PORTABLE GAS CHROMATOGRAPH-MASS SPECTROMETER (GC-MS)

LLNL has also developed portable spectrometers for the analysis of complex organic samples. Gas chromatography-mass spectrometry is generally recognized as one of the most powerful analytical separation and analysis methods available, and is widely employed in the forensic community and environmental monitoring laboratories. The combination of GC and mass spectrometry for field work can provide a great deal of information that can uniquely identify a suspect compound, providing that the available is stored in a mass spectral database (e.g., sarin, VX, sulfur mustard, etc.). The LLNL portable GC-MS system has been deployed to several locations to support various law enforcement agencies (Figure 3).

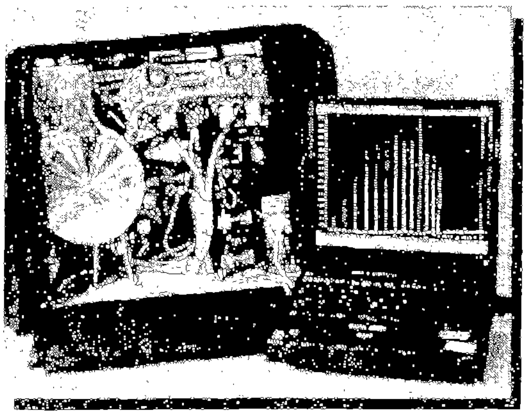

Fig. 3. LLNL Portable gas chromatograph mass spectrometer (GC-MS)

Under the leadership the Department of Homeland Security and the cooperation of other DOE laboratories, the framework to enable LLNL to assist local communities and federal agencies during time of need will continue. In addition, as LLNL develops new and improved on-site detection technologies, and they mature, they can be transition to the first responders units.

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TO QUESTION OF NPP POWER REACTOR CHOICE FOR KAZAKHSTAN

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The specific feature of atomic engineering development in Kazakhstan is an absence of any atomic power stations (" to start with a pure sheet); the unique power station with reactor on fast neutrons BN-350 has been closed. Kazakhstan is free from building work already done, constructional hobble and traditions of the modern atomic power stations as against Russia and Ukraine. Therefore Kazakhstan can choose the optimal way of development of atomic engineering from the very beginning. Kazakhstan should be oriented on construction of the most safe and economically competitive atomic power stations meeting the highest international requirements of XXI century.

Basic requirements to reactors, being created in Kazakhstan:

1. Safety of NPPs (nuclear power plants) which meets the highest international requirements, necessary for the nuclear power plants in the middle of XXI century
   - probability of heavy accident with a core melt should not increase 10^{-6} ^{1}/reactor years and maximal emission of radio-activity into environment - not more than 10^{-7} ^{1}/reactor years.
2. High requirements to the reactor technical parameters:
   - service life of the considered reactors not less than 60 years;
   - duration of a fuel cycle 18 - 24 months;
   - high design core burn- up to 60 GW d/t U and more;
   - practical exception of extreme emergency measures and reciprocal action (such as evacuation or resettlement, restrictions in food stuffs) outside of the industrial zone of the nuclear station at any heavy accident with a core melt.
3. Profitability and competitiveness of NPP with other alternative energy sources
4. Minimal import of materials and products.
5. Maximal use of own raw, industrial, technical and manpower resources of the Republic of Kazakhstan.
6. NPP creation would initiate a development of other branches industries and sciences of Kazakhstan.

Creation of atomic engineering means not only construction of a number of atomic power stations. It needs to develop Kazakhstan science and industrial technology up to a level of requirements of atomic engineering. It is necessary to create a required infrastructure, to provide a professional high level training for the specialists for atomic engineering, to provide some conditions for education of the population in spirit of understanding of atomic engineering advantage, to exclude a radiophobia, to rehabilitate atomic engineering in opinion of the population.

Due to world experience, any country, intending to develop atomic engineering, studies the compiled world experience. Moreover, the international market has created a number of magnificent projects on nuclear power plant of high safety, reliability and economic competitiveness, meeting licensing criteria of the projects in other countries. Works on further improvement of power reactors are permanently carried out to increase their safety and economic competitiveness; international cooperation of organizations and countries started development of reactors, called reactors of IV generations with parameters, exceeding modern international requirements.

Due to the above-mentioned, the comparative analysis of projects of the most advanced atomic power stations, developed in various countries of the world had been carried out. Primary we projects of reactors with water under pressure with light and hard water coolant-moderator_(type PWR and PHWR) have been considered. These reactor installations at the given stage are the most widespread, developed and studied, having the best qualities from the view point of nuclear, radiation and ecological safety, reliability and economic competitiveness. Moreover, it was important to choose reactors for the initial stage of atomic engineering development in Kazakhstan. Development of a long-term reactor strategy is a problem to be solved in the future.

The most advanced projects of reactors of the above- mentioned type of a different power range: high power (700 MW el. and higher), medium (300 MW el. - 700 MW el.) and small power (a few MW el. - 300 MW el.).

PROJECTS OF REACTORS HAVE BEEN SUBJECTED TO THE COMPARATIVE ANALYSIS

High-power:

- **EPR**- French-German reactor, development of "Siemens" and "FRAMAT" with their branch "Nuclear Power International" (NPI);

- **CANDU-9** Canadian heavy water reactor, development of Atomic Energy of Canada, Limited (AECL);
- **System 80+** - evolving reactor, development of ABB Combustion Engineering company, USA;
- **KNGR** - Korean next generation reactor, development of Korea Power Engineering Company, Inc.;
- **APWR** - Japanese advanced reactor, development of companies Japan Atomic Power Company, Mitsubishi Heavy Industries, Westinghouse Electric Company,USA;
- **WWER-1000 (V-392)** - vessel type reactor, development of Atomenergoproect /Gydropress, Russian Federation;
- **EP 1000** - European passive station, development of companies Westinghouse, USA and Genesi, Italy.

Medium power:

- **AP-600** – passive PWR, development of Westinghouse company, USA;
- **CANDU-6** - Canadian heavy water reactor, development of Atomic Energy of Canada, Limited (AECL), Canada;
- **AC-600** - passive PWR, development of the Institute of Nuclear Energy, China;
- **WWER-640** – vessel type reactor, development of OKB "Gydropress", Russian Federation;
- **MS-600** – PWR, development of Mitsubishi, Japan;
- **KSNP-600** – PWR, development of Korea Power Engineering Company, Inc., Korea.

Small power (integrated, modular type):

- **IRIS** – reactor of IV generation, developed by the International Corporation of 13 organizations from 7 countries;
- **SMART** – development of KAERI (Scientific Research Institute of Atomic Energy of Korea),
- **CAREM-25** – development of the Argentina National Commission on Atomic Energy CNEA and INVAP, Argentina;.
- **MRX** – Project of Marine Reactor X for civil applications, developed by the Japanese Scientific Research Institute of Atomic Energy (JAERI);
- **"UNITERM"** - development of FGUP NIKIET, Moscow, Russia;
- **ATEC-80** – AHEC (Atomic heat electric central) development of GUP OKBM, Nizhni Novgorod, Russia.

The International Project on Innovative Reactors INPRO has occurred essentially later than our job performance; requirements of the atomic power station users with respect to the project have appeared only in 2003. As we have begun the present job much earlier in 1999, so 15 most important criteria including the requirements of nuclear and radiation safety and economic competitiveness to analyze and compare of the listed projects of power reactors have been developed by us. Appeared, that accepted by us in year 1999 comparative criteria of reactor installations (RI) comply with INPRO requirements for RI of 2003 year from the viewpoint of nuclear, radiating and ecological safety. They are a little bit simplified.

CRITERIA OF NUCLEAR AND RADIATION SAFETY AND ECONOMIC COMPETITIVENESS FOR COMPARISON OF REACTORS

1. General characteristic of the power unit (type of a reactor, electrical power, fuel)
2. Peculiarities of barriers of deep separation protection.
3. Reactor self-protection while increase of the reactor power and reactivity, decrease of flow rate and phase transformations of the core coolant (availability of negative feedback).
4. Systems of the reactor shut down, corresponding to the principles of the variety, independence and reservation. Availability of passive means of initiation and operation of emergency protection.

5. Emergency core cooling. Availability of passive means of cooling. Availability of reservation of water provision of different safety systems.
6. Emergency electrical supply, it's reliability, availability and degree of reservation.
7. Measures of prevention of heavy accident. Decrease of probability of heavy accident with core melt.
8. Account of the heavy accident, causing the core melt, while development of protection levels.
9. Measures for decrease of consequences of heavy accident; management on beyond design-basis accident.
10. Protection from external destroying influences (earthquake, falling of the plane, explosions).
11. Results probable safety analysis (PSA), their conformity to modern requirements. Technological criteria of safety for the 4th level of protection (for heavy accident).
12. Limiting radiation criteria for each level of protection, in particular for the 4th level of protection (for beyond-project accidents).
13. Testing of safety means (principles, elements, technical decisions) under regular conditions, former experience or tests.
14. Measures for reduction of construction cost, equipment, materials and operation of station. Economic parameters.
15. Specific features of the reactor with respect to the previous reactors, increasing it's safety.

All considered reactors of high, medium and small power have been subjected to medium to the careful analysis with respect to 15 criteria accepted by us. We have disintegrated all considered projects of reactors by 15 criteria as on shelfs, and have compared them among themselves.

Unfortunately, I have no opportunity to stop on details of the analysis and comparison of reactors by the accepted criteria because of limited time of the report. I can offer a pre-print in which the comparative analysis is in detail submitted.

Further, analysis of a present status and prospects of development of energy production and energy consumption, stations and networks in Kazakhstan till 2030 year, necessary for a choice of reactor projects of the atomic power station for Kazakhstan has been carried out on the basis of official documents. Some results are submitted below.

SOME PARAMETERS OF MODERN CONDITION AND PROSPECTS OF THE KAZAKHSTAN POWER COMPLEX

1. Balance of energy manufacture and consumption at the level 59 billion kW/hour was received in 2002.
2. Misbalance in energy manufacture and consumption is available in different areas of RK, caused by the USSR failure:
   - Northern and Eastern regions of the Republic overproduce the electric power. Energy surpluses from Northern regions are exported to Russia.
   - Southern region imports up to 15 % of the electric power from the united Central Asia electric system.
   - Western Kazakhstan, having essential stocks of hydro carbonic fuel, imports up to 68 % of the electric power from Russia.
   - Despite of decrease of volume of the power consumption in 1999, 3.4 billion kW.h was imported: 2.2 billion kW.h – from Russia, 1.2 billion kW.h - from Republics of Central Asia.
3. Development of own electric power sources to provide Kazakhstan by electric power is planned to 2015. Capacities, generating electricity, will be introduced for these purposes: in 2005 year – 860.7 MW, in 2010 - 1501.1 MW and in 2015 – 1725.5 MW.

According to suggested data, balancing of the production and consumption of energy in the country at a level 59 billion kW.hour is achieved. However, the strong disbalance on regions of Republic takes place.

The atomic power can participate in indemnification of deficiency in manufacture electric and thermal energy and in providing of the power safety and the power independence of the Republic. Application of atomic engineering is promoted also by the following circumstances:

- Kazakhstan occupies one of leading places in the world on stocks of uranium. According to accounts Kazakhstan has concentrated 923 thousand tons of the reconnoitered stocks of uranium or about 25 % from world stocks, from which 70 % can be developed by the most economic and non-polluting method – a method of a underground leaching
- Besides there are really basic components of the nuclear fuel cycle in the Kazakhstan, excepting processing of the fulfilled fuel and the manipulation with highly radioactive waste products.

Nowadays nuclear stations of medium and small power are considered to be the most appropriate for construction in Kazakhstan because of limitation of power consumption capacity of industrial - agrarian complex of the country, insufficient bandwidth of electric mains, and also essential amount of small consumers removed from electric mains.

Therefore results of the analysis of reactor projects of medium and small power, performed with respect to the above-mentioned 15 criteria of safety and economic competitiveness are given in the report.

Following conclusions can be made while comparing results of the analysis on medium and small power reactors:

(1) Results of the comparative analysis indicated that all considered reactors of medium and low power corresponds, and in some cases surpass modern requirements on installations safety.

(2) Nevertheless, by our opinion, projects of the atomic power station of medium capacity with passive reactor AR-600, heavy water reactor CANDU-6, PWR MS-600 are most attractive; among reactors of small power, projects on reactors "IRIS are most preferential - project NPP of IV generation, NPHS "UNITERM" and MRX – Project of Marine Reactor X for civil applications. (Table 1)

These conclusions are made proceeding from the viewpoint of nuclear, radiating and ecological safety, reliability and economic competitiveness according to 15 criteria.

Table 1. The Most Attractive Reactors for Application in Kazakhstan

Reactor	Power	Developer
Medium Power Reactors		
AR-600 – passive reactor	600 MW (el)	Westinghouse (USA) и GENESI(Italy)
CANDU-6 - heavy water reactor on natural uranium	665 MW (el)	AECL,Canada
MS-600 – PWR	600 MW (el)	Mitsubishi,Japan
Small Power Reactors		
IRIS - reactor of IV generation	100-335 MW (el)	Consortium of 13 organizations from 7 countries.
AS "**Uniterm**"	30 MW	NIKIET, Russia
MRX - Project of Marine Reactor X for civil application	100 MW (heat)	Japanese Scientific Research Institute of Atomic Energy (JAERI)

French – German passive reactor EPR and Canadian heavy water reactor CANDY-9 will be the most attractive if high-power reactors will be necessary further.

Further I shall tell shortly only about some the most important advantages of the specified reactors.

THE MOST IMPORTANT FEATURES OF MEDIUM POWER REACTOR "AP – 600"

1. All safety systems are passive. Systems use only natural forces, such as gravity, natural circulation and compressed gas no action of the operator within 72 hours after accident.
2. The minimal probability of risk of heavy accident with a core melt, emission of the big radio-activity beyond containment is lower on more than twice order with respect to requirements of IAAE.
3. The most tested and advanced reactor project ever considered by the Commission on Nuclear Settlement of the USA.
4. Atomic power station with reactor AP600 can compete by electric power cost with the stations having biggest power (nuclear or coal), developed nowadays.

THE MOST IMPORTANT FEATURES OF MEDIUM POWER REACTOR "CANDU-6"

1. Unique peculiarity - ability to prevent melt of the fuel channel after accident with loss of the coolant even if the emergency system of injection of the coolant does not work.
2. Heavy water moderator in calandria can be used as the coolant device in a hardly probable case of the emergency coolant loss in the heat transport system, accompanied with damage of the core emergency coolant system. In case of circulation loss of heavy water moderator, heat can be removed by light water of the protective tank around calandria for which both active, and passive heat removal is provided.
3. Continuous overload of fuel (on natural uranium) on the power, excluding reactivity accidents.
4. Probability of heavy accident with melt of a core and emission of a limiting radio-activity is lower on more than one order with respect to requirements of IAAE.
5. Fuel on natural uranium is used. It is important for the countries having no expensive concentrating factories.

THE MOST IMPORTANT FEATURES OF MEDIUM POWER REACTOR "MS-600"

1. Low density of power of the reactor core with respect to the previous projects 600 MW (el).
2. Reactor Pressured Vessel is developed for the working period 60 years with the general fluence of neutrons, not exceeding 10^{19} nvt.
3. Reactor MS-600 has double containment, consisting of steel primary containment and secondary containment, having structure of steel sheets filled with concrete.
4. Innovative hybrid systems of safety are applied on MS 600 reactor, passive systems are expanded, and active ones are simplified to improve safety, reliability and profitability:
   - Passive systems: automatic seal failure, advanced accumulators, mine of gravitational injection, horizontal steam generators with providing of feedwater under action of gravitation.
   - Active systems of safety: consist of forcing pumps of injection, auxiliary pumps of a feedwater; and system of removal of residual heat.
5. Emergency electrical supply of a reactor.
   - Two lines by 440 V AC;
   - Two diesel generators.
   - Four systems of power supply by accumulators of direct current DC 4x4000 Ah.
6. "Leak- before- break" concept is accepted.

7. "Secondary containment" should provide good protection against external shells.
8. Frequency of damages of the core is lower on more than one order with respect to working nowadays PWRs.

THE MOST IMPORTANT FEATURES OF THE SMALL POWER REACTOR «IRIS»

1. IRIS is the International Project of innovative and safe reactor of IV generation. It is developed by 13 organizations from 7 countries.
2. Integrated configuration of the equipment of the first contour is applied.
3. "Safety provided by design" is realized by IRIS.
4. Totally passive reactor.
5. IRIS excludes core dewatering and accordingly core melt at any accident type LOCA.
6. Control rod drive mechanisms are located in a reactor vessel.
7. Long fuel cycle (8 years), direct burning of a core without reactor shut down or additional load of nuclear fuel.

THE MOST IMPORTANT FEATURES OF SMALL POWER REACTOR UNITERM

1. Integrated, modular assembling of the equipment of the first contour.
2. There is the safeguard vessel (containment), locating flowing up water at LOCA. While alignment of pressure between a reactor and the safeguard vessel outflow stops. The core remains under water at any accident with heat-carrier loss (LOCA).
3. Completely passive reactor. The core is cooled by naturally circulating coolant of the first contour.
4. Direct burning of a core without reactor shut down or additional load of fuel during service period 20-25 years;
5. The concept of a reactor management due to negative temperature factors of reactivity at absence in RI of mobile and automatically working system of regulation. Decrease of reactivity, caused by fuel burning out and slag formation, is compensated by burning out by absorbers and temperature effect, composing approximately 1 % per year.
6. Full manufacturing and test of RI industrially, delivery in the equipped condition on a place of operation by large modules, exploitation with no overload of a core, removal of a reactor without its opening, etc.
7. Ecological purity of station is provided by lack of any emission into environment, except for thermal, directed into atmosphere.

CONCLUSION

In conclusion I would like to note that the given job is only a beginning one. It will be continued with attraction of new projects of reactors, possibly with application of project INPRO requirements.

Kazakhstan is interested in cooperation with other countries and companies in a choice of projects of power reactors, atomic power station and development of the atomic energy of Kazakhstan.