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Iranian Nuclear Fuel Cycle Experience

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As was mentioned at the 2002 symposium, according to the *Table 1* it has been decided by Iranian government to produce 6000 MWe nuclear energy by year 2020. Nuclear power plants will be constructed to produce this amount of energy in various part of the country and it is necessary to provide their fuels.

For the fulfillment of this requirement, nuclear fuel cycle activities have been started by AEOI and it is hoped to produce the fuel at least for some of them. *Figure 1* shows activities of nuclear fuel cycle in Iran.

National Uranium Exploration plan

In the nuclear fuel production cycle, reconnaissance and evaluation of the uranium deposits throughout the country, as the first link of this chain, are of great importance in necessary fuel supply for nuclear plants.
Besides supplying the raw fuel for the reactors, exploration of the uranium resources brings out the Country's independence.

To cover the whole country and to restrict the favorable target areas, first stage is to carry out small scale exploration namely reconnaissance phase, after which the large Scale exploration activities are implemented. In general, exploration is done under four projects as follows:
1. Evaluation of potential areas and project generation, (reconnaissance).
2. Exploration in favorable Target areas, (Preliminary Phase).
3. Semi – detailed exploration, (Semi – detailed Phase).
4. Ore reserve estimation and exploitation before development, (detailed Phase).

The above – mentioned phases are further subdivided to the other stages.

1. As the first stage, airborne exploration has been carried out on 1/3 of the country (650000 km^2). Using these valuable data and integrating them with the small scale satellite, geological, structural and metallogenic data will result into recognition of new anomalies. Thus the airborne exploration data and remote sensing interpretation play the key roles in preparation of uranium genetic models.

2. After recognition of favorable target areas, the big scale ground exploration study is implemented. In Preliminary Phase, for studying uranium mineralization potential in the interested areas, the different ground data including physical and chemical characteristics, mineralization, and extension of the ore are studied. For this purpose different geophysical methods such as radiometry, spectrometry, magnetometry, radon measurement, IP … are used. Integration of the obtained results through geochemical, geophysical, sampling and analyzing will outline ore body schematic, which after drilling provides us with more information.

3. In preliminary phase, after carrying out the above – mentioned stages, the speculative reserve is calculated and in case of good result The semi – detailed study (big scale) including detailed geological mapping, Surveying and grinding, excavation of trenches and drilling in the mineralized zones, borehole logging, excavation of underground tunnels, core sampling and laboratory analysis will be implemented, which leads to the determination of the size, shape and grade of the ore body. In other words the estimated reserve is calculated in this stage.

4. In detailed phase different works such as supplementary drilling, ore reserve extension and ore reserve estimation are carried out. Based on geometric dimensions depth, extension, grade, tonnage and mining methodology one can define feasibility study and development program.

At present, exploration in different phases are carried out mainly in Central Iran including Narigan, Khoshomi, Zarigan, Chah – juleh, Esfordi, Lakeh – Siah and Ariz, and the work is continued for recognition of the other favorable basins for uranium mineralization.

Saghand Uranium mine Division *(Figure 2)*

This project is situated at a distance of 185 Km North-east of Yazd city, covering an area of 20 Hectares. The preliminary exploration related to this project terminated at the end of year 1990 and the detail exploration was finished in Year 1994. The detail exploration was concentrated on two important anomalies called no 1 and 2. The results achieved from these activities concluded to the calculation of a reserve amounting 1580000 tones of uranium ore, having an average grade of 533 ppm.

After termination of exploration activities, developing studies including feasibility studies and Basic engineering and detail engineering were continued till end of Year 1997. These activities opened the way towards mine opening and mine equipping which are explained as follows:

Engineering service studies

This project which contains about 1.7 percent of total plan, includes preliminary economic and technical studies, Basic engineering and detail engineering studies, preparation of KMD maps related to about 14 thousand square meters of sacrificial buildings , preparation of site maps (20 hectares), daily mapping , services , consulting , construction , supervisory services and etc …..

About 92 percent of the project has already been done and the rest will be done according to the related time schedule which will end in year 2005.

Infra structure constructions

This project which consist of 21 percent of total mother project, concentrates over activities as below:
Leveling and preparation of total site contour line maps (20 hectares) construction and installation of buildings with industrial , semi – industrial , official , and other usages (about 14000 m2), construction and installation of tow towers at shaft mouths (each having 32.5 meter height and 100 tones weight) , Hoisting systems , ventilation systems , electrical power , communication facilities , cement production , Pneumatic air can be mentioned as other parts of this project . The average work progress for this project is about 74% and the rest will be done parallel to the other projects and will continue till year 2005 shaft sinking and shaft equipping: this project includes, preparation and installation of several thousand tones of machinery and other mining equipment throughout the underground mine network, sinking and equipping tow vertical cylindrical shafts each having about 350 meter length, using cement as liniment, and related cross sections and tunneling networks at six levels of each shaft and connecting tunnels in between the two shafts, in order to construct exploitation work shops. The volume of these project activities sums up to 37.5 percent of total mother project activities and the reaming work will be terminated in year 2005.

Equipment and machinery purchasement

This project includes purchasement of machinery and other requirement such as power supply; air supply, heavy and light machinery related to mine equipping phase and also investment for development phase, mainly, covering underground tunneling network and exploitation shops work. The volume of activities of this project sums up to 20 percent of total mother project and the remaining amount will end in year 2005.

Employment and training of human force

The tasks related to this project includes : employment of required Iranian human force ranging from semi skilled to skilled workers , junior and senior stuff , training , housing , transportation , payments , budgeting and other related services . The weight of this project sums up to 19.8% of total project from which 69% has been done and the remaining amount will be finished in year 2005.
Apart from a.m. activities, a vide range of administration work and technical services has been given to the contractors, personnel, being engaged in the project. e.g . . . . About 1200 man months of Chinese personnel from year 1999 till November 2002.
However , apart from above stuff , about 14 persons in the frame of administration body have fulfilled their task in the central office which this means that the whole activities has been governed by the director of uranium mine Div of AEOI .

Summary of present situation

On the whole about 64.3 percent of total activities have been done so far and this work progress is in accordance with the formal time schedule and remaining work which will promote to the exploitation phase will be year 2005.
However, the amount of the spent budget so far sums up to 68913.5 million rails and the remaining amount (166500 million rails) which will be spent during the coming years.
Finally, it is worth mentioning that this large uranium project, from mining point of view can be assessed as most exceptional in the history of Iranian mining activities.

Yellow Cake Production (YCP)

From the beginning of the activity of fuel department of AEOI achievement of nuclear fuel was its main job. On the basis of such a goal, researches and laboratory experiences were carried out to process Iranian mines' ores. In 1994 following exploration of Saghand mine and determining of its reserve, the project of construction of a 50 tones / year uranium production mill was approved at AEOI. The object of this project was to achieve the technology of uranium oxide production to provide a portion of Booshehr nuclear power station fuel.

Performance explanation

Engineering and design

In 1995 a contract was made with Atomredmetzoloto-a Russian company-for feasibility study, basic and detailed design of a plant producing annually 50 tones of uranium as oxide using anomaly 2 of Saghand mine. Russian experts made experiences in laboratory, bench and pilot scales in Tehran and Moscow on samples from core of the mine. Finally in 1996 they completed the design and submitted documents in different parties. On the basis of this design annually 120,000 tons of ore with an average concentration of 553-gr/ton of uranium processed by acid leaching and resin in pulp method.

Pilot Plant modification and startup

In parallel to YCP design, the existing Pilot Plant at Ore Dressing and Fuel Department was modified and partly redesigned and constructed with cooperation of Russian specialists. The main aim of this activity was to reach to the technology of uranium processing in a pilot scale.

Redesign

Since Russian design of YCP for constructing of plant and equipment was not familiar to non-Russian contractors-as western designs are- and Russian documents and drawings were not according to Iranian standards, redesigning of the project or in a better word converting of documents was propounded.

Moreover, the selected site, which was beside the mine from the viewpoint of some fundamental utilities, especially, water and electric power. was not found suitable, so the decision of redesigning became more serious. Hence, in 1999 a contract was made with Pioneer Energy Industry Co (Pishgam) to overview Russian documents and redesigns it to an adaptable one to the new site.

New Site Selection

The former predicted site for constructing uranium mill was beside the mine of Saghand but because of some reasons like the lack of reliable resources of water to feed the plant, high expenses of supplying electrical power, the cost of constructing of living area for employees due to the far distance of site to the nearest urban area and finally the problem of employing efficient personnel was not recognized suitable and selecting a new site was inevitable. For this reason some places in Yazd and Isfahan provinces were studied and considering factors like ease of transporting ore from mine, availability of water, electricity, telephone and no need of constructing the living area also considering local and social condition of site ultimately the new site was selected 35 km north of Ardakan city by the of Isfahan-Chadormaloo railroad.

Site Preparation.

Immediately after approving of the new site technical studies were started, including preparation of topographic drawings, meteorology and ecologic reports, geo-electric studies, geology and tectonics, underground water, faults of area, seismic study, geotechnical study, soil analysis and its resistance, environmental and geochemical survey and natural radiation dosimetery of site area. Considering results of studies of site layout in three categories of A) plant area, B) tailing dam and C) amenity and lateral buildings were designed by contractor.
After specifying general layout different activities were carried out like: construction of accessing roads, constructing and equip of temporary camping, constructing of water network, supplying and starting of electric power network, commissioning of wireless communication system, digging of a well and equipping it, installing of radio antenna and starting up of the communication network of the site. Parallel to the above activities execution on construction of two of the industrial buildings have been started.

Uranium Conversion Facility (UCF) *(Figure 4)*
The Uranium Conversion plays an important role in nuclear industries, which can affect industry and economics of any country. There are many attempts to achieve nuclear fuel production by many countries but so far, few countries have been able to achieve this key technology.
Although there are lots of technical problems and international pressure, Uranium Conversion Facility (UCF) project considering capabilities of country's experts is going to be utilized.
This project has been designed in order to produce four kinds of nuclear fuels as follow:

1- Natural UO_2 powder	11.3	t/a
2- Up to 5% enriched UO_2 powder	34	t/a

It is worth mentioning that 280 t/a UF_6 will be produced as an important medium compound in nuclear fuel cycle.
All of these products must be obtained under precise processes since all of products will be directly applied in power and research reactors.

Main Goals of UCF Project

UCF project consists of five main process lines, which are as follows:
- Production of UF6 from U_3O_8
- Production of F_2 from HF
- Production of UO_2 from natural U_3O_8 and enriched UF_6

Brief Description of each Process

1-Production of AUC from U_3O_8 (Yellow Cake)
300 t of U3O8 is converted to 480 t AUC each year.

2-Production of UF_4 from AUC
480t produced AUC will be converted to UO_2 and then with HF gas will be converted to UF_4 .The amount of UF_4 is 282t/a. About 95% of it will be used to produce UF_6 and 5% to produce U-ingot.

3-Production of UF_6 from UF_4
265 t/a of produced UF_4 will be converted to 285 t/a UF_6 which is maintained in a special drum for future application (this product is one of the most valuable products in UCF).

4-Production of depleted UF_4 from depleted UF_6
In order to solidify and maintain depleted UF_6, from about 250t of UF_6, 223 t/a depleted UF_4 will be produced. It is necessary to consider that depleted UF_4 has no special application, and this process is just to simplify waste management procedure.

5- Production of F_2
Production of F_2 is a complicated chemical process and will be produced by electrolyzing of HF and KHF_2.

6- Producing of natural & enriched UO_2 powder
UO_2 powder is produced in two forms; natural & enriched 11.3, and 34 t/a respectively, and their application is in research & power reactors.

About 800 experts are employed to utilize this project.
Main utilization plans are summarized as employing required experts, outline and performance of necessary training according to requirements of international standards and International Atomic Energy regulation.

Zirconium Production Plant (ZPP) *(Figures 5&6)*

One of the most important factors for achievement of nuclear technology in every country is access to design and material manufacturing know–how needed for nuclear installations. Among these materials, Zirconium metal is of greater importance. The above mentioned metal is among the strategic metal that countries having this production technology do not render it easily to the other countries and selling this technology is dependent on the political situation and mutual relationship among governments.

The Zirconium Production Plant has been established in an area located 15 kilometers south – east of Esfahan which is east side of Esfahan Nuclear Fuel Research Center for fulfillment of future needs and access to technical knowledge of nuclear industries in Atomic Energy Organization of Iran as well as its particular applications , for local industries.

Primary objective of producing 50 tons of Zirconium sponge per year, 10 tons of tube and 2 tons of strip and bar from Zirconium alloys annually as the main product and 100 tons of magnesium and 5 tons of Hafnium as by-product annually. In addition to the above mentioned products, the production line of this plant shall be capable of producing further industrial products. Briefing, these products and capabilities are:

Production of pure Magnesium , Zirconium alloys , Titanium and its alloys, ability for casting Ferrous and Non- Ferrous metals , forming of Stainless Steel, Ferrous and Non- Ferrous metals .

The total area of the plant is approximately 54 acre including industrial areas, warehouses, administration and engineering supportive buildings, landscape and extension area.

The primary raw material supply for this plant is Zircon concentrate with purity of 63% in units of sponge production which includes 8 workshops with the overall area 8800 square meters. After the processes of Carburization, Primary Chlorination, Primary Purification, Extraction, Secondary Chlorination, Secondary Purification and Reduction, the Zirconium sponge with high purity is produced.

Due to the need of secondary purification and reduction unit in sponge production, for reduction of Zirconium Tetrachloride, a reduction agent with high purity Magnesium is needed. So, next to the sponge production units, a Magnesium production unit has been designed and built. This metal is of great importance due to strategic and application of this metal in other industries. Magnesium ingot with percent purity of 99.99 is produced after electrolysis and distillation processes on primary Magnesium Chloride in the Magnesium production unit which includes of tow workshops in an area of 2300 square meters.

After production of zirconium sponge in the units of tube, strip and bar manufacturing which includes 9 workshops in an area of 9500 square meters , it is turned to alloys with elements of Iron, Chromium, Tin , Nickel and Niobium, and after the processes of casting , Forging , Extrusion, Hot Rolling , Cold Rolling , cold Drawing , Pickling , Heat Treatment and Finishing , it is formed in tube shape with outside diameter of 8 to 16 mm, thickness of 0.3 to 0.8 mm and length of 4800 mm, strip with thickness of 0.5 to 2 mm and width of 150 mm and bar with diameter of 9 to 17 mm.

For utility services to these production units such as electricity, water and compressed air, three units with an area of 3200 square meters have been built which are in the stage of utilization now.

For storage of raw and consumable materials, spare parts, equipments and etc. thirteen units with an area of 2400 square meters have been built.

To process and manufacturing control of mid and final products based on the defined standards, Quality Control operations including chemical composition control, mechanical and metallurgical properties, resistance against corrosion and dimensional control on raw materials, mid and final products shall be done in ultrasonic and Autoclave units at the industrial scale in an area of 980 square meters while the rest of Quality Control shall be done in engineering support units of the plant.

Administrative an engineering support unit includes 14 units in an area of 17000 square meters which are currently under the construction.

Fuel Manufacturing Plant (FMP) *(Figure 7)*

The Fuel Manufacturing Plant (FMP) is the last and most important chain operation in nuclear fuel production to be used in nuclear power plants and research reactors. For attaining self – sufficiency in manufacturing of fuel assemblies for Bushehr Nuclear Power Plant and with due regard to two under construction plants, i.e. ZPP and UCF whose end products could be used in FMP, the design and construction of FMP was planned . A nuclear power plant of 1000MW electric power annually requires about 30 tons of fuel consisting of 54 fuel assemblies (16740 fuel rods). The annual production capacity of FMP is 30-35 tons in the preliminary phase extendable to 120 tons of fuel production for nuclear power plants and 20 tons for research reactors.

Present Status of FMP

The salient activities carried out towards establishing Fuel Manufacturing Plant so far are given as below:
Site selection, equipment layout, buildings and auxiliary system basic design.
Conceptual design of powder and pellets handling systems.
Conceptual design of cladding tube and fuel rod handling system between different operational stations such as electron beam welding, vacuum drier , x-ray radiography , washing , anodizing and lacquering baths.

Conceptual design of storages for powder, green and sintered pellets, fuel rods and assemblies.
Conceptual design for pellet stacking and loading machines and fuel rod loading machine for loading rods into skeleton.
Conceptual design for skeleton and fuel assembly mounting tables.
Purchase of some QC equipment
preparation of technical specifications for main and QC equipment
Proceeding for purchase of main equipment such as furnace, grinding machine, vacuum drier, welding machine, etc.
Proceeding for manufacturing of main equipment such as powder, pellet and rod handling systems, mounting tables, pellet stacking and loading machines.
Conducting research activities towards obtaining know-how such as powder quality control, production of sintered pellets and electro polishing, anodizing and lacquering and delacquering of fuel rods.
Preparation of parts of preliminary safety analysis report (PSAR) of the plant including environmental analysis, dose assessment, radiological protection, criticality calculation, waste management system and quality assurance.

Waste Management *(Figure 8)*

Waste Management includes all administrative and operational activities in handling, treatment, conditioning, transportation, storage and disposal of radioactive waste.
The objective of Waste Management is to protect human and his environment now and in the future without imposing undue burden to the future generations.
The Waste Management Department of AEOI is responsible for management of radioactive waste in Iran. At the present time in addition to management of current institutional waste, WMD is trying to develop the required infrastructure for safe management of wastes for future generating from operation of NPPs and nuclear fuel production program through three technical cooperation projects with IAEA. These projects could be described as following:

Establishing a Centralized Facility for Treatment of Low and Intermediate Waste

Normal operation of the 5-MW research reactor as well as radioisotope applications in medicine, agriculture, and industry generates significant amounts of low and intermediated level radioactive waste.
The main objective of this project is set up a centralized waste processing and interim storage facility for treatment of mentioned wastes.
In this project a building with an area of 2292 m^2 in two floors including treatment areas, four laboratories, offices and small storage area is constructed. The four labs (Active, Inactive, Health Physics and Analysis) are equipped with monitoring and á,â,ã spectrometers system.
The final part of the project is construction of a large storage building for L&ILW which is located in Karadj 40 km from the capital. It has an area of 1500 m^2 and special places for storage of SSS (Spent sealed sources) have been designed. A fifty percent progress is achieved by now. The main objective of this area is safe storage of conditioned waste in 200 Lit drums and the hospital wastes for decaying to clearance level.

Establishing a National Waste Management Strategy

The main objective of this project is to develop a comprehensive waste management strategy and qualified staff capable of managing waste in the future.
During implementation of this project a workshop was held in WM department in which seven experts from IAEA have participated.
During this workshop the following items have been established and developed:

Waste generation and waste inventory, waste characterization
Establishing draft of National Waste Management Strategy, objective and structure
Waste minimization strategy, pretreatment, treatment and research and development methods
Waste transport, interim storage, and storage strategy
Exception, Clearance, Discharge Limit, QA and SAR
Control and disposal of NPP operational waste
Drafting of regulations and requirements for WM department

Characterization of Candidate Sites for L&ILW Repository

The main objective of this project is to select a suitable disposal site for conditioned radwaste which will result from the future operation of Bushehr NPP.
In this project disposal of radwaste in accordance with national regulations, technical considerations and safety is planned.
After development of site selection criteria, whole territory in the country was studied and investigated for suitable regions.
By the assistance of two IAEA experts and AEOI exploration department after specific consideration and review of all area of country three regions are selected as candidate regions now and study them is continuing for selection of suitable areas and consequently the suitable sites.

Subproject (Research and Development)

In order to find optimum methods, regarding to mentioned projects, the staff members of waste management are executing the following research projects:
Treatment of reactor radwaste with precipitation methods;
Immobilization of radwaste in cement; Separation of Ra-226 with algae from liquid waste.

Safety and Quality Assurance

1. Safety
2. QA
3. Training
4. Research & Development

Safety

Site evaluation and selection.
Preparation of Site Evaluation Report (SER).
Preliminary Safety Analysis Report (PSAR) preparation.
Quality Assurance Programe (QAP) development for all activities.
Environmental Studies.
Preparation of Environmental Report (ER).
Preparation of Final Safety Analysis Report (FSAR).
Application for licensing and certification of operational staff.
Supervision of commissioning safety activities.
Preparation of commissioning report.
License application for operation.
Establishment of and ensuring the implementation of operational safety measures.
Establishment of and ensuring the implementation of emergency measures.
Facilitation of liaison between NNSD and the fuel fabrication cycle plants.
Compilation of safety codes & standards.

Quality Assurance

Implementation and assessment of QA activities for Sitting.
Implementation and assessment of QA activities for Design.
Implementation and assessment of QA activities for Construction.
Implementation and assessment of QA activities for Manufacturing.
Implementation and assessment of QA activities for Operation.
Implementation and assessment of QA activities for Decommissioning.

Training

Provision of training (in-house and external).
Qualification and certification.

Research & development

As per IAEA codes and standards and NNSD requirements, for all activities related to Nuclear Fuel Production, NFPD shall apply for and obtain relevant Licenses for various stages of Nuclear Fuel Production cycle, ensuring adequate safety. To undertake the Licensing application and ensuring safety, it is felt necessary to establish a department responsible for the provision of such services and safety assurances.
The named suggested for this department is: SAFETY AND QUALITY ASSURANCE DEPARTMENT.
Among the responsibilities of this department would be: carrying out the safety analyses of NFPD projects, preparation of safety analysis reports for submission to NNSD, carrying out QA activities, and to arrange training for the operational staff.
The Safety and QA Department will have three sections as follows:

TRAINING

Esfahan Nuclear Fuel Research &Production Center

Esfahan Nuclear Fuel Research & Production Center (ENFRPC) was founded in 1974 in order to support the country's Nuclear Power Plants scientifically and technically, also to train the Personnel required in this industry.
ENFRPC is located in a site with a total area of 2405 hectares.
Area under construction is about 3.5 hectares and the green area, which has been created for environmental protection, is about 165 hectares.
The Center started its activities under the supervision of Technique Atom (a French company) before Islamic Revolution, but stopped its activities during 1979-1981, as the foreign experts left the country.
The Center followed a few research activities and the construction of some Research Reactors until 1988.
Since 1989 the Centers 5 years long Plan has been prepared and confirmed by Planning & Management Organization and afterwards the Center's important projects started.
The following scientific & technical projects have been implemented at the Center's so far:

Graphite sub Critical Reactor,
Sub critical Reactor,
Zero Power Reactor,
Incinerator
Miniature Reactor

At Present two important projects, namely Uranium Conversion Facilities (UCF) and Zirconium Production Plant (ZPP) are being implemented at the Center. In Parallel with these projects, the research activities are carried out and there are over 40 research projects at different departments of the Center, ten of which have been completed.
ENFRPC consists of the following departments:

Nuclear Engineering Department
Metallurgical Engineering and Fuel Department
Chemistry Department
Electronic & Control Department
Health Physics Department
Miniature Reactor Department

The above departments are performing the AEOI's projects and have scientific & technical Cooperation with other scientific and industrial Centers including the country's universities and institutes. Presently a few MS and Ph.D. students are performing their university theses at the Center.

ENFRPC has had an important role in the implementation of large projects at the Atomic Energy Organization of Iran.
Following is several projects which have been completed at this center.

1. Graphite Sub Critical Reactor

The Graphite absorbent reactor was designed as an experimental reactor in 1989. The reactor equipments and the Neutron Accelerator was built and installed. The Commissioning of the reactor was done in 1990.

2. Sub Critical Reactor

This project was defined with the aim of experimental use for the design of the reactor core. Its construction and installation was finished at 1990. Since then it has been used for the experimental purposes.

3. Zero Power Reactor (ZPR)

Design of ZPR was started at 1985. Installation of this reactor was done with the supervision of Chinese experts. This reactor uses Natural metal Uranium, Graphite absorbent and Heavy water. The maximum power of this reactor is l00^{w}.

4. Miniature Neutron Source Reactor (MNSR)

This project was accomplished with cooperation of Chinese institute of atomic energy and ENFRPC. The purpose of the project was to design a reactor to server as an instrument for analyzing samples, preparing radioisotope and as a research and educational tool.

JABER IBN HAYYAN RESEARCH LABORATORY

Jaber Ibn Hayyan Research Laboratory, a newly founded center (1986) in atomic Energy Organization of Iran, supports its scientific board and experienced personnel with more than 30 laboratories for nuclear research, process, engineering science, instrumental analysis and operation safety. Research activities in this center include different areas which may exceed the laboratory demands.

Pishgam Energy Industries development Co.

Pishgam Energy Industries development Co. (PEI) is a big consulting engineer with more than 300 engineers and technicians. PEI is capable of working in different fields of engineering and enjoys the necessary expertise in all the engineering disciplines including Architecture, Structure, Civil, Pressure Vessel and Tank Design, Piping, HVAC, Electrical Systems, Communication Systems, Process, Control and Instrumentation, Inspection and Non-Destructive-Testing (NDT) and also Supervision of construction and installation works of industrial projects.

As the main consulting engineer for Atomic Energy Organization of Iran (AEOI), PEI undertakes the engineering and technical support of AEOI's projects and produces engineering documents especially for the utility units and non-process parts. Based on the Know-how provided by AEOI and the requirements of

projects, PEI produces the necessary technical documents that are further submitted to project executive groups.
To the date, in addition to various projects in petrochemical, oil and gas industries, PEI has cooperated with AEOI in the following projects:

Zirconium Production Plant (ZPP) – In the design of this project, which its know-how belongs to China, in addition to producing engineering documents for utility units, site networks and other supportive sections (more than 7,000 documents including more than 63,000 sheets), PEI was responsible for the checking of Chinese documents (from the sufficiency point of view). Besides, PEI is responsible for the purchase and supply of almost all equipment (except key equipment which are in the scope of Chinese side) and the technical supervision on the construction, installation and commissioning activities of the project have been also defined in the scope of PEI (more than 3,000 engineering man-month). At present, this project has a total progress of about than 80% and it is under commissioning.

Yellow Cake Plant (YCP) – In this project, based on the know-how documents provided by AEOI, PEI will produce necessary engineering documents for establishing the plant. Regarding the urgency dictated by AEOI, construction works of this project should be carried out in parallel with design. For this reason the technical supervision on executive activities (including construction, installation and commissioning) are also in the scope of PEI.

Uranium Conversion Facilities (UCF) – In this project which its know-how has been provided by AEOI's experts, design of utility units and also producing engineering documents for non-process parts have been defined in the scope of PEI.

Fuel Manufacturing Plan (FMP) – The know-how of this project belongs to AEOI and PEI as consulting engineer is responsible to produce necessary engineering documents for establishment of utility units and non-process parts. At present, the basic engineering design of this project is going to be completed.

Table 1. Electrical Energy Production In Iran – Past, Present Status And Future Planning

	Capacity(MWe)	Fossil Oil, gas, coal	Nuclear	Renewable
1980	10,000	10,000	–	–
2000	30,000	30,000	–	10
2005	3,2000	31000(97%)	1000(3%)	100(0.3%)
2020	60,000	54000(90%)	6000(10%)	1000(1.6%)

Figure 1. Nuclear Fuel Cycle Experience In Iran

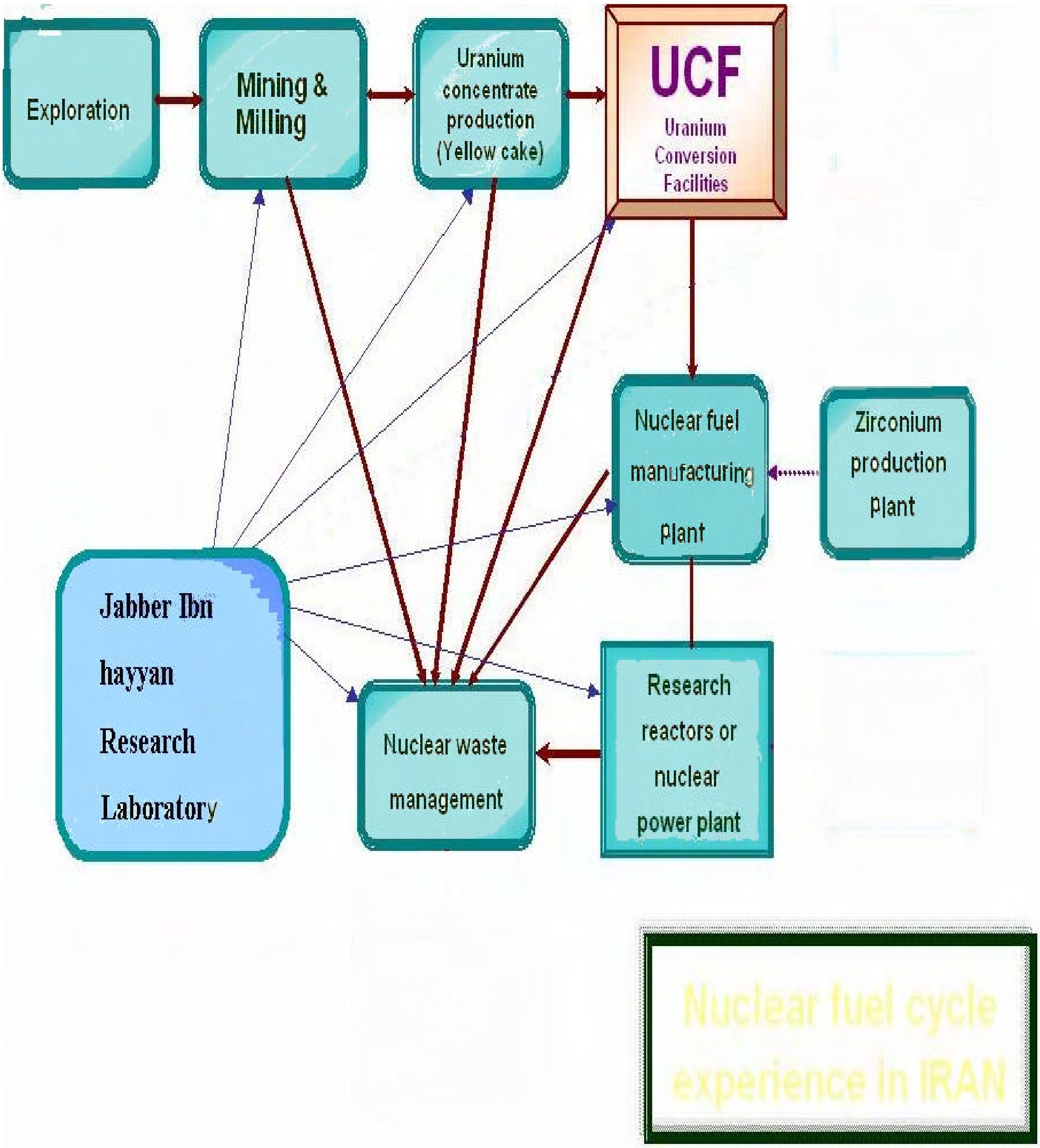

Figure 2. Saghand Uranium Mine Flow Diagram

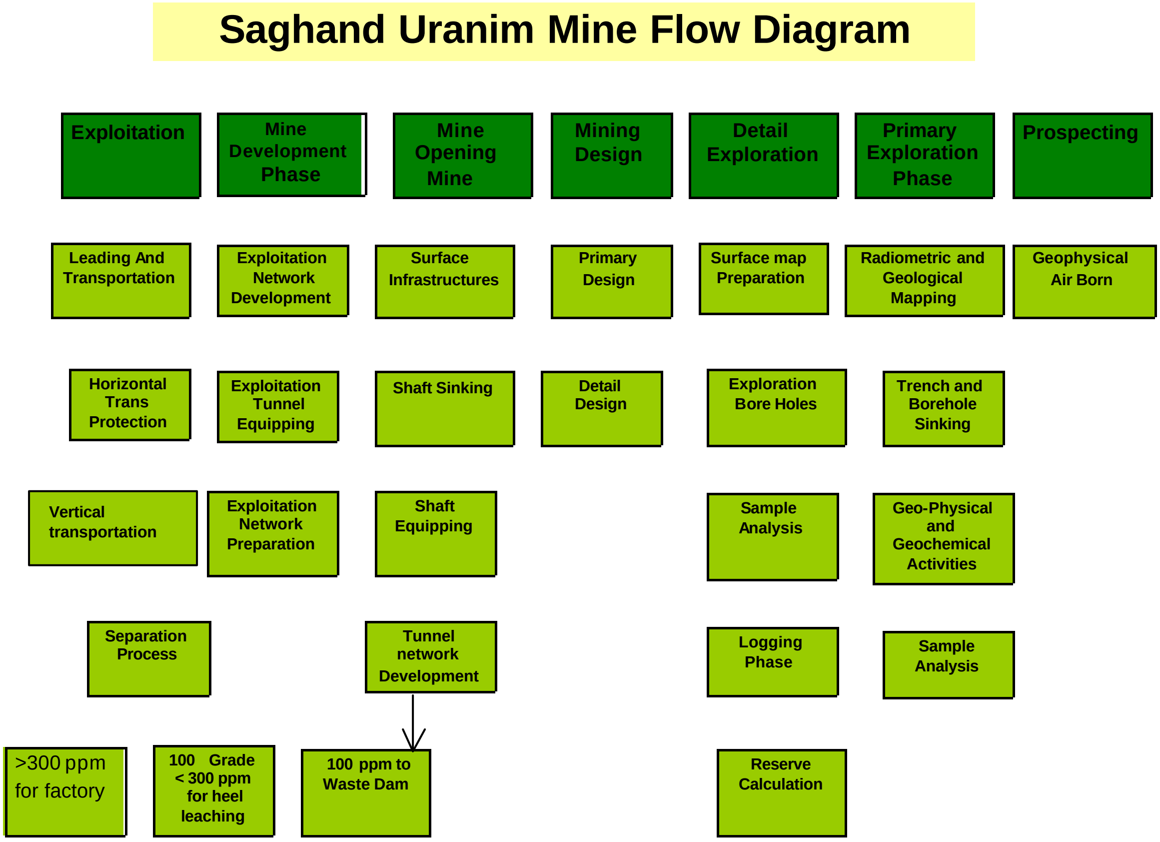

Figure 3. ORE Feed

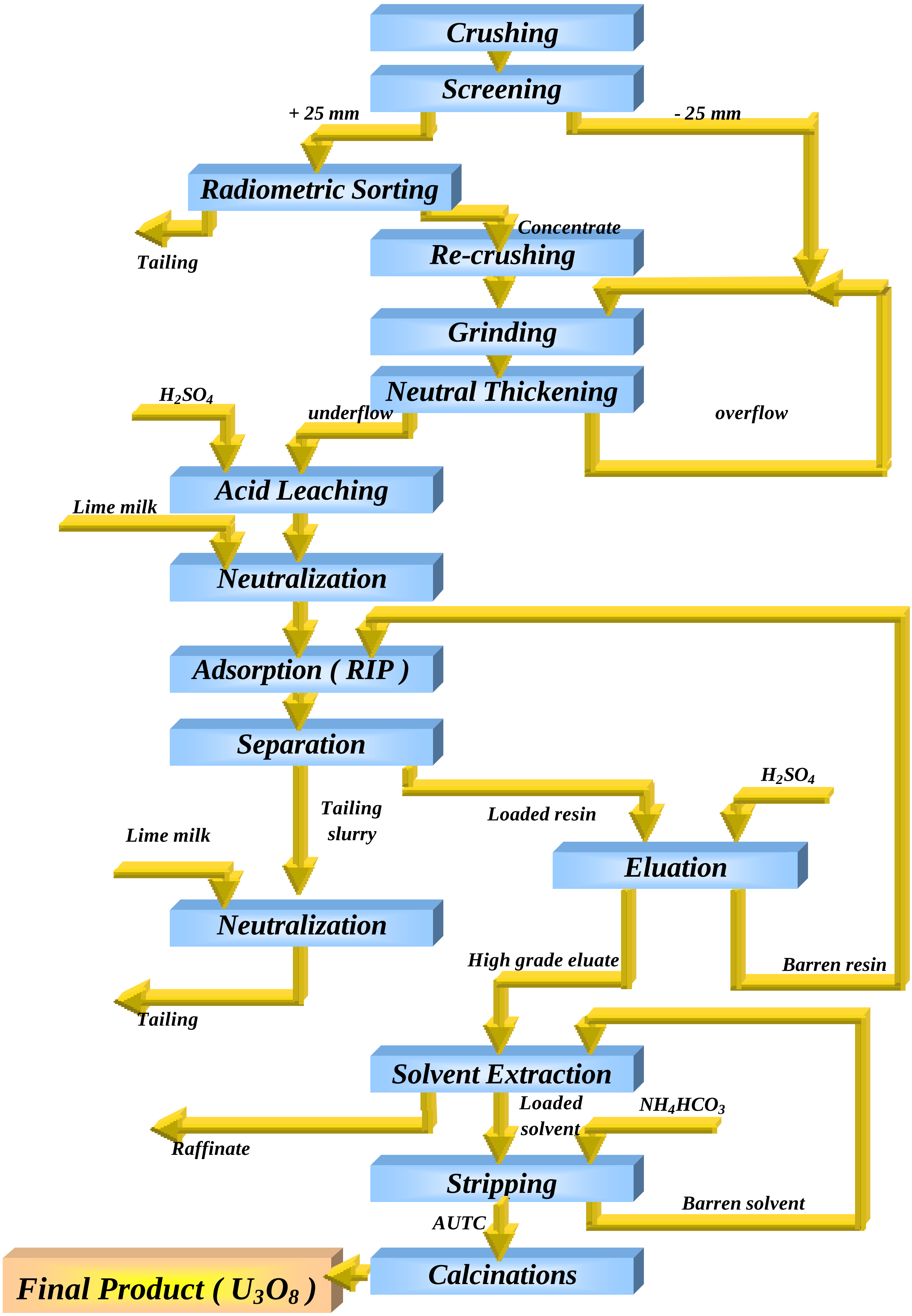

Figure 4. A Schematic Figure Of Process In UCF

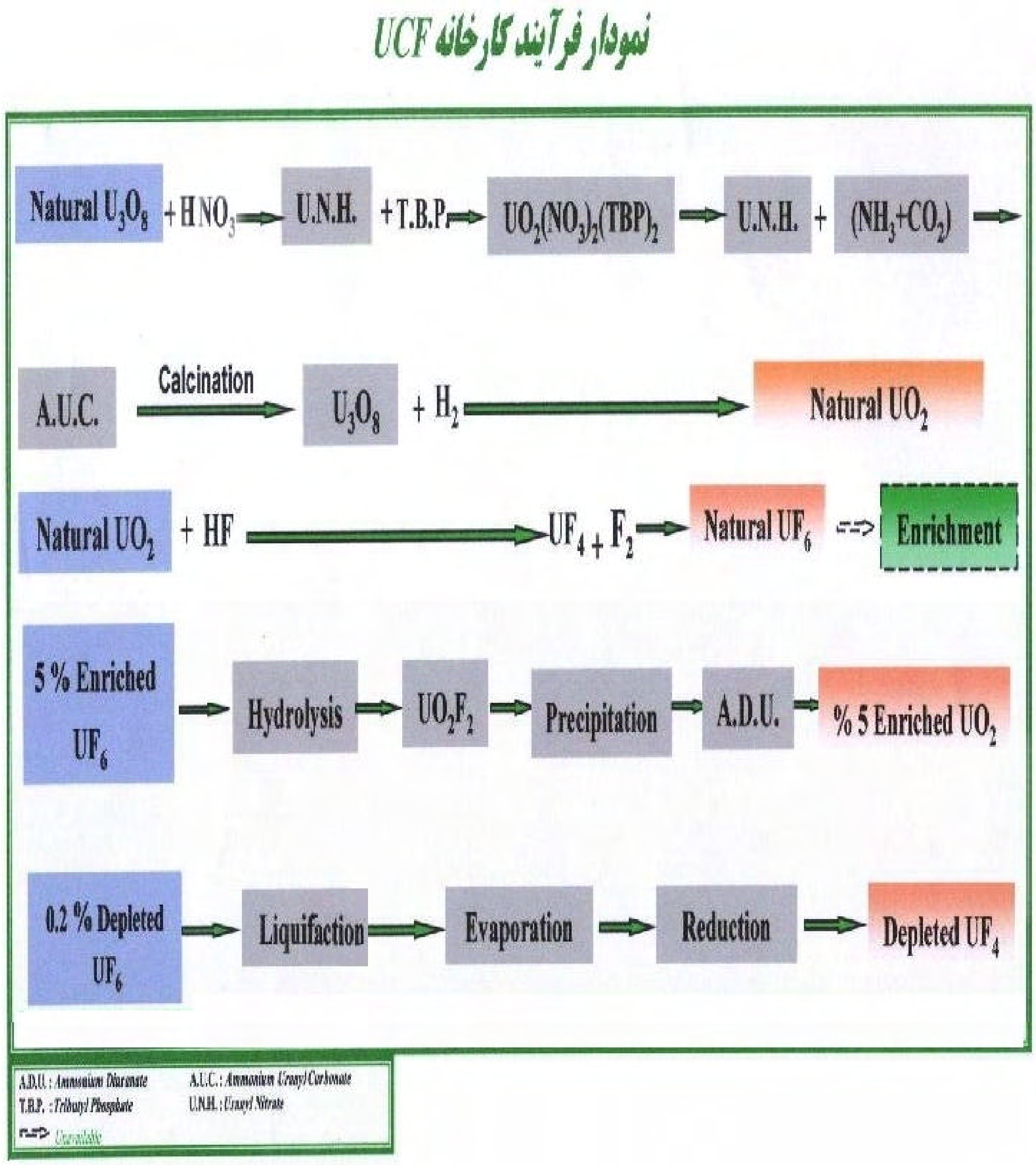

Figure 5. Zirconium And Magnesium Production Flow Sheet

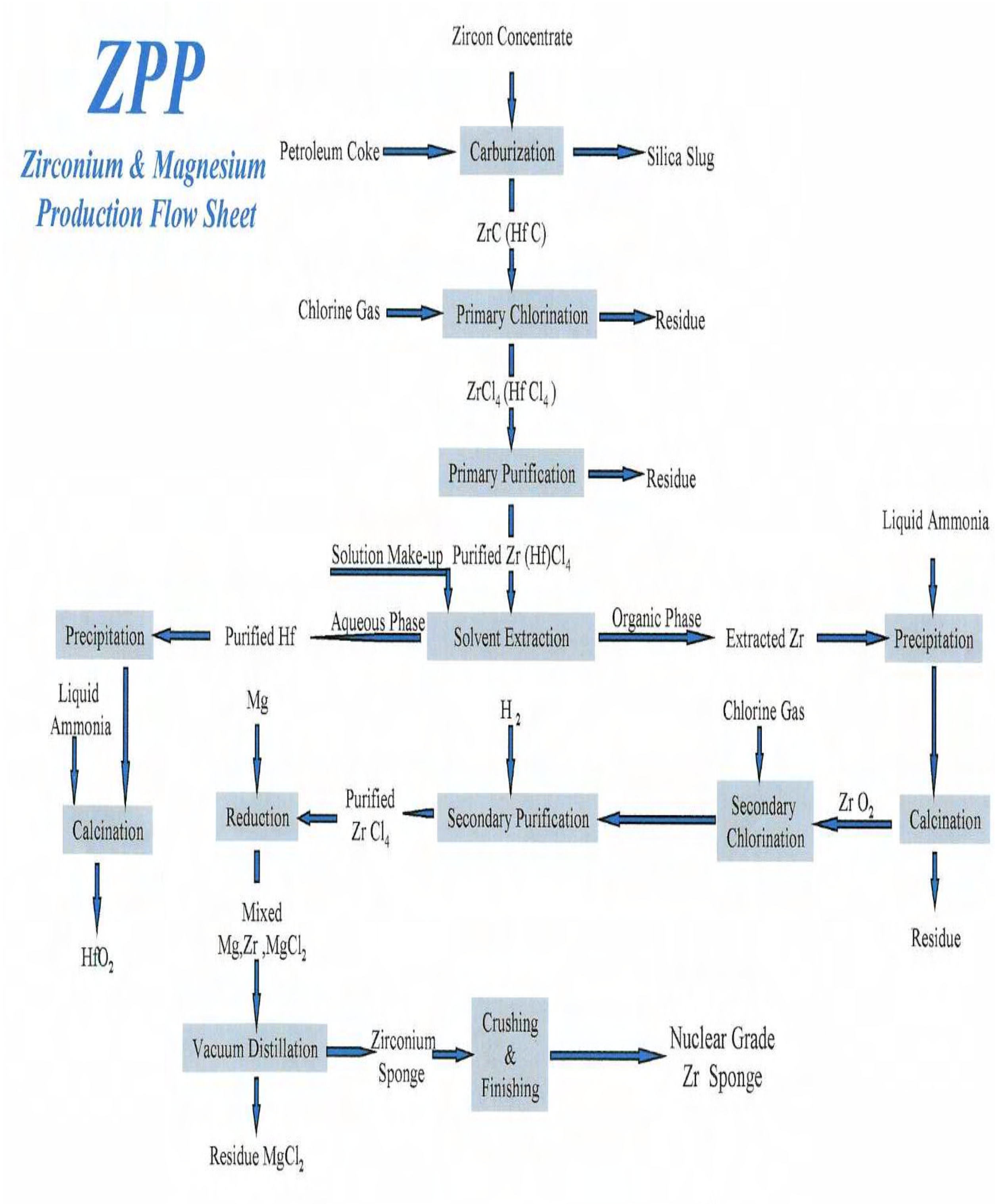

Figure 6. Tube, Strip And Bar Manufacturing Flow Sheet

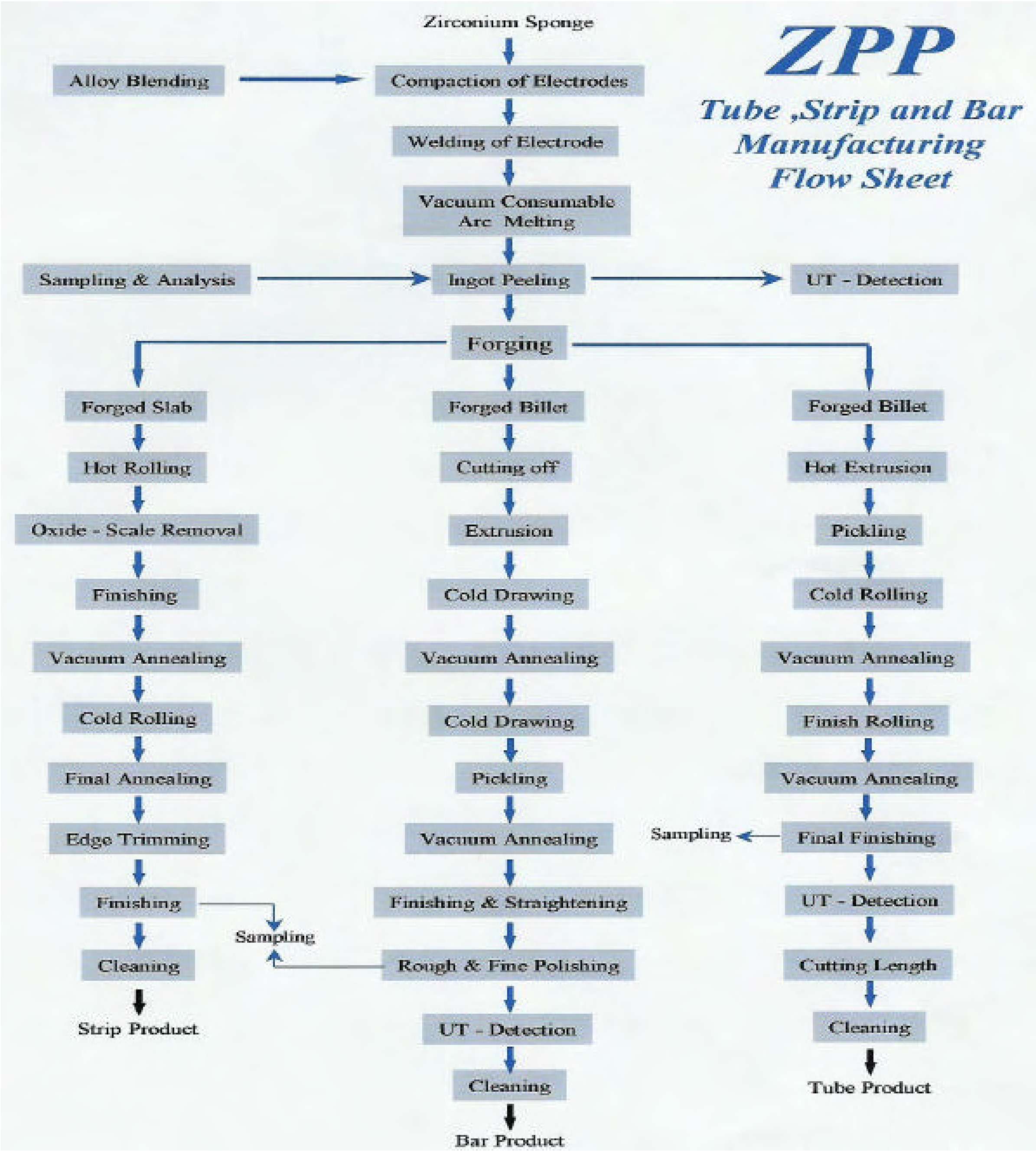

Figure 7. Process Of Fuel Assembly Production In FMP

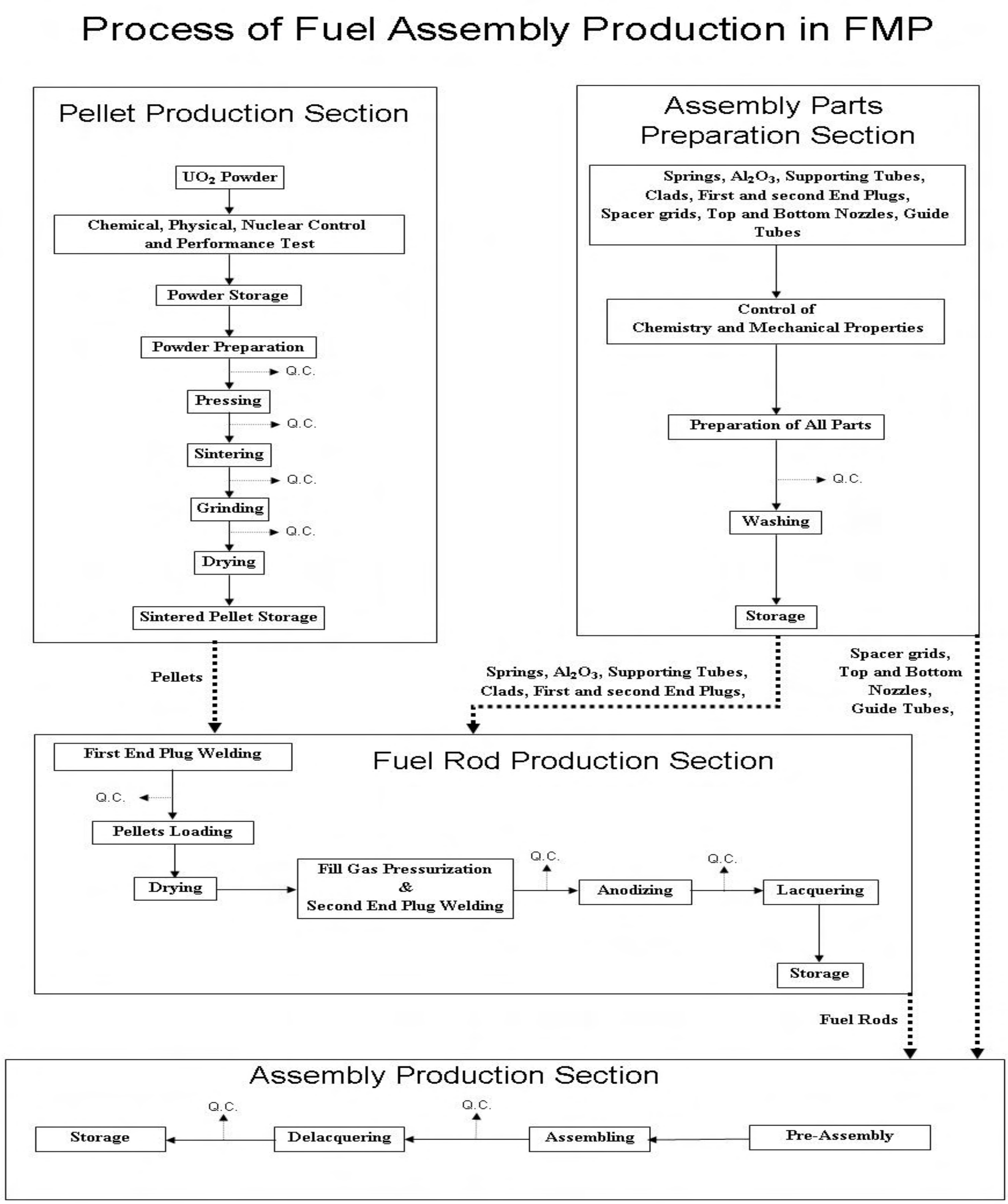

Figure 8. Future Waste Flow Diagram In Iran