possible costs. In many cases, expensive devices have failed to provide acceptable quality and protection.

Therefore, electrical equipment and devices can be protected to a large extent.

Control: Industrially speaking, control can be an extremely traditional or smart and modern topic. An example is to turn on a light using an ordinary switch or controllers like PLC. In any case, a switchgear acts as a control and protection center for devices

and equipment. The topic of control, as far as switchgears are concerned, is a wide topic that cannot be summarized into a single view. In general, control requirements depend on several factors:

- System and protection requirements
- Economic considerations
- Anticipated needs and future development
- Client's need and requirements

1-5-1-A Look into the Consumption Trend over the Past Five Years

Over 250,000 switchgear cells can be manufactured domestically in a year, but only 750,000 cells are used and the rest remains unused. This means that less than 30% of domestic production capacity has been used. In addition, assuming that each cell is priced at 7 to 8 millions, a considerable employment and income capacity has been lost.

The current conditions place increasingly growing pressure on manufacturers although even under these conditions, over 10,000 individuals are directly employed according to official statistics. On the other hand, this area of economic activity is capable of creating jobs more than three times the current capacity.

1-5-2-Manufacturing Process

Switchgears are manufactures in factories through the process described below:

Technical conditions:

Standards and Sources

The content of the Budget and Plan Organization's Circular 110 as the legal authority; existing standards developed by the Institute of Standards and Industrial Research of Iran on electrical equipment and facilities are included to ensure compliance of project specifications with IEC and VDE and domestic and international standards for manufacturing electrical equipment and switchgears. As-built drawings will be developed at this stage starting from negotiations with clients and proposal presentation to the start of work at production line by the engineering and sales departments of the company:

(a) Receiving and reviewing documents and drawings (if client only provides general information and specification, the engineering department of the company will develop single-line diagrams and submit them for client's

approval), information regarding the type and layout of switchgear, and price estimation

(b) Closely reviewing drawings and specifications for a list of device and equipment based on their brands and making recommendations

(c) Negotiating with client and, after conclusion of contract, with consultant and seeking feedback on technical matters

(d) Ensuring that developed drawings and documents match valid standards and client's and consultant's instructions, modifying the documents and drawings (if needed) to manufacture a high-quality product within the shortest time possible.

Preparing as-built drawings including

- Isometric drawings (cubicle)
- Layouts
- Drawings for power and control circuits with wire and terminal numbering (wiring diagram)
- Presenting as-built drawings with a list of requirements and equipment for client's approval and returning the same to factory to start the production process
- Planning for different parts of the production line for ongoing projects or those still pending negotiations

General structure of switchgears:

(a) All switchgears (whether free-standing, LV wall-mounted, distribution, or control switchgears) will be made of oil-impregnated sheets 1.5-2.5 mm in thickness.

(b) Free-standing LV switchgear frames will be made of oil-impregnated steel sheets 2 mm in thickness.

(c) Switchgear housing consists of chassis and casing fastened together using nuts and bolts.

(d) Multi-cell switchgears are made of segregated sells bolted together.

(e) All cells are equipped with a lockable hinged door in the front with a side door for installing plastic parts.

(f) Cells are properly designed to have the required space to allow for inspection, maintenance, access to devices, busbars and equipment in addition to further access for adding extensions.

(g) The backside of the cells is bolted to the frame using oil-impregnated sheets. Hinged doors are available depending on client's demands. In both cases, the

devices and equipments inside the switchgear will be easily accessible for inspection and maintenance.

(h) To prevent potential damages to installation parts, cable input/output, control, and measurements area are separated to the extent possible. Measurement tools and instrumentations are installed in the upper front part to provide easy access and visibility.

(i) Depending on the project requirements, the cell containing incoming lines will be designed at one side, with the cell containing the outgoing lines placed at the other side: main busbars (phase connection) will be installed at the upper back side and the neutral and ground busbar will be installed in the bottom part of the cells across the switchgears.

(j) Switchgear cases or housing will be made in a way that enables any changes with no need for repainting or re-welding (by properly positioning holes and using movable parts with bolts and nuts).

(k) The switchgears will be equipped with a hook at the top for handling.

(l) Cable boxes will be embedded in free-standing switchgears for incoming and outgoing cables.

Painting/coating process:

١- Cleaning and removing oil
٢- Paint stripping
٣- Phosphate conversion coating
٤- Painting /coating

Oil removal

Oil, fat, grease, and dust may prevent water from reaching the surface of the work piece. These are removed in the following ways:

(a) Cold removal using neutral solutions like perchloroethylene, trichloroethylene, oil or gasoline

(b) Hot removal using basic solutions like sodium hydroxide and sodium carbonate

(c) Electrical removal using cathode-anode or ultrasound techniques

*Note: Hot removal using basic solutions is more common in metal industries due to its lows cost and lower initial investment required.

Oil removal by immersion:

In this method, parts are immersed in tanks filled with oil-removing basic solutions. A circuit connected to the tank will ensure uniformity and speed up oil removal by constantly stirring the solution.

Treatment time:

In immersion method, the work piece should remain immersed for 12 to 20 minutes.

Paint stripping:

The following techniques are used:

(a) Wire brush:
This is often used for removal of paint blisters, welded spots, or maintenance under limited conditions.

(b) Sandpaper:
Sandpapers and mechanical discs are used for small surfaces.

(c) Chemical removal:
Sulfuric acid, Hydrochloric acid, or phosphoric acid solutions are used for paint removal. This is a good technique but requires careful control for corrosion and, following paint stripping, the work piece must be thoroughly washed with water. Usually, some corrosion inhibitors are added to the solution. Given the small thickness of switchgear walls, it is a good choice to use sulfuric acid 30% v/v with corrosion inhibitor. In this method, phosphoric acid stops acting on the iron as soon as it passes through the rust layer. And in cases where phosphate coating is needed, this acid layer enhanced the phosphate treatment effect. Sodium nitrite is used as rust inhibitor once this stage is completed.

Phosphate conversion coating:

The oil- and paint-less metal surface starts to form crystals with phosphoric and nitric acid salts under certain conditions. The irregular surface of the crystal enhances adhesion of paint layers.

Advantages of phosphate coating:

Phosphate conversion coating

(1) Prevents rusts;
(2) Enhances adhesiveness;
(3) Enables easy pressing; and
(4) Isolates treated parts from electrical current

In addition, when used with immersion, it

- Needs only small investments;
- Is inexpensive in terms of maintenance and energy supply;

- Is small and compact;
- Is suitable at any production capacity;
- Can be used on very small parts; and
- Takes a long time to complete.

Types of phosphate conversion coating:

(1) Treatment on iron
(2) Treatment on zinc

*Note 1: In general for parts that are painted following phosphate conversion coating, it is preferable to create small crystal “balls” as they make stronger bonds with metal and paints.

*Note 2: In the immersion type, phosphate conversion coating must be done at 55-60 °C. The temperature must not exceed 65 °C as it can blacken the coated sheets.

Painting/coating:

Once oil removal, paint stripping, and phosphate coating are completed, longer life for a switchgear can be guaranteed by selecting the right paint and painting/coating technique. The following questions should be considered when choosing the right paint:

- Is to switchgear to be installed indoor or outdoor?
- Will it be operated by laypersons?
- Is it possible to seasonally repair the switchgear where it is to be installed?
- Will the switchgear be installed at a place with hard work conditions? (for example, at a mine, chemical plants, *etc*.)
- Will it be safeguarded against potential damages?
- Will it be assembled part by part or will it be welded in a monolithic structure?
- Will the switchgear be installed immediately after it is manufactured or will it be stored for a long time? For the second case, will it be stored at open warehouse or a roofed one?
- What useful life is planned for the switchgear given the conditions of the place where it is to be operated?

Selecting the right coating

Coatings with life expectancy of over 20 years: powder coating containing zinc, aluminum, epoxy, and alkyd paints, 100-200 μm in thickness

Coatings with life expectancy of 10 to 20 years: two-component powder coating containing epoxy and coal tar epoxy, 85 to 150 μm in thickness

Coatings with life expectancy of 5 to 10 years: single or two-component powder coating containing zinc and aluminum and antichemical agents, 50 to 100 μm in thickness

Coatings with life expectancy of less than 5 years: single or two-component powder coating containing epoxy, 40 to 80 μm in thickness

*N.B.: Thin coatings are used for favorable environments while thick coatings are used for unfavorable chemical environments. Shiny paints must be avoided on switchgears.

Effects of temperature and time on paint flexibility and hardness:

Paints are dried at high temperatures of furnaces in order to shorten the drying period and further complete the reactions. At high temperatures, paint penetrates to the deepest pores of the phosphated crystals, leading to stronger coating.

Electrostatic powder coating:
Once the oil removal, paint stripping, and phosphate conversion coating are completed, sheets are moved to the coating section. First, the sheets must be phosphate coated, washed through immersion, and transferred to the drying oven/furnace. Once completely dried, a sheet enters the coating section where electrostatic powder coating is used to apply uniform layers of polyester and epoxy coatings. The type of coating is selected based on indoor/outdoor installation and client's instructions.
Typically, polyester coating is used for outdoor switchgears and epoxy coating for outdoor ones.
Once uniform application of electrostatic powder coating is completed, coated sheets are directed to paint curing ovens. Curing temperature and time vary based on the standards developed by the manufacturer.
In general, an electrostatically powder coated sheet should be cured for 10 minutes at 200 °C before it is ready for operation and assembly.

Physical test in coating stage:
Cured sheet must be assessed for quality control using 5 tests:

(1) Pull-off test
(2) Impact resistance test
(3) Elasticity test
(4) Hardness test
(5) Gloss test

In hardness test, an object like a pencil or a nail is used to scratch the coating on a coated sheet. The coating is of an acceptable quality if the force applied does not affect the surface and the coating remains unscratched.
In gloss test, a sheet is placed on a gloss meter for reading the gloss measurement.
Housings:
Housings must be made of metal and in a way that meets the following conditions when installed.

The floor, even if made of non-metal materials, should be regarded as a part of the housing. The protection grade should be agreed upon by manufacturer and consumer.

The walls of the room are not considered a part of the housing.

Electrical devices and equipment are assembled based on assembly layout drawings taking into account the following steps:

(a) Selecting the right type of bolts and nuts to fasten electrical equipment based on the type of the equipment and the dynamic forces applied when the switchgear is connected to a source of electricity
(b) Devices and components are installed in a way that enables easy replacement while minimizing the downtime of switchgear.
(c) These components and devices are installed on the frame and pre-fabricated trays and installation on the switchgear casing is avoided to the extent possible.
(d) Pin insulators and beams are installed on a mechanically strong base and are capable of withstanding allowable short circuit currents.

1-6-Applications in Domestic and Foreign Markets

A switchgear is, in fact, a housing for electrical equipment, although it sometimes contain pneumatic equipment such as solenoid valves, compressors, *etc*.

In general, it is important to note that learning the techniques used in connection to switchgears requires introduction to a number of essential items as described below:

- General principles and standards of switchgears and electrical equipment housing, including IP, protection grade, segregation grade, protection against weather conditions, *etc*
- Professional principles of switchgears, nominal voltage and current ratings, *etc*
- Introduction to electrical equipment, their functions, and how to properly select them

- Introduction to electrical facilities and calculations
- Introduction to such topics as relays and protection, substation design, *etc*
- Introduction to control and logic circuits

Each of these topics must be learned separately. However, the first two items noted above are more important when it comes to switchgears. Switchgear manufacturing also involves other sciences like ergonomic, which will not be discussed here.

In general, there are important principles, standards, and definitions in connection to switchgears, including switchgear structure (*e.g.* free-standing, wall-mounted, rack, desktop switchgears) with particular functions and applications.

1-7-**Assessing the Market for Product**

Major domestic consumers: A considerable portion of demand for this type of switchgears comes for investors in housing and construction sector.

1-8-Export Conditions

Given the demand in the neighboring countries like Iraq and the geographical location in region, Iran can export the product to this country.

1-9-Import Conditions

All materials and items required can be domestically supplied with the remaining parts imported from China.

2-Assessment and Determination of the Minimum Economic Capacity including Fixed Investment Value in Rials and Dollars (Using the Available Data of Ongoing Units, UNIDO, Internet and Global Databases, Equipment & Technology vendors, *etc.*)

The annual nominal capacity of the project is as follows, considering the domestic demands (especially Khuzestan province) and exporting.

<u>As presented in the table below</u>

An actual capacity of full (100%) nominal capacity is anticipated given that the company has been continuously manufacturing the products over the past years.

It is estimated that completion and purchase of equipment will take 12 months to complete. In addition, it is anticipated that this amount of product will be produced in 300 business days using an 8-hour shift.

Production and sales plan over the next 5 years

Year 5	Year 4	Year 3	Year 2	Year 1	Year of Operation / Title	
100	100	100	100	100	Capacity Percentage	
50	50	50	50	50	3-cell substation (input, measurement, output)	
100	100	100	100	100	200-kw demand	
100	100	100	100	100	100-kw demand	
100	100	100	100	100	50-kw demand	
100	100	100	100	100	250-kw demand	
100	100	100	100	100	200-kw capacitor bank	
					Revenue	
3500	3500	3500	3500	3500	3-cell substation (input, measurement, output)	
650	650	650	650	650	200-kw demand	
500	500	500	500	500	100-kw demand	
360	360	360	360	360	50-kw demand	
760	760	760	760	760	250-kw demand	
500	500	500	500	500	200-kw capacitor bank	
452.000	452.000	452.000	452.000	452.000	**Sales**	
					Million Rials	**Total Sales**
					Million Euros (1€=280,000R)	

Project Investment Details:

Total Cost		Required Cost					Cost (million Rials)	Item
Million Euros	Million Rials	Total (Million Rials)	Rial	Foreign Currencies				
			Million Rials	Equivalent to Rials (Million Rials)	Million Yuan	Million Dollars		
	22.000						22.000	**Land**
	2500	1000	1000				1500	**Landscaping**
	28.000	8000	8000				20.000	**Construction**
	3000	-	-				3000	**Facilities**
	150.000	130.000	130.000				20.000	**Equipment and Machinery**
	3000	2000	2000				1000	**Workshop Equipments**
	4900	4000	4000				900	**Transportation**
	20.000	10.000	10.000				10.000	**Office Equipment**
	8000	8000	8000					**Unforeseen Expenses**
	241400	**163.000**	**163.000**				**78400**	**Total Fix Assets**
	-	-	-	-		-	-	**Pre-Operation Costs**
	241400	**163.000**	**163.000**				**78400**	**Total Fixed Investment**
	40000	20000	20.000				20.000	**Working Capital**
	281400	183.000	183.000				98400	**Total Investment**

- 1 Euro = 280,000 Rials
- 1 Dollar = 255,000 Rials
- 1 Yuan = 60,000 Rials

Land Details:

Equivalent to Euros	Total Cost of Available and Required	Total Cost (Million Rials)		Area (m^2)		Item
		Required	Available	Required	Available	
	22.000				2000	**Land**

Building Details:

Equivalent to Euros	Total Cost (Million Rials)			Unit Price (Rials)	Area (m^2)		Item
	Total	Required	Accomplished		Required	Accomplished	
					200	800	Production Hall: Industrial Shed
					100	170	Raw Material and Products Warehouse: Industrial Shed
						400	Offices
						100	Electrical Room and other facilities
	28000	**8000**	**20.000**			**1470**	**Gross Floor Area and Total Costs**

Facilities Details:

Equivalent to Euros	Required Cost (Million Rials)			Technical Specifications	Item
	Total	Required	Accomplished		
	1.00		1.00		Power Supply
	800		800	1 inch	Water
	400		400	30 m^3	Gas Supply
	500		500		Air conditioning
	300		300		Other
	3000				**Total**

Production Line Machinery:

Equivalent to Euros		Total (Million Rials)	Cost (Million Rials)		Equivalent in Million Rials	Equivalent in Dollars		Number		Machinery	Num.
			Required	Accomplished		Required	Accomplished	Required	Available		
										Laser cutting machine	
										Triple-function hydraulic machine	
										Guillotine shearing machine	
										Automatic bender	
										Stud welding machine	
										Other	
		150.000	**130.000**	**20.000**				**Total**			

Office and Service Equipment

Equivalent to Euros	Required Cost (Million Rials)			Number		Items
	Total	Required	Accomplished	Required	Accomplished	
				2	2	Office Furniture
				10	5	Chairs
					1	Faxes
					1	Telephone/Modems
				10	8	Computers
				2	3	Printers
				2	1	Other
	20.000	**10.000**	**10.000**		**Total**	

Working Capital Costs:

Equivalent to Euros	Total Cost				Duration (months)	Item
	Total (Million Rials)	Rials	Foreign Currencies			
		Million Rias	Equivalent to Million Rias	Million Yuan		
	170.000	50,000			2	Raw Material and Packaging
					1	Other

					1	Liability
					1	Petty Cash
	17.000					Working Capital

Production Costs:

Equivalent to Euros	Cost (Million Rials)	Items
	240.000	Raw Material and Packaging
	263	Energy (Power, Water, Fuel, . . .)
	500	Repair and Maintenance
	500	Unforeseen
	600	Depreciation
	9450	Personnel
	100	Office and Sales
	-	Financial Facilities
	300	Factory Insurance
	251713	**Total**

3-The volume of Annual Required Raw Materials and Where to Supply Them From (Domestic or Foreign), The Cost (in Rials and Euros) and Examining the Fundamental Changes in the Process of Supplying the Required Items in the Past and Future

Equivalent to Euros	Total Price			Supply Location	Unit Price		Consumption Required per Total Capacity	Consumption per Unit of Product	Consumption Unit	Item	Num.
	Total (Million Rials)	Foreign Currency (Yuan)	Domestic (Million Rials)		Foreign Currency (Yuan)	Domestic (Million Rials)					
				Iran	175.000	35000	50		-	3-cell substation (input-measurement-output)	1
				Iran	65.000	650	100		-	200-kw demand	2
					50.000	500	100			100-kw demand	3
					36.000	360	100			50-kw demand	4
					76.000	760	100			250-kw demand	5
					50.000	500	100			200-kw capacitor bank	6

	452.000			**Total**

4-Human Resources and Employment Status

The project will create 52 jobs. Specialized human resources will be available due to high-quality universities and technical and vocational training centers in Khuzestan province.

5-Assessment and Determination of Power, Water and Fuel Supply and Telecommunication and Transportation Facilities (Roads, Railways, Airports, Ports, . . .) and How to Provide Those to a Zone Suitable for the Project

Annual Salary and Benefits - 14 months	Salary - Rials	Number	Item	Num.
700	50,000,000	1	**Manager**	**1**
1680	40,000,000	3	**Quality Control Manager**	**2**
1260	30,000,000	3	**Technical Expert**	**3**
3500	25,000,000	10	**Skilled Worker**	**4**
1750	25,000,000	5	**Administrative and Marketing Staff**	**5**
560	20,000,000	2	**Worker and Driver**	**6**
9450		**24**	**Total**	

Total Cost - Million Rials	Unit Price - Rials	Annual Consumption	Unit	Item	Num.
11	1,100	10000	kwh	**Power**	**1**
10	1,000	10,000	m^3	**Water**	**2**
32	4000	8000	liter	**Diesel Fuel**	**3**
210	30,000	7,000	liter	**Gasoline**	**4**
263	**Total**				

6-Commercial and Economic Support for the Project

Several supporting projects are ongoing to promote the industry.

- In order to evaluate, discuss and resolve the obstacles and problems facing the production units, a “Production Facilitation Committee” was appointed in all the provinces whose members are governor-general (chairman), provincial unit head of Ministry of Industry and Mines (secretary), head of provincial management and

planning organization, head of the provincial chamber of commerce, industries, mines and agriculture, head of the provincial chamber of industry, mining and commerce, etc. The most important responsibility of the committee is to

- facilitate, complete and launch semi-finished production projects and develop them
- support and help the export of provincial products
- evaluate the cause of stagnation or suspension of production unit operations and try to solve the problem

- **Resistive Economy (Economic Prosperity) Committee:** Ministry of Industry, Mines and Commerce issued a resolution (12868) on May 15th, 2016 by which the completion of industrial projects with more than 60% physical progress and support of small and medium production units were funded.
- **Small Industries Investment Guarantee Fund:** Issuing credit guarantees facilitates the financing of small businesses and warrants the payback of principal plus interest to the bank. The guarantee will be issued after a thorough inspection and validation and offering the proper collateral.

6-1-Supporting Custom Tariff (of Products and Machinery) by International Tariffs

The tariff for importing the machinery required for the project is 5 to 10 percent to facilitate the technology provision and support domestic production. The tariff for importing the goods is 40% to prevent the importing and support domestic production.

6-2-Financial Support (of Available Units and Projects) by Banks - Investment Companies

The funding by banks can be accomplished by

١- **Foreign Exchange Reserve Fund:** The oil revenue surplus is allocated to manufacturers and exporters to finance some of their foreign currency needs in the form of Islamic contracts and approved regulations and according to domestic import and export of commodity and services regulations.

٢- **Resistive Economy (Economic Prosperity) Committee:** Funding is considered to complete the industrial projects with more than 60% physical progress and support the small and medium production units.

۳- Foreign Investment Encouragement and Protection Law

Since 1955, the framework of foreign investment in Iran's law has been to attract and support foreign investment. In order to make reforms in the economic structure of the country, the Iranian parliament proposed new law on foreign investment called the Encouragement and Support of Foreign Investment Act which was finally approved in 2002. This new law has led to the development of the legal framework and the environment for foreign investors in Iran. Some of the progress made by the new law in the field of foreign investment are:

- The Government of the Islamic Republic of Iran welcomes the foreign investment of foreign entities, both natural and legal, in all areas of economic activity.
- Recognition of new investment methods in addition to foreign direct investment
- Facilitating the process of applying and approval of foreign investment
- Establishment of an organization called Foreign Investment Services Center within the Organization for Investment Economic and Technical Assistance of Iran in order to provide centralized and effective support to the activities of foreign investors in Iran

In case of attracting foreign investment, the government has considered incentives some of which are:

١. Tax exemption for products of foreign investment companies
٢. Providing insurance coverage to investors
٣. Granting customs exemptions on the import of inputs required by foreign investment companies
٤. Provide subsidies for local labor training
٥. Creating free-trade zones for investment
٦. Providing cheaper infrastructure and public services such as water and electricity
٧. Guaranteeing the return of profits and principal and preventing their confiscation and nationalization

7-Analysis, Conclusions and Suggestions:

Since the project site is located near the capital city of the province and given the considerable demand for implementing the project, investors' willingness to provide the revolving funds and a portion of the development process, the project has acceptable economic indices. In addition, the project can rely on the market in the neighboring cities. On the other hand, the project represents a good option for joint venture because of the availability of proper facilities, specialized workforce, and international experience.

- **Environmental Expert Report**

None of the predetermined environmental criteria including air, soil and noise pollution and waste disposal were violated and thus, the project can be completely implemented.

- **Management Expert Report**

Due to the growing demand for these products, if the prices are considered based on export prices, the relevant indices will grow considerably. On the other hand, the company can rely on its good management indices and its connections to domestic industries and departments to extend its potential market. There is also a considerable domestic demand for these products.

251713	Production Cost
As detailed in the tables above	Product Sales Price
452.000	Total Sale (Million Rials)
74%	Sales Percentage at Break-Even Point
200287	Profit (Million Rials)
71%	Internal Rate of Return
5913	Net Value Added (Million Rials)
1.4 years	Payback Period