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DEVELOPMENT OF SCIENCE AND TECHNOLOGY CAPACITY-BUILDING IN KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH

by

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Development of Science and Technology Capacity Building in Kuwait Institute for Scientific Research

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Introduction

The role and the impacts of scientific knowledge, technological know-how, and research and development (R&D) on societal progress and advancement have been witnessed and, since World War I. These impacts have been increasing tremendously during the last three decades. The status of any societal development depends mainly on the extents of introduction, utilization and dissemination of science and technology. Such effects have been elaborated, and witnessed more in the occident. It is believed that the divisional level of societal development, i.e. developed or developing, relies primarily on the ability of any society to introduce, handle and employ science and technology in the various sectors of the economy (Al-Sultan, 2000).

The policy-makers in Kuwait have realized and acknowledged, since the 50's of the last century, the vitality and the necessity of employing science, technology, research and development in the socio-economic development plans. This concern was reflected by establishing, funding and nurturing various scientific and technological and research organizations (Al-Sultan, 1998).

Kuwait Institute for Scientific Research (KISR) as one of the major scientific organizations in Kuwait was established in 1967 to conduct applied research and train cadres in various fields in research. To achieve such objectives, KISR's managements were inclined and exerted various efforts to initiate and enhance science and technology capacity building in several areas and domains.

The present research paper would elaborate on KISR's experiences and endeavors in science and technology capacity building in three main research areas, namely, development of water resources, plant tissue culture and energy conservation in buildings.

Kuwait Institute for Scientific Research: Establishment, Mission and Achievements

Kuwait Institute for Scientific Research (KISR) was established in 1976 by initiatives, from His Highness the present Amir of Kuwait SHEIKH JABER AL-AHMED AL-SABAH who was then in charge of finance and Oil in Kuwait, when he requested the Arabian Oil Co. (Japan) to establish, finance and administer an applied research institution in Kuwait as part of Oil concession.

In July 1973, KISR has become national entity chaired by a cabinet Minister. KISR has witnessed several reorganizations in both mission and administration. In 1981, law No. 28 was promulgated for further development of KISR objectives, management and outputs. (Al-Sultan, 1984).

Law No. 28 of 1981 states that the mission of KISR is the promotion of scientific and applied research, particularly in matters relating to industry, natural and food resources, and other primary constituents of the national economy, in an endeavor to serve the goals of economic, technological and scientific development" and to offer advice to the government on scientific matters and on science policy issues.

Consequently, the main objective is to conduct applied R&D closely linked to national needs, whether in the study of Kuwait's resource base, environment and means of diversifying the national economy, or in solving the problems of individual users in various sectors of the economy.

The first five-year research strategic plan was formulated and implemented in 1978/79. This necessitated enhancing the research programmes by facilitating proper and advanced setups. The research plans called for six research programmes, namely:

- Food Resources
- Oil and Petrochemicals
- Engineering
- Water Resources
- Environment
- Techno-economic

For more details on KISR activities and accomplishments, refer to: (Al-Sultan 1989, Al-Sultan 1998, KISR 1999, ESCWA 1997, and ESCWA 1999).

KISR's 2000-2005 Fifth Strategic Plan

Since 1979, KISR has been implementing its research program through development of a 5-year Strategic Research Program Plans.

These has been as follows:

* 1979 – 1984 The Plan introduced the 'Research Management System' and the 'Division' structure.
* 1984 – 1989 The Plan adopted the concept of Technical Research Program including Program Element Substructures.
* 1992 – 1995 The Plan introduced a Transitional Strategic Program, rebuilding of KISR and assessment of damages.
* 1995 – 2000 The Plan focused on activities of national interest and working with relevant organizations.

The Fifth Strategic Plan (2000 – 2005) was prepared with full knowledge of KISR's prior organizational developments, and also with understanding of the meaningful accomplishments, which had already been achieved. Past and current achievements serve as realistic indicators of whether or not the proposed plan can be executed during the plan period. With the New Millennium, KISR is being especially challenged to use this Fifth Strategic Plan to bring science and technology into the national development process. KISR endeavors to fulfill this challenge in spite of sectoral and national constraints, which it faces, or will presumably face in the future.

KISR conducted an in-house analysis, which shows that there are critical gaps in the chain of knowledge that sustains Kuwait's economic and social development. These gaps become more apparent when we carefully examine the sectors of industry, energy, national economy, water, agriculture and environment. It is and has been amply demonstrated that KISR's capability in applied research and development apply across the board to the development, transfer, adoption and pre-commercialization of technology to optimally contribute to development of each of these sectors.

In preparing for the development of the new (5-year) Strategic Program Plan (2000-2005), KISR successfully undertook the following tasks:

- Appointing a committee of local experts to review and evaluate sectoral needs and suggest future research directions.
- Selecting a specialized international firm (Technopolis) who has in turn selected consultants in coordination with KISR to conduct a peer review of past achievements and guide the development of a new Strategic Plan.

The outcome of the deliberations and recommendations of the two committees may be summarized as follows:

1. Development of the 5th Strategic Program Plan with clear achievable goals and objectives.
2. Reduction of research programs with intent to focus on significant research areas.
3. Encouragement of better return on investment regarding human resources and research facilities.
4. Optimization of utilization of Information Technology (IT).
5. Organizational changes to enhance performance with more resources devoted to R&D sector.
6. More commitment for human resources development.
7. Development of strong linkages with renowned R&D organizations to augment deficiencies.
8. Improvement of KISR image and client relation.

A Strategic plan Steering Committee was formed to guide the process of plan preparation. The Steering Committee prepared directives outlining thrust areas that should be emphasized in KISR 5th Strategic plan, and a Core Committee was appointed to undertake the task of preparing the details of the plan. The core Committee, guided by the Steering Committee's directives, solicited inputs from all KISR organizational units about each thrust areas. After considerable deliberation and discussions of the inputs within the Core Committee and further discussions with the organizational units, a draft plan was prepared and submitted to the steering Committee for further review. The Plan was subsequently reviewed by KISR Board of Trustees and the beneficiary sectors in the country before finalization.

KISR's Program Plan identified three core activities as major thrusts during the next five years. These are:
- Research and Development.
- Scientific and Technical Consultancy.
- Human Resources Development.

The following are highlights of each of these core activities:
- **Research and Development**. KISR has consolidated its research programs into five (5) programs and fourteen (14) focus areas, in comparison to the existing six (6) research programs and twenty one (21) program elements. The research programs and focus areas are as follows:

i. Petroleum Resources program, which includes three focus areas, Oil production, Petroleum Refining and Petrochemical Processes.
ii. Water Resources Program, which contains two focus areas, Water Technologies and Water management.
iii. Food Resources Program, which includes three focus areas, Arid land Agriculture and Greenery, Aquaculture, Fisheries and Marine Environment and Biotechnology Application.
iv. Environment and Urbanization program which contains four focus areas, Environment Management, Coastal Management and Atmospheric Pollution, Urban infrastructure and Advanced Systems.
v. Techno-Economics Program, which includes two focus areas, Economic Studies and Quantitative Analysis and Modeling.

- **The Scientific and Technical Consultancy** will emphasize provision of technical consultancy and services to key national industries, and the private sector as well as regional and international organizations ensuring maximum utilization of KISR available expertise and laboratory facilities.

- **Human Resources Development** will continue to engage in activities aimed at developing skills and expertise of KISR's manpower base (research, support and administrative) and will also expand this role for wider participation in general public training and academic training capitalizing on KISR expertise in technical and scientific fields.

Underlying KISR's core activities are processes that are the means by which the institute can implement its plan. These processes termed 'Crosscutting Processes' include:
1. Development and Maintenance of KISR Science and Technology (S&T) infrastructure.
2. Utilization of Information Technology.
3. Organizational Management.

4. Science & technology Awareness Program.

Within each of these crosscutting processes, KISR has identified objectives to be achieved during the next five years. These may be summarized as follows:

i. Maintaining and upgrading the Institute's R&D facilities and Central Analytical Laboratory.

ii. Implementing the approved and budgeted Master Plan for physical facilities including the new building for agriculture and water resources.

iii. Establishing KISR as a major center for developing information technology, and for collecting, producing and disseminating information.

iv. Enhancing and maximizing KISR's operational efficiency to ensure a coordinated implementation plan for the new strategic plan.

v. Promoting R&D activities in Kuwait society and enhancing KISR image at large.

vi. Establishing new R&D strategic alliances with concerned government, private, regional and international entities.

The successful implementation of this plan will make KISR a more viable research entity with focused research programs that address the country's social, economical and technological needs. It should also help KISR in achieving the required impacts from its efforts in Research and Development as Kuwait moves into the New Millennium.

During the final two decades of the last millennium impressive achievements have been attained by KISR in executing its research and development activities. These are obvious from its successes in the difficult rebuilding and restructuring phase immediately following the end of the Iraqi occupation, its subsequent contribution to rebuilding the country and finally its efforts during the past five years in contributing to the social and economic development of the nation. The institute has been re-established as the leading research and development organization in the country and its work is highly appreciated in the regional and international arenas.

Now, entering the new millennium, KISR is dedicated to making even greater contributions to the national development by revitalizing its research and development strategies, human resources capabilities and operational procedures. Its new (2000-2005) five year strategic plan has a more focused vision that when realized would make KISR's research and development programs major contributor to the social, economical and technological advancement of the country. The successful transfer of state-of-the-art-technologies and their diffusion into society would be a major realization of this vision, achieved through a concentrated interdisciplinary approach to research and development. Strong strategic alliances will be firmly in place with other local, regional and international organizations, ensuring that a better science and technology awareness permeates through the country and a solid national science and technology policy or at least a research and development policy emerges (Al-Sultan, 2000). Positive steps will also have been made towards achieving the establishment of a critical core of national expertise and facilities capable of meeting the scientific and technological demands of the nation and its sectors.

The following are three case studies on KISR's endeavors for science and technology capacity-building namely:

- Development of water resources.
- Plant tissue culture.
- Energy conservation in buildings.

KISR Endeavors in Science and Technology Capacity-Building

As it has been mentioned earlier, KISR's mission is to conduct scientific research, technology development, technical consultancy and human resources development that serves the national needs and supports the economic and social development in Kuwait. Notwithstanding, such ambitions and responsibilities could not be fulfilled with availability of proper and advanced facilities and experienced manpower.

The following are illustrations of some of KISR's efforts in science and technology capacity building.

I. Development of Water Resources

Fresh Water is a basic human need and an essential input for agricultural and industrial development. Lack of this basic resource severely hindered the development of Kuwait for many years in the past. But when the funds in the form of oil revenues became available, Kuwait, being located in a coastal desert, turned to the sea for its fresh water supplies. The phenomenal social and economic growth witnessed in Kuwait during the past 50 years has been backed up by fresh water supplies from the sea, using distillation type desalination methods, and thus made Kuwait the world's leader in production of fresh water by means of seawater desalination using the method commonly known as multi-stage flash (MSF). Kuwait's current total installed MSF capacity of 284 million imperial gallons per day (MIGD) is one of the largest in the world.

Whereas MSF is still the dominant method in terms of total installed desalination capacity, another membrane-type desalination method known as Reverse Osmosis (RO) is also progressing at a fast rate.

1. Achievements

The research activities carried out at the Doha Reverse Osmosis Plant (DROP) resulted in many important achievements in desalination including:

1. The reliability of the reverse osmosis technology in Kuwait under the severe conditions of the Gulf seawater; very high salinity (5% salt content) and temperature variation between winter and summer (14-35°C) as indicated by four year of continuous successful operation of three commercial reverse osmosis units at DROP.
2. High load factor of the reverse osmosis plants (exceeding 90%) has been achieved.
3. Operational results obtained from DROP, proved that polyamide and composite seawater RO membranes are reliable to produce desalinated water for a long period (more than three years).
4. Hollow fibre and spiral wound modules are reliable to desalinate Gulf seawater, while the plate and frame modules are not suitable due to technical and economic reasons.
5. Substantial reduction in capital and operating costs (estimated at 25% of the total water product costs) through a single-stage desalination system instead of a two-stage system.
6. The cost of unit water production using seawater RO technology is less by one third compared to the cost of the same unit produced by MSF.
7. Maintaining high availability of RO units using conventional pretreatment of surface seawater feed. Mechanical modification and chemical optimization of the process were achieved.
8. The reliability and cost effectiveness of using beachwell as well as a non-conventional method to treat the seawater feed is indicated. Other methods such as micro/ultra-filtration were ongoing at the time of the invasion.
9. Three post-treatment techniques to treat the RO desalinated water for drinking purposes were assessed. Increasing the alkalinity of the desalinated water through the usage of limestone bed, proved to be the best technique from technical and economic point of view.
10. In addition to the on-job-training of KISR and MEW engineers and operators, several training courses on desalination, science and technology were organized in cooperation with Division of Training of KISR through which 80 engineers and 55 operators from MEW, Kuwait and other Gulf States received organized training.
11. Design criteria and technical specifications for commercial seawater RO plants were established.
12. Preliminary evaluation of seawater RO implementation in Kuwait was made.
13. Feasible research areas to enhance the development of seawater RO technology were identified. Research projects were aimed at improving the state of development of the RO technology, establishing technical and economic database needed for decision-making for future application of the technology in Kuwait.

14. Kuwait Institute for Scientific Research has taken a leading role in water resources research, and has given this research area a high priority. To upgrade the performance level of the Desalination staff, the Program adopted a continuous In-house, Local, Abroad and On-the-job Training policy. Training in the aforementioned areas covers the fields of Desalination, Computer and Management. To fulfill the Program needs of specialized Kuwaiti staff in the fields of Desalination, the Water Resources Division utilized KISR's scholarship and study leave programs to have young Kuwaiti professionals sent abroad to pursue their specialized studies.

2. Strategic Goals

To engage in research and development that will provide high quality technical support for implementation of the RO system for economical desalination of the Gulf water.

3. Rational for Strategic Focus

The major contributing factor to the fast growth of RO is that it is inherently more efficient and much simpler than MSF. The MSF process is carried out at elevated temperatures (requires an access to boiler) and involves change of phase from liquid to vapor and then back to liquid. Consequently, it has relatively more scale and corrosion problems and in addition to requirement of highly skilled operating and maintenance personnel, needs relatively large space. The RO process, on the other hand, is carried out at ambient temperature, involves no change in phase, and, therefore, has comparatively much less scale and corrosion problems. The RO plants require less energy and are easy to operate and maintain, and require much less space. Cost wise, there is a world-wide agreement that, because of the inherent simplicity of design and low energy consumption of RO, the unit cost of desalted water by RO is anticipated to be lower than by MSF.

4. Objectives

1. To solve problems associated with the RO process such as scaling and fouling to enhance recovery of fresh water from the saline feeds.
2. To achieve design specific specifications for a new RO plants implementing state-of-the art.

5. Strategies

1. Efforts will be made for establishing contacts and links with international and regional industries and institutions that are active in areas of RO water desalination technologies to ensure good exposure to the latest scientific advancements.
2. Test and evaluate the implementation of technologies developed or transferred.

II. Plant Tissue Culture

The agricultural sector of Kuwait is considered as provider of certain level of food security, employment, and recreational activities. Farming communities in Wafra and Abdally districts may play a major geopolitical role as border demarcation that cannot be ignored in any future border dispute. One of the main objectives of Food Resources Division at KISR is the support of the agricultural and fishery sectors of the Kuwaiti economy. To achieve this objective, KISR is always seeking the development, the adaptation and the implementation of the most recent technical advances, that shows great promise of successful implementation in Kuwait. Among these research areas is the plant tissue culture. During the past two decades, plant tissue culture science and technology had evolved and rapidly progressed from the basic research laboratories into commercial application and successful production of many plants and in many countries. The advocates of the agricultural sector expansion in Kuwait countries are trying to put the sector in a prominent position in the developmental plans for the purpose of achieving certain level of food security, greenery and environmental enhancement.

Plant tissue culture supports the agriculture sector via three major applications; mass propagation of desired plant varieties, variety improvement and elimination of certain plant diseases. Research in KISR is being pursued in all three areas with emphasis for the time being on mass propagation. Date palm is an important

tree for the Gulf countries, since it is planted for the fruits and as ornamental tree. Thus, date palm has been receiving adequate attention at KISR. A strategy for date palm improvement utilizing tissue culture technology for propagation and new variety development was planned with a series of research projects that run in sequence or in parallel to achieve the objectives in most efficient manner. Other crops of interest for mass propagation are: native plants of Kuwait, trees of Zizyphus, olive, and pomegranate, ornamental and medicinal plants.

1. Achievements

1. In February 1988, an action plan was initiated to develop research capabilities in the area of plant tissue culture at KISR with initial emphasis on date palm propagation. The action plan was based upon the Upper Management's favorable evaluation of the technology potential for commercial applications and advancement of agriculture in Kuwait.
2. A number of Kuwaiti nationals received tissue culture training in-house and abroad in Germany, U.S. and England. Currently, a candidate is studying for her Ph. D. degree at Colorado State University after obtaining her M. Sc. degree in tissue culture at University of Arkansas. Another candidate is studying for her M. Sc. at Biological Sciences Department, Kuwait University, under a joint supervision of a KISR senior scientist. The third candidate is receiving an on-the-job training and is a task leader in several on going projects. An in-house formal training course was offered as a part of the genetic engineering course organized by Food and Agriculture Organization (FAO).
3. A research scientist, with extensive experience in date palm tissue culture and documented achievements in the commercial application of plant tissue culture technology, was hired in October 1989 to design the research program and to prepare and defend research proposals, train the national manpower, design an integrated facility for tissue culture.
4. A modern and fully equipped facility was built and became operational in 1995. The tissue culture laboratory at KISR is the most modern laboratory in the Middle East and one of the largest worldwide.
5. Establishment of the tissue culture program. The tissue culture program is aiming at the full support of the agriculture sector and establishing itself as a center of excellence in the production of certain crop plants from tissue cultures. Crops such as date palm, ornamental plants and native plants are now being produced on a pilot scale

2. Objectives

1. Establish KISR as a center of excellence in tissue culture research and development while developing date palm tissue culture technology.
2. Develop and or adopt tissue culture techniques for propagation of crop and ornamental plants to increase food production and help green Kuwait.
3. Emphasis should be made on the projects with potential commercial applications.
4. To develop tissue culture technologies for trees, desert plants and potato by the year 2002.
5. To implement the developed technologies for large-scale propagation of plants and prepare economic feasibility studies by the year 2004.
6. To develop the tissue culture technology services and contacts by the year the year 2004.

3. Rationale for Strategic Focus

Tissue culture propagation offers many and varied advantages depending upon the plant and the location. Among advantages of tissue culture propagation of plants are the following:

1. Rapid propagation of desirable varieties or new introductions that are in short supply.
2. Significantly lower cost of clonal plants to provide much greater economic efficiency for plantation establishment.
3. Enhanced availability of disease-free plants.
4. Better root development, with considerably greater ease of establishment, and lower attrition rate in the plantation.
5. Greater uniformity of high quality plants.
6. Opportunity to accelerate selection and improvement through somaclonal variation.

7. Offer possibilities of establishing germplasm bank for maintenance of unique and rare germplasm.

4. Strategic Goals

1. Transfer and develop tissue culture technologies related to propagation of plants such as date palm with emphasis on determination of genetic fidelity.
2. Intensively produce high quality date palm plants for determination of technical capability and commercial feasibility.
3. Develop methods for quality control of tissue culture produced plants.
4. Determine the economic feasibility of any technology developed and provide all technical details for effective and economic planning of the technology utilizing date palm as a model plant.
5. Develop methods for mass propagation of economically important plants, such as potato, fruit trees and native plants.
6. Employ tissue culture techniques for breeding salt-tolerant new plants.
7. Train Kuwaiti manpower on technical details and administrative aspects of tissue culture research.
8. Transfer and follow-up the implementation of technologies developed at KISR, at different governmental agencies and private enterprises.

5. Strategies

The strategy is to capture the three main advantages of tissue culture namely; mass propagation, disease elimination and plant variety improvement. Two major types of activities are being considered, they are Technical Services and Research Projects. The development of technical service capability is a two way street in which research direction will be benefiting from the close interaction with the commercial sector and the technical services will be relied upon the advanced research and development capabilities. The technical know-how available at FRD in the area of tissue and cell culture can be offered as services to the commercial sector in many ways, such as:

1. Pre-production contract for tissue culture propagation of certain plant variety for which the technology is already available in -house. For example date palm, strawberry, potato, ornamentals.
2. Development of tissue culture technology for a new plant variety.
3. Assistance in designing commercial tissue culture production facility, training of personnel, providing basic data for feasibility studies.
4. Sale of tissue cultured plant materials to tissue culture production laboratories.
5. Providing consultant services for trouble-shooting in tissue culture laboratory.

The above-mentioned services are not available in any of the Arabian Gulf or Middle East countries. KISR can lead by being the first institute to provide such services, especially at the time being where countries of the region are looking seriously into a large-scale implementation of the technology to develop their agriculture sector. The following are areas for emphasis in the research projects of the strategic plan:

1. Date palm tissue culture technology development and Pilot scale propagation.
2. Mass propagation of stress tolerant desert plants by tissue culture.
3. Selection of genes and germplasm suitable for salt-tolerance breeding in three vegetables for Kuwait.
4. Micropropagation of virus-free strawberry.
5. Micropropagation of rubber plant as a model of indoor ornamental plants.
6. Potato tissue culture technology development.
7. Development of tissue culture technology for Cidr (Zizyphus spp.).
8. Development of new date palm cultivars.
9. Evaluation and propagation of male date palm pollinators.

III. Energy Conservation in Building

Kuwait has experienced an economic boom ever since the commencement of oil production in the early fifties. This boom reached disproportionate levels in the late seventies following the rise in oil prices and the

attendant increase in national revenue. The boom occasioned a rapid expansion in the construction and development field year after year, and brought about an increasing demand for electrical energy.

Another factor contributing to the rapid increase in demand was the prevailing price of electricity for consumer, which was held at KD 0.002/kWh for over 30 years and continues to the present date. This price is presently around 1/7 (about 13%) of what it actually costs the government for production. The historical origin of this heavy electricity subsidy is based on a sincere wish by the government to help the residents of Kuwait pay for an essential commodity. An outcome of this subsidy, however, has been the lack of concern given to the energy efficiency of buildings and the growth of wasteful practices.

In response to these factors, the demand for electrical energy rose to disproportionate levels, with an annual increase in the range of 20-50% during the fifties and sixties, reduced to around 10-14% in the late seventies early eighties. The recent per capita level of about 12000 kWh/yr rivals that of the most industrialized nations, and little of this electricity is consumed in productive industrial processes. The building sector accounts for the bulk of the national demand for electricity. This sector is taken to include residential, commercial and institutional buildings. Further in view of the extremely hot summers, the air conditioning equipment is estimated to account for 60-70% of the peak demand and 50-60% of the annual electrical energy consumption of buildings.

In response to the rapid increase in demand for electricity, therefore, conservation measures had to be introduced and enforced to curtail the energy requirements for the air-conditioning of buildings. In the early eighties, the Ministry of Electricity and Water (MEW) concluded an agreement with KISR to conduct the necessary investigation leading to the development of a comprehensive Code of Practice for Energy Conservation in Buildings.

1. Achievements

The development of the code of practice for energy conservation in buildings required a senior researcher with good expertise in this area. This resulted in substantial technology transfer particularly in the area of computational heat transfer analysis in building elements. This was a logical and essential step forward in the capacity building process under the energy conservation program. Consequently, a number of professionals were trained in the use of the technology at that time and many were sent on scholarships to obtain their higher education degrees, MSc. or a PhD.

The capability development includes setting-up of important laboratories and measurement and data recording instruments for use in laboratory or for field studies. The following sections give an overview of the major capabilities developed under the energy conservation program. The research capabilities developed come under the following three levels: Laboratory Investigations, Field Investigations, and Modeling and Analytical Investigations

During the tenure of the building and revision of the Code a number of scientists and engineers, dealing with various projects have been trained in Kuwait and abroad. Many of the Kuwaiti staff have earned higher academic degrees in the areas of relevance to the objectives of building the Code and energy conservation in buildings in general.

2. Strategic Goals

Due to the importance of the energy conservation program, the focus of research was on two basic areas:

1. Development of energy standards.
2. Development of techniques and procedures that allow the full potential of energy conservation in buildings to be realized.

3. Rationale for Strategic Focus

In spite of the implementation of the energy conservation Code, the peak power and electricity demand in Kuwait grew at the rate of 6.8 and 7.3%, respectively at the end of 1995. To arrest this trend, a multilevel

analytical, experimental and field oriented R&D program was launched to revise the Code based on the science and technology capacity building in the program. This resulted in the development of a comprehensive proposal on the Advancement of Energy Conservation Standards and Practical Measures for Their Implementation in Kuwait. The R&D program involves developments towards energy-efficient buildings, cooling systems and operation strategies to achieve energy efficiency especially during the non-occupancy period. The main objective of the project was updating and widening the scope and applicability of the current energy conservation standards.

The research program was divided into three different elements as follows:
1. Development of energy-efficient buildings.
2. Development of energy-efficient cooling systems.
3. Development of energy-efficient operation strategies

4. Objectives

The main objectives of energy conservation can be summarized as follows:
1. To increase the energy efficiency of new buildings.
2. To reduce the growth rate in the demand for energy.
3. To reduce the negative impact on the environment resulting from pollutants emissions and thermal pollution.
4. To reduce the budget cost with respect to the expansion in power generation capacity particularly in the case where the utilities are nationalized.
4. Achieve leveling of energy supply and demand.

5. Strategies

1. A follow-up program is planned to ensure that expected benefits and gains are fully achieved after the new Code for energy conservation in A/C buildings are implemented in the year 2000.
2. Kuwait Institute for Scientific Research and one of the local consulting companies shall jointly conduct this important study to develop the Kuwait Building Energy & Environment Assessment, based on BREEAM, a well-established tool for building assessment launched in 1990 by the Building Research Establishment. It is proposed to involve Environment Canada, as consultants. The study will include a reporting on the current environmental performance of some of the existing buildings as case studies. The assessment would define best practices. Buildings would be assessed in terms of how closely they approach those practices. The program can be used as a standard procedure for assessment of existing buildings and as a tool for design of new ones. Also, the program would be much needed monitoring procedures for Ministry of Electricity & water to assess the extent to which Code for energy conservation in A/C buildings have been implemented by the building owner. In fact the rating procedures shall consider many other important aspects of environmental issues and the building use pattern besides the energy conservation aspect. Project will require 2-years period at an estimated cost of 0.35 million US$.
3. Demonstration Projects

A scheme for implementation of energy conservation and power management has been planned for different types of air-conditioned buildings.
4. Energy conservation and power saving measures are to be implemented in the existing buildings by conducting on-the-spot study involving the following:
- Develop building power demand profiles,
- Identify major users of electricity,
- Develop and implement energy-efficient operation strategy,
- Identify conservation measures which can be retrofitted,
- Conduct cost-benefit analysis for the proposed measures,
- Short list conservation measures in order of their merit.

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