AECS

Syrian Preparatory Process for the First NPP Project

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Introduction

Phase 1 and 2 (IAEA Bulletin 49/1)

Nuclear legal framework, Regulatory system, Human resources, Financial matters, communication, Programs (operation, decommissioning, radioactive waste management) and responsibilities.

The Atomic Energy Commission of Syria (AECS) was founded in mid seventies. In 1981, AECS assumed its duties as a governmental agency responsible for peaceful utilizations of atomic and nuclear technologies. Research departments, facilities and laboratories were founded and manned with skillful workforce towards carrying out basic and applied research in the fields of atomic and nuclear applications.

Introduction

The AECS represents Syrian Arab Republic in regional and international gatherings related to nuclear and atomic issues. In 1963, Syria became a member of the International Atomic Energy Agency. It has fulfilled its international obligations with respect to nuclear safeguards by signing the NP treaty in 1967. AECS is actively complying with radiation safety regulations. The AECS is the regulatory authority in Syria.

Considering a nuclear power program, the AECS becomes the most appropriate organization in Syria to assess design option, establish user requirement, and prepare bid documents.

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Regulatory Infrastructure:

Regulatory infrastructure is fairly far developed. In compliance with the IAEA rules and agreements the AECS has established a Radiological and Nuclear Regulatory Office (RNRO).

RNRO Structure:

- Licensing and inventory section
- Medical inspections sections
- Industrial inspections section
- Border control section
- Nuclear safety section
- Studies and safety assessment section

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RNRO functions:

- Preparation of regulations and guides
- Issuing authorizations
- Radiological Inspections
- Emergency Preparedness
- Radiological monitoring at border crossings
- Safety/risk assessment
- Nuclear inspections

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Law

- Law No. 12 (1976):

promulgates establishment of AECS.

- Prime Minister Decision no.6514 (1997): details functions of the AECS as being the Regulatory Body for radiation safety in Syria.

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Law

- 3rd of August 2005
- New law (legislative decree No. 64) was issued by the President of the Syrian Arab Republic.
- This legislative decree complies with the international standards as specified in the BSS and GS-R-1
- It nominates AECS as The regulatory authority in respect to radiation protection and safety and security of radiation sources.
- New general regulations are issued by Syrian Prime Minister Decision No 134 in January 2007 in which Chapter 11 is concerning with medical exposure control.
- Authorizations are granted directly by the head of RNRO on behalf of the Director General of the AECS, according to the international requirements stated in (BSS no.115/ 1996).

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Law

- The Law No. 64 (2005) prescribes sanctions in case of non-compliances.
- The sanctions scheme takes into account the risk associated with the radiation sources.
- AECS has to develop an enforcement policy based on this law and to put this policy in application

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Nuclear Safeguards Office:

- The Syrian Arab Republic was one of the first countries to sign the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) . It was ratified by Legislative Decree no. 169 of 5 August 1969.
- Based on Article /3/ of NPT, the Syrian Government had signed with the International Atomic Energy Agency (IAEA) , as early as 1992, the Comprehensive Safeguards Agreement, under which a national system for accounting and monitoring of the movement of nuclear materials waste established.
- The AECS since 1992 has the full responsibility to fulfill its international obligation with the IAEA in accordance with the NPT Full Scope Safeguard Agreement.
- Sine then, the Syrian Research Reactor – MNSR is subject to the IAEA inspection missions in accordance with the Full Scope Safeguards Agreement, and all results of the agency reports for those missions were satisfied with the IAEA requirements and criteria.

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Human Resources Development:

- **Research and development**

- The MNSR reactor has been in operation since March 1996. The AECS had established a Nuclear Engineering Department. It consists of four divisions: Reactors Physics, Reactors Safety, Reactors Operation & Utilization, and the Radioactive Waste Management Division (RWMD). The (RWMD) is responsible for all matters related to the radioactive waste Management in Syria. The nuclear desalination is of great interest.
- In addition to training staff on operation and maintenance of the nuclear reactor, the main goal is to conduct research activities in the fields of nuclear reactors while applying all safety and safeguard regulations.

- **Research activities related to MNSR reactor incorporate**
    1. Reactor physics calculations

Selected Publications in International Journals:

1. Calculation of the fuel burn-up and radionuclide inventory in the Syrian miniature neutron source reactor using the WIMSD4 code, **K. Khattab**, *Annals of Nuclear Energy, 32 (1122-1130), 2005.*

2. A 3-D Neutronic Model for the Calibration of the control rod of the Syrian MNSR, **M. Albarhoum**, *Progress in Nuclear Energy 46, 2, (159-164), 2005.*

3. The effect of temperature and control rod position on the spatial neutron flux distribution in the Syrian Miniature Neutron Source Reactor, **K. Khattab, H. Omar, N. Ghazzi**, *Nuclear Engineering and Design, April, 2006.*

4. Prediction of the in-core power and the average core temperature using dose-rate measurements in the Syrian Miniature Neutron Source Reactor, **I. Khamis, H. Jamal**, *Journal of radioanalytical and Nuclear Chemistry Vol, 269. No 1, (81-85), 2006.*

5. Monte Carlo simulation of a conceptual thermal column in the Syrian miniature neutron source reactor using MCNP-4C, **I. Khamis, I. Suleiman**, *Annals of Nuclear Energy, 33 (622-626), 2006.*

6. Data analyzer computer program for neutron activation analysis, **S. Al-Ayoubi, A. Sarheel, N. Al-Somel**, *Journal of Radioanalytical and Nuclear Chemistry, Vol. 271, No.3 (2007) 651-653.*

7. Analysis of MNSR core composition changes using the codes WIMSD-4 and CITATION, **F.Alhabit, N. Ghazi, A. Hainoun**, *Applied Radiation and Isotopes, 66 (1492– 1500), 2008.*

8. Determination of the axial thermal neutron flux non-uniform factor in the MNSR inner irradiation capsule, **K. Khattab, N. Ghazi and H. Omar**, *Nuclear Instruments and Methods in Physics Research, Section A,575(2007), 456-46*

9. Design of a permanent Cd-shielded epithermal neutron irradiation site the Syrian Miniature Neutron Source Reactor, **K. Khattab, K. Hadaad and H. Haj-hassan**, *Journal of radioanalytical and Nuclear Chemistry Vol, 277. No.,2008 , 311-316.*

10. Four energy group neutron flux distributions in the Syrian Miniature Neutron Source Reactor using the WIMSD4 and CITATION codes, **K. Khattab, H. Omar and N. Ghazi,** *Progress in Nuclear Energy, 2008*

11. Burnup effect on 95Nb/95 Zr ratio – cooling time correlation, **K. Haddad**, *Journal of Nuclear Materials, 345, (86-88), 2005.*

12. Determination of the Gamma Self-Attenuation Correction Factor Using Intensity Ratios, **K. Haddad, H. Suman**, *Journal of radioanalytical and Nuclear Chemistry Vol, 268. No 1, (109-112), 2006*

13. Sensitivity analysis of reflector types and impurities in a 10 MW MTR type nuclear research reactor, **K. Khattab, I. Khamis**, *Indian Journal of Pure and Applied Physics, Vol. 45, June 2007, pp 491-495.*

14. Estimation of the activation of local reactor shielding concretes **S. Alhajali, M.H. Kharita, B. Naoom, S. Yousef, M. AlNassar**, *Progress in Nuclear Energy (proof), 2008.*

15. Heat effect on the shielding and strength properties of some local concretes, **S. Yousef, M. AlNassar, B. Naoom, S. Alhajali, M.H. Kharita**, *Progress in Nuclear Energy, (proof), 2007.*

16. MTR BENCHMARK STATIC CALCULATIONS WITH MCNP5 CODE, **Anis Bousbia-Salah, Hocine Benkharfia, Nateekoool Kriangchaiporn, Alessandro Petruzzi1, Francesco D´Auria1, Nidal Ghazi**, *Annals of Nuclear Energy, Volume 35, Issue 5, May 2008, Pages 845-855.*

- **Research activities incorporate:**
  2. Thermal hydraulic and reactor safety analysis using computer codes PARET, MERSAT, CFD

Selected publications:

1. Full-scale modeling of the MNSR reactor to simulate normal operation, transients and reactivity insertion accidents under natural circulation conditions using the thermal hydraulic code ATHLET, **A. Hainoun, S. Alissa**, *Nuclear Engineering and Design 235 (33–52), 2005.*

2. Conceptual Design Modifications of the Cooling System of MNSR Reactor to increase its Maximum Continuous Operation Time, **F.Alhabit, N. Ghazi, A. Hainoun,** *Nuclear Engineering and Design 237 (2275–2281), 2007.*

3. Modification and Validation of the Natural Heat Convection and Subcooled Void Formation Models in the Code PARET, **F.Alhabit, N. Ghazi, A. Hainoun**, *Annals of Nuclear Energy, 35 (395-403), 2008.*

4. Simulation of LOFA and RIA for the IEA-R1 research reactor using the code MERSAT, **F.Alhabit, N. Ghazi, A. Hainoun**, *Annals of Nuclear Energy, 35 (2093-2104), 2008.*

5. Construction of the Hourly Load Curves and Detecting the Annual Peak Load of Future Syrian Electric Power Demand Using Bottom-up Approach, IJEPES, **F. Alhabit, N. Ghazi, A. Hainoun**, *International Journal of Electrical Power and Energy Systems, 2008.*

6. Analysis of an RO plant to remedy the water shortage in the rural area of Damascus, **S.Suleiman, F. Kroma, J. Momjian**, *Desalination 177 (281-289), 2005.*

7. Analysis of the Syrian Long-Term Energy and Electricity Demand Projection Using End-Use Methodology, **A. Hainoun, M.K. Seif-aldein, ALMostafa**, *Energy Policy 34, (1958-1970), 2006.*

Research activities incorporate:

3. Reactor kinetics to measure selected MNSR kinetic parameters.

Selected publications:

1. Measurement of the Syrian MNSR delayed neutron fraction and neutron generation time by noise analysis, **I. Khamis, A. Hainuon, W. Suleiman**, *Annals of Nuclear Energy 31 (331-341), 2004.*

2. Dynamic Analysis of the closed – Loop Transfer Function in MNSR, **A. Hainoun, I. Khamis, G. Saba**, *NED 232, 2004.*

Human Resources Development:

Education and training:

- The Atomic Energy Commission of Syria (AECS) has strengthened education and training in radiation protection since early 90's.
- In cooperation with Damascus university, the AECS has established a Postgraduate Educational Course (PGEC) in radiation protection .
- AECS and the IAEA in collaboration with the Higher Institute of Applied Science and Technology (HIAST) and with the University of Damascus have upgraded this PGEC into one full academic year post graduated specialized diploma. This postgraduate specialized Diploma courses have been running since 2000.
- This course was upgraded to Master degree course (Radiation protection and safety of radioactive sources) in 2006 and has been running till now.
- In total, 211 Arab students (from 16 different countries) have been through these PGECs, 71 of them are from Syria.

Education and training:

Number of PGEC Graduates:

Country	Number of students										Total Number for each country
	PGEC 1997	PGEC 1999	PGEC Diploma 2000-01	PGEC Diploma 2001-02	PGEC Diploma 2002-03	PGEC Diploma 2003-04	PGEC Diploma 2004-05	PGEC Diploma 2005-06	PGEC Master 2006-08	PGEC Master 2007-09	
Algeria	1	1	-	-	-	-	-	-	-	-	2
Egypt	2	3	-	1	1	1	2	-	1	-	11
Iraq	2	2	-	-	-	-	-	2	3	-	9
Jordan	2	1	1	3	-	-	4	2	2	-	15
Kuwait	2	-	-	1	1	-	-	-	1	-	5
Lebanon	3	1	2	2	2	2	2	1	2	1	18
Libya	-	2	-	-	2	-	-	-	-	-	4
Morocco	1	-	-	-	-	-	-	-	-	-	1
Palestine	-	-	-	-	3	2	1	1	-	-	7
Qatar	1	2	-	-	-	-	-	-	-	-	3
Saudi Arabia	2	1	4	2	2	2	1	1	2	-	17
Sudan	1	1	-	2	1	2	1	-	2	-	10
Tunisia	1	1	-	-	-	-	-	-	-	-	2
Emirates	1	2	2	1	-	-	-	-	-	-	6
Yemen	2	2	3	3	3	4	1	4	4	4	30
Syria	8	8	4	5	5	5	9	12	7	8	71
Total	**29**	**27**	**16**	**20**	**20**	**18**	**21**	**23**	**24**	**13**	211

Education and training:

- In collaboration with Damascus University the AECS established at the Faculty of Mechanical Engineering **the Nuclear Engineering Section**. The section is teaching nuclear engineering for the undergraduate study level. The undergraduate program consists of 5 years. The first three years are devoted for basic study and the last two years for the specialization in the field of nuclear engineering.
- The nuclear Engineering program comprises 24 courses of 70 units for theory and 38 for laboratory experiments and codes calculations.
- The last year includes a final study project related to running research activities at AECS.

Education and training:

- The selection of program courses rely upon the nuclear engineering courses of recognized university like, MIT, Berkley, University of Florida, University of Missouri, University of Maryland, University of Tennessee in the US and Universitaet Karlsruhe in Germany.
- The main courses of the undergraduate program consist of:
  - Reactor Engineering, Reactor physics, Reactor Safety, Reactor Dynamic;
  - Thermal Hydraulic Analysis, Energy System Analysis;
  - Fuel Cycle, Fuel Management, Waste Management;
  - Reactor Shielding, Radiation Protection;
  - Radiation Application.
- **MNSR reactor is used as a training tool to perform selected nuclear engineering experiments.**

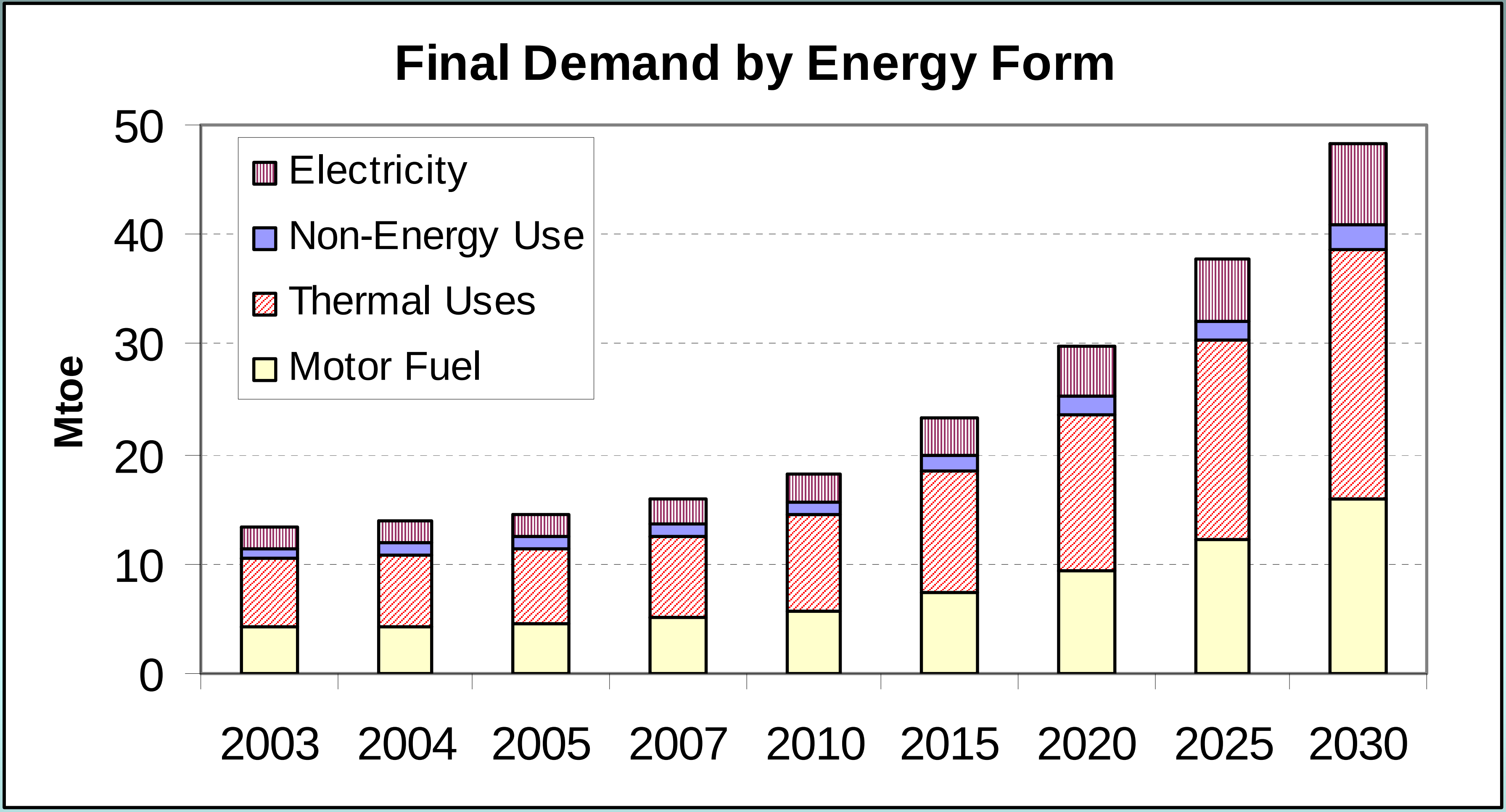
TC projects with IAEA

- TC-Project (SYR/006) on:

Analysis of Energy and Electricity Demand Projection in Syria (Covering the period 1999-2030)

Output:

Projection of future final energy demand for Syria for the next three decades. The study is made According to socio-economic & technological development scenarios.



The final energy demand will grow up from about 13 Mtoe to almost 50 Mtoe. This distribution illustrate the type of consumption: electricity, motor fuel, thermal use and none-energy use.

TC projects with IAEA

- Regional TC-Project (RAS/043) on:

Comparative assessment of electricity generation options

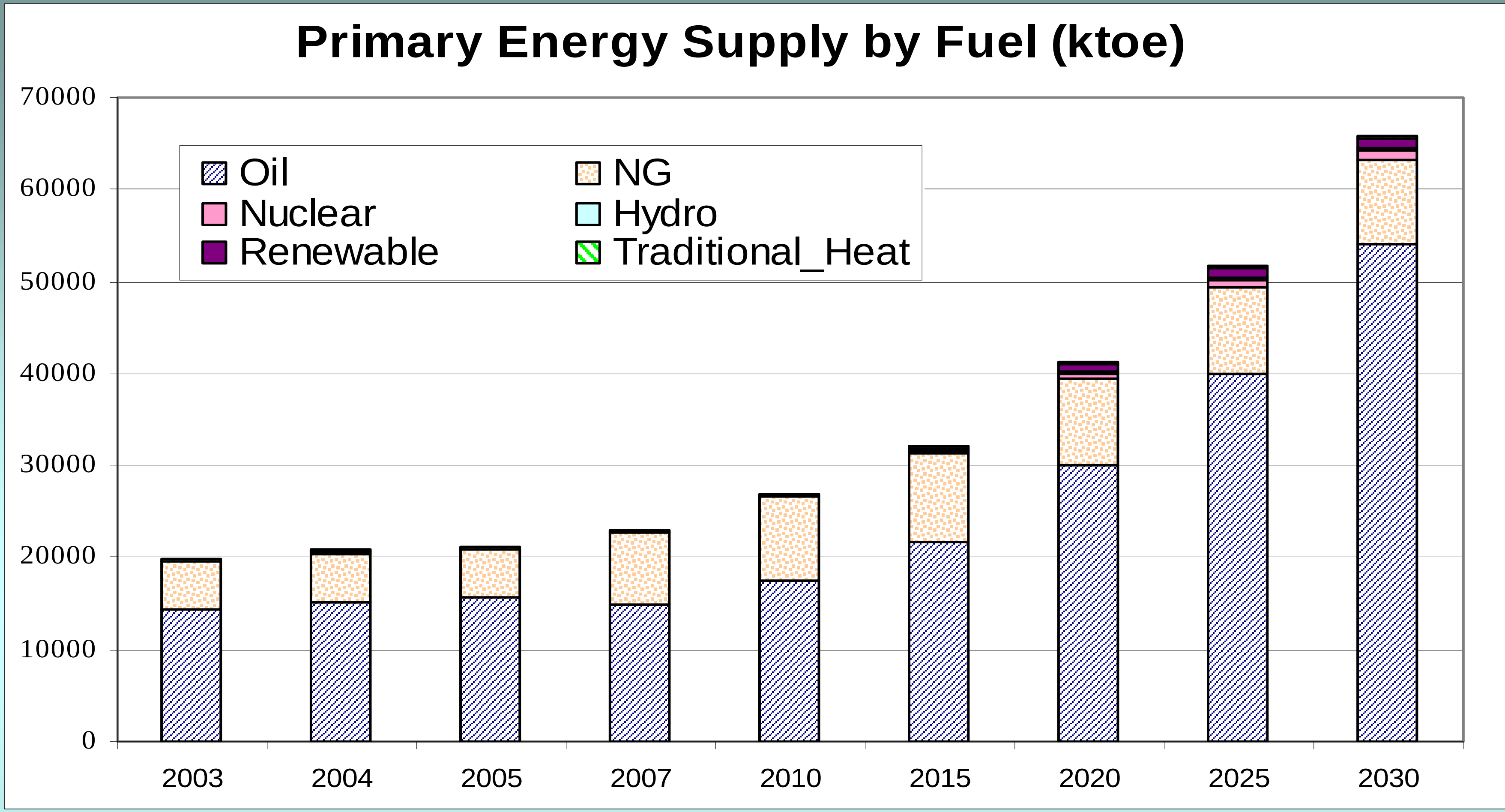
Output:

- Formulating the optimal energy supply strategy to meet the expected demand using the national resources and considering new resources like nuclear and renewable.
- Developing the least-cost electric expansion plan and identifying the role of nuclear power.

The optimal energy supply strategy is an optimization for the whole energy system carried out using WASP and MESSAGE Codes.

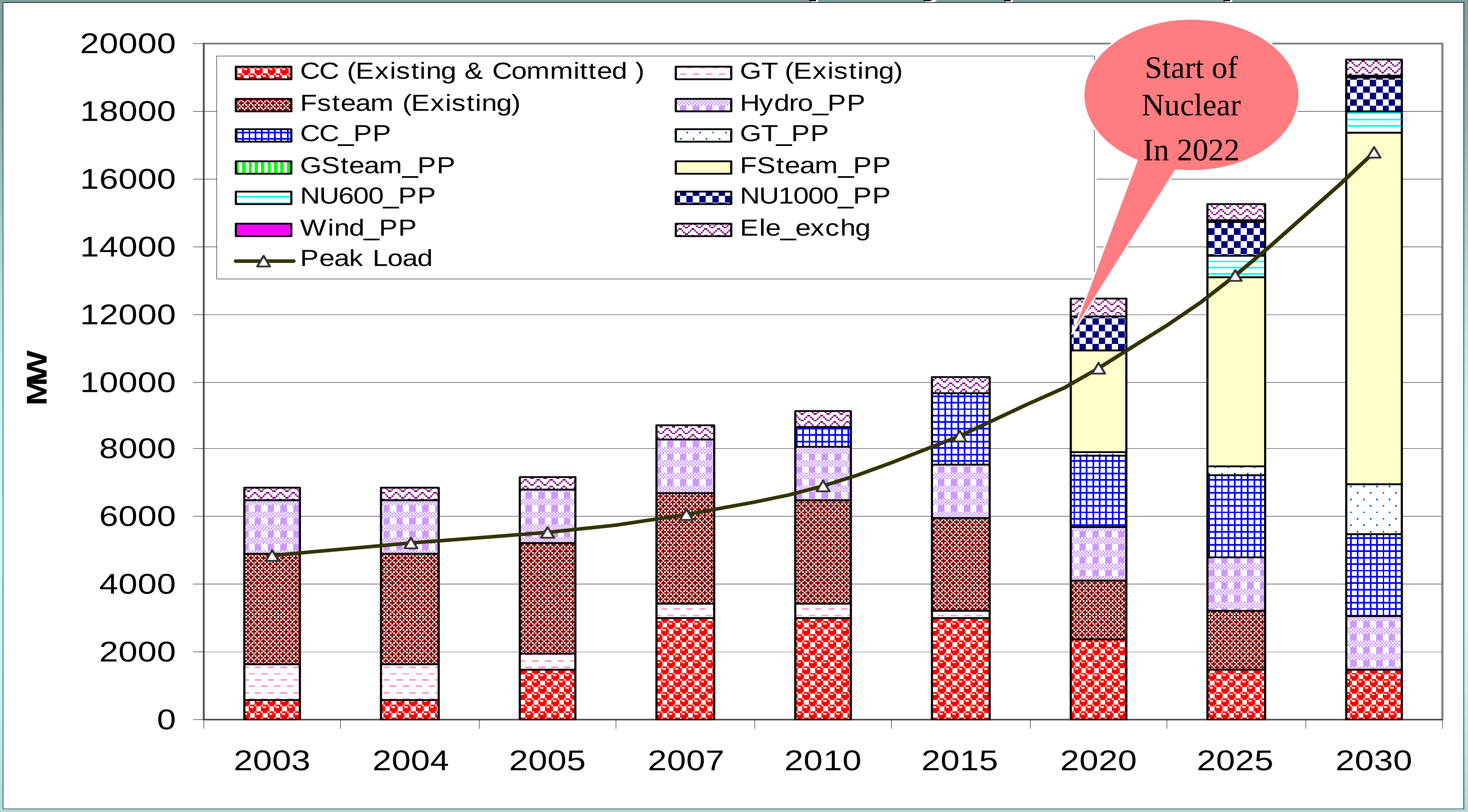
(WASP: Wien Automatic System Planning Package)

(MESSAGE: Model for Energy Supply Strategy Alternative and their General Environmental Impacts)



- Results for the optimal energy supply strategy for the next three decades prove the competitiveness of nuclear option in the future generation mix and indicate the introduction of first nuclear power plant in the time horizon of 2020-2022. The proposed nuclear capacity addition amounts at 1000 MW.

Evolution of Future Installed Capacity Optimal Expansion



- This figure shows the expected future development of the total installed capacity to meet the expected future electricity demand distributed by all types of generation.
- In the year 2022 the first nuclear power plant will enter the system with installed capacity of 1000 MW and in the next period up to 2025 the next power plant of 600 MW can enter the system.

Challenges

The introduction of the first NPP is a great opportunity for development of different sectors (scientific community, industry, human resource ...) in the country. It is preferable for the first NPP project to be implemented by a joined contract.

Challenges to be met:

- **The high construction cost:**

  Electricity generation cost of NPP should be competitive with that of the comparable base-load electricity sources in the country. Capital cost should be minimized to the extent possible.

- **Safety, Security & Safeguard:**

- The NPP should use only proven safety systems as safety systems are the main indicator for competitiveness and acceptance of nuclear option.
- The safety of the NPP design should be demonstrated by the best combination of deterministic and probabilistic safety analyses.

Challenges

- **Fuel cycle:**
  - The user should have the right to realize a reliable fuel supply over the plant lifetime. Otherwise the nuclear option couldn't fulfill the sustainable supply requirements.
  - Return of spent fuel to supplier country is the preferred option.
  - The NPP should be designed to allow for different fuel suppliers.
- **Licensing:**
  - The reactor system should be licensed in the country of system origin and the licensing information should be made available.
  - The Supplier should support the user in the preparation of license application and associated documentation.
  - The supplier should arrange a comprehensive human resource development program for licensing issues.

Challenges

- **Regulatory body:**

  Due to the lack of experience in developing countries in license and regulation aspects, the regulatory body in the Supplier's country should provide support to the regulatory body in the User's country for carrying out its licensing and regulatory functions and particularly in implementing approaches and codes for safety analysis.

- The AECS will be responsible for regulation and safety issues of NPP while the operation of NPP will be the responsibility of ministry of electricity.

- **Supporting the human resources development:**

  The Supplier should provide assistance for training the user's personnel, with the objective to increase their capabilities to undertake activities associated with construction, operation and maintenance of the NPP throughout its life.

Challenges

- **Development of the national industrial sector:**

  As the utilization of available local infrastructure reflects in cost reduction and knowledge transfer, the supplier should assist the user in preparing a comprehensive development program to enable an increase in local participation over the life of the nuclear power program including future NPPs. The introduction of the first NPP will stimulate efforts and competition between manufacturers leading to the development of quality assurance and quality control culture.

Questions

- How can the user country insure security of fuel supply?
- How can we reduce the high capital cost without jeopardizing the safety issue?
- Has the problem of spent fuel disposal been completely solved yet?

THANKS FOR YOUR ATTENTION