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IMPACT OF THE ENERGY POLICIES FOR THE STATE OF KUWAIT

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Abstract

Science and technology have played a major role in the development of human civilization, as is clearly evidenced by its great effect on a variety of aspects of life in today's world. The Kuwait Institute for Scientific Research (KISR) was established in 1967, and later reorganized in 1973, at which time KISR became attached to the Cabinet of Ministers, under the supervision of a Board of Trustees, chaired by the Minister of State for Cabinet Affairs. KISR conducts its R&D activities via research programs are Petroleum, Petrochemicals and Materials Program, Water Resources Program Food Resources Program, Environment and Urbanization Program, and Techno-Economics Program.

The purpose of this paper is to give an overview picture of the energy policy and its impact in the nation. The 1983 code of Practice specifies minimum thermal resistance for walls and roofs, size and quality for glazing, fresh air requirements, and performance standards for A/C systems. More importantly, the code fixes the maximum allowable power for the A/C system and lighting of buildings based on the application, area and type of A/C system. . It is estimated that implementation of the code, until 2005, resulted in over 2530 MW savings of peak power, 1.26 million RT of cooling capacity, and nearly 131 million barrels of fuel. The estimated cost of these benefits is well over KD2.25 billion, in addition to the release of over 55 million metric tons of CO_2 in Kuwait's environment. The purpose of the revision of 1983 code of practice is to make necessary changes to further enhance the energy efficiency of buildings and to reduce both the annual energy consumption and peak load demand for the nation. Some of the features of the revised code is addressed in this paper. At the end, some techniques can be used to promote for energy efficiency in the society.

Key words: Annual energy consumption, Code of Practice, energy efficiency, energy policy, peak load demand science and technology

Development of Research and Technology in the State of Kuwait

Science and technology have played a major role in the development of human civilization, as is clearly evidenced by its great effect on a variety of aspects of life in today's world. The scientific revolution, that started at the beginning of the 20th Century, led to the creation of numerous technologies and sciences, as well as the advancement of knowledge, which, in turn, served to propel civilization into a new era of development in a variety of fields. As a new century has begun, mankind must strive to make sure that they are keep abreast of such developments to make sure that they are made full use of, in order to achieve the best development for humanity.

In today's world, science and technology have become the standard by which the social and economic advancement of country is measured. Consequently, most of the advanced countries of the world invest a major part of their total national income in scientific research to achieve their development objectives. For instance, countries such as Japan, the United States of America (USA), and Germany spending 3%, 2.1%, and 2.6%, respectively on scientific research.

The State of Kuwait has realized the importance of science and its technological applications, and their roles in the development process. Thus, it established a number of scientific research institutions which operate in parallel with other activities in the society that are aimed at promoting progress in Kuwait's society, and achieving the country's objectives for building an effective and modern society. Some of which are dedicated to conducting applied research, e.g., the Kuwait Institute for Scientific Research (KISR), which was established in 1967. Other institutions conduct scientific activities along with a separate basic mission, e.g. Kuwait University (KU), which was established in 1966, and the Public Authority for Agricultural Affairs and Fisheries Resources (PAAAFR), which was established in 1983. In addition, supporting scientific research is included in the basic mission statements of a number of institutions such as the Kuwait Foundation for the Advancement of Sciences (KFAS), the Environment Public Authority (EPA), the funds of the Public Authority for Awqaf.

Historical Background of KISR

The Kuwait Institute for Scientific Research (KISR) was established in 1967, and later reorganized in 1973, at which time KISR became attached to the Cabinet of Ministers, under the supervision of a Board of Trustees, chaired by the Minister of State for Cabinet Affairs.

In appreciation of Kuwait, and of the important of scientific and technological research in raising the plane of the country's development, and economic and social progress, an Amiri decree was issued as Law No. 28/1981, declaring KISR to be a public institution of an independent and legal nature. It also stated that KISR was to be supervised by a minister selected by the Cabinet of Ministers. In addition, the decree specified the objective of KISR to be the development of scientific and applied research especially that related to industry, power, natural resources, food resources, and the other major elements of the national economy. Thus, KISR was to work in the interest of the State's objectives for economic, technological, and scientific development, and render consultations to the Government, including the provision of a scientific research policy for the country.

KISR Role in the Field of Science & Technology in the State of Kuwait

KISR seeks to achieve its main objective, i.e., the promotion of scientific and applied research, particularly in matters relating to industry, natural and food recourses, and other primary constituents of the national economy, in an endeavor to serve the goals of economic, technological, and scientific development. In addition, KISR offers advice to the government on scientific matters and on science policy issues. These objectives can be achieved by implementing the following criteria:

- Conducting scientific research and studies relevant to the development of national industry and the preservation of the natural environment, in coordination with other concerned parties.
- Encouraging Young Kuwaitis to pursuer scientific research.
- Studying natural resources and the best means for their utilization, including developing water and power resources, and improving agricultural utilization, in cooperation with other concerned parties.

- Providing research, and scientific and technological consultations to governmental and private institutions.
- Keeping abreast of the latest developments in and adopting modern techniques for science and technology (S&T).
- Establishing and strengthening cooperative relationships with institutions of higher education and scientific and technological centers in Kuwait and around the world , in order to conduct joint research, and exchange information and expertise.
- Contributing to the study of the diversification of the nation's economic resources, and working towards the development of the country's economy.
- Providing consultative and applied services and expertise, and conducting scientific and technological research to serve the development objectives of the Gulf Cooperation Council (GCC) countries in particular, and of the Arab World in general.

KISR conducts its R&D activities via **Five Research Programs**, namely:

- Petroleum, Petrochemicals and Materials Program
- Water Resources Program
- Food Resources Program
- Environment and Urbanization Program
- Techno-Economics Program

The Energy R&D activities are encompassed with the Environment and Urbanization Program and charged with the following responsibilities:

- Assess new technologies, materials and systems for enhanced energy conservation in domestic, industrial and commercial sectors and implement pilot studies using available facilities, tools and data bases to demonstrate the potential savings to be gained in their application.
- Make appropriate recommendations for revision of codes.

Energy Scenario in the State of Kuwait

Availability of electricity in plenty has been a normal phenomenon in Kuwait for decades till the recent load shedding of 2006. It has forced energy policy makers in the country to review the current scenario and implement short and long term measures to ensure that situation of 2006 is never repeated again.

Due to fast economic growth and rapid urbanization, demand for electricity, both for power and energy had been steadily growing in Kuwait (MOE, 2000-2006) (Fig. 1). However, a rapid increase in construction of all types of buildings in recent years has pushed the peak load demand considerably. Average growth in peak load between 2004 and 2006 was 7.5% as against a normal growth of 5% (Fig. 2). The peak load demand between 1999 and 2004 grew at an annual average rate of 318 MW/y, while between 2004 and 2006; it increased to 575 MW/y.

Code of Practice

A significant portion of the world's oil and other fossil fuel resources is consumed in comfort conditioning of buildings. Kuwait, where air-conditioning (A/C) is a must for all types of buildings, is no exception. In Kuwait, A/C accounts for 70% of the electricity annual peak load and 45% of yearly electricity consumption. More importantly, it accounts for over 20% of fossil fuel consumption, with fossil fuel being the country's only natural resource and sole source of revenue.

Fig. 1. Annual peak load demand and electricity consumption.

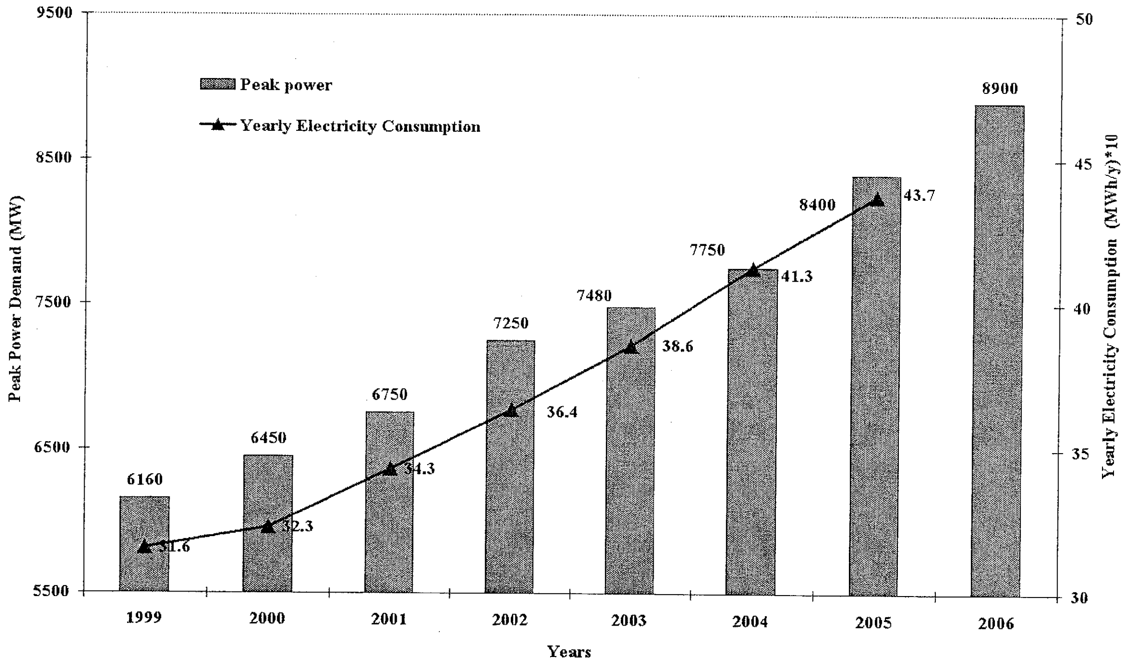
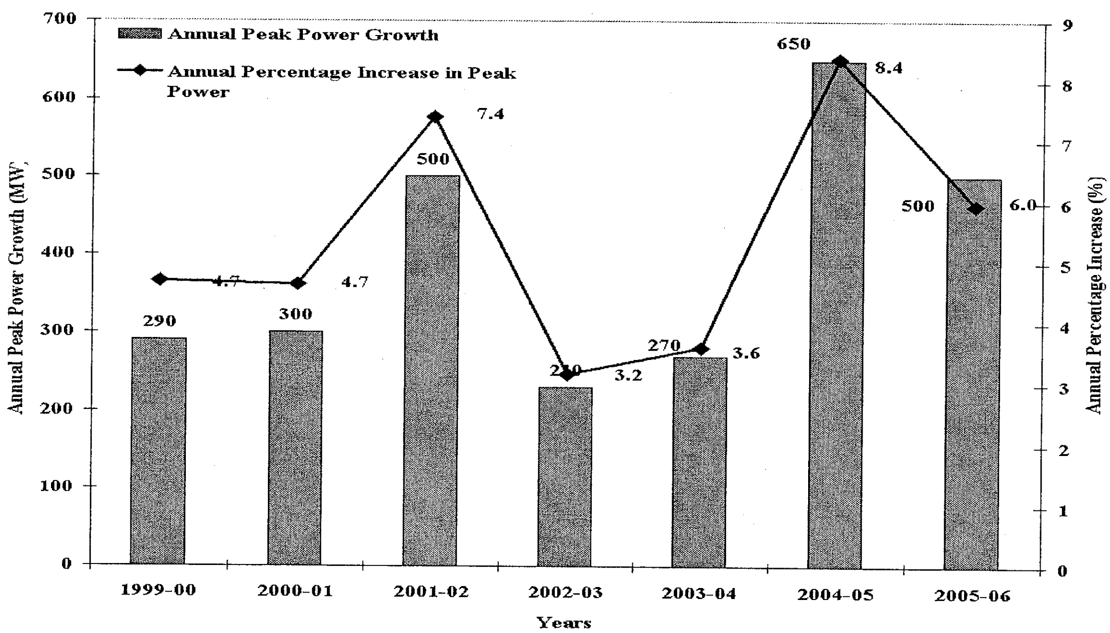


Fig. 2. Pattern of annual growth of peak load demand in Kuwait.



Minimum requirements for efficient energy use in buildings have been enforced by the Ministry of Energy (MOE) for all new and retrofitted buildings since 1983, through an Energy Conservation Code of Practice that takes into consideration the fact that consumers pay only a fraction (5 to10%) of actual cost of power and energy. The 1983 code specifies minimum thermal resistance for walls and roofs, size and quality for glazing, fresh air requirements, and performance standards for A/C systems. More importantly, the code fixes the maximum allowable power for the A/C system and lighting of buildings based on the application, area and type of A/C system.

By implementing the code, buildings need 40% less cooling, and more than 40% less peak power and annual energy. It is estimated that implementation of the code, until 2005, resulted in over 2530 MW savings of peak power, 1.26 million RT of cooling capacity, and nearly 131 million barrels of fuel. The estimated cost of these benefits is well over KD2.25 billion, in addition to the release of over 55 million metric tons of CO_2 in Kuwait's environment.

In 2003, the MOE spent KD160 million for the purchase of a new power generation plant besides spending over KD300 million more (at a rate of KD5/barrel) on fuel. During the past 2 years, the energy and power demand grew at a rate of 6% per year, If the same trend continues, Kuwait's peak power demand will reach 27,000 MW in 2025 (Al-Sayegh et al, 2005).

The energy conservation code, as legislation, helps foster economic growth and reduces adverse environmental impacts. The purpose of this revision is to reassess the efficacy of the 1983 code and make necessary changes to further enhance the energy efficiency of buildings and to reduce power ratings of A/C systems. The power rating is defined as the power required in kilo watts (kW) per unit of cooling (RT) for A/C systems and their components. This revision of the 1983 code needs to be viewed in light of the following changes that have come to pass in Kuwait:

- Revision in design conditions;
- Development of sophisticated building energy simulation programs for accurate prediction of cooling demands and energy requirements;
- Major advances in building envelope construction including insulation and glazing, and in lighting technology;
- Significant improvement in the energy efficiency of A/C hardware and motors;
- Incorporation of site-related features for a variety applications;
- Establishment of design features and power ratings for major components of A/C systems; and
- Growing concern with regard to indoor air quality (IAQ), resulting in an increase in ventilation requirements, as per the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards.

A comprehensive comparison of the scopes of the old and the revised version of the Code of Practice for Energy Conservation is presented in Table 1. The code has been revised using a multilevel analytical, experimental and field-oriented research and development (R&D) program that included:

- Engineering-economic analysis of passive energy conservation measures and cooling energy requirements for buildings;
- Establishment of power ratings for A/C systems and their major components using cost-effective energy conservation measures and techniques; and
- Assessment of operational techniques for A/C systems for power and energy savings.

This revised code establishes minimum requirements for the energy-efficient design of buildings, and types of A/C systems and their components.

Table 1. Scopes of the Old and the Revised Versions of Kuwait's Code of Practice for Energy Conservation

Old Version	Revised Version
• Thermal insulation of walls and roofs excluded columns and beams.	• Thermal insulation of exposed columns and beams is to be made mandatory whenever possible.
• A common glazing-to-wall area ratio was specified regardless of building class.	• Maximum glazing-to-wall area ratios are specified for each class of buildings.
• Three-dimensional thermal bridging due to window frames was not considered.	• Thermal breaks for window frames are mandatory to prevent thermal bridging.
• Limits for U-value, SHGC and visible transmittance for windows were not specified.	• Acceptable ranges of U-values, SHGC and visible transmittance for whole window assemblies are specified for different types of glazing.
• One set of design weather conditions was specified for the entire state of Kuwait.	• Separate design weather conditions are defined for Kuwait's coastal and interior zones.
• Application of water-cooled A/C systems was mandatory for capacities higher than 1000 RT.	• The capacity for mandatory use of water-cooled A/C systems is reduced to 500 RT for interior areas while 1000 RT for coastal areas to be continued.
• ASHRAE's 1979 standard ventilation rate of 5 CFM/person was used.	• The higher of ASHRAE's latest ventilation rate of 20 CFM/person or 0.5 ACH + exhaust air is used.
• Application of thermal storage systems was not considered.	• Cool storage systems are mandatory for buildings with partial occupancy.
• Thermal insulation of exposed floors was not considered.	• Thermal insulation for exposed floors with R-value of 10 is mandatory.
• No different R-value was specified for different surface colors.	• R-values as a function of surface color are specified.
• No rigorous analysis on the application of cooling recovery units (CRUs) was made.	• Use of CRUs for more than 2000 CFM (940 l/s) of recoverable exhaust air, taking into account weather zone and building type, is mandatory.
• Application of programmable thermostats for A/C control was not considered.	• Clear recommendations are made for the application of programmable thermostats, including recommended precooling levels.

SHGC = solar heat gain coefficient; A/C = Air-conditioning; ASHRAE = American Society of Heating, Refrigerating and Air-conditioning Engineers; ACH = air change per hour

Some Important features of the Revised Code of Practice

The revised Code of Practice has some good important features that will help to make the building more energy efficient. Some of these features are:

Standard Buildings. The basic energy conservation requirement of a standard building is determined by adopting a peak wattage per square meters for the A/C system and lighting, the two major consumers of electricity in a building. These values for different types of buildings and A/C systems are given in Table 2.

Table 2. Basic Energy Conservation Requirements of Different Standard Buildings**

Building Type	**Lighting (W/m^2)**	**A/C Systems (W/m^2)***				
		DX*	**Air-Cooled Chiller**	**Water-Cooled Chiller**		
				.250 RT	**250.RT.500**	**.500 RT**
Residential						
- Villa	10	60	71	53	46	44
- Apartment	10	60	71	53	46	44
Clinic	20	85	100	75	65	63
School	20	100	118	88	76	74
Mosque						
- prayer area	20	115	135	101	88	85
Fast food restaurant						
- Stand-alone						
- In a mall	20	145	171	128	111	107
	20	120	141	106	92	88
Office	20	70	82	62	54	51
Shopping mall	40	70	82	62	54	51
Community hall, dinning hall, theatre	20	115	135	101	88	85

*DX = direct expansion; A/C = air-conditioning
** This table is based on zero diversity.

Updating of National Standards. Present code, which was established in 1983 specifies a power rating (PR) of 1.4 and 2.0 kW/RT for the AC systems with water-cooled and air-cooled condensers, respectively. The latter includes direct expansion systems such as packaged units and mini-splits and the chilled water system. In view of significant improvement in energy efficiency of AC hardware and motors, updating of national standards with more realistic PR values can be very beneficial. Using the market information from the leading manufacturers, a recently concluded study has arrived with more realistic PR for different types of AC systems (Maheshwari et al, 2000). The recommended PR values for different types of AC systems are given in Table 3. For window, split, and packaged units, the recommended PR of 1.7 kW/RT is 15% lower than the value fixed by the 1983 MEW energy conservation code (MEW, 1983).

Table 3. Maximum Power Rating for Different Types of A/C Systems and their Component

System		Power Rating (kW/RT)					
Type	**Capacity (RT)**	PR_{CHIL}	PR_{CTF}	PR_{CW}	PR_{CHW}	PR_{AH}	PR_{T}
Ducted Split and Packaged units	All						1.700
Air-cooled	.100						
	100-250	1.600			0.050	0.350	2.000
	.250						
Water -cooled	.250	0.950					1.500
	250-500	0.750	0.040	0.060	0.070	0.380	1.300
	.500	0.700					1.250

A/C = air-conditioning; RT = refrigerating ton; kW = kilowatt; PR = power rating
Subscripts; CHIL=chiller, CTF=cooling tower fan, CW=condenser water pump, CHW=chilled water pumps, AH=Air-handling fan unit, T=total

Time-of-Day Controls for Energy Savings. Time-of-day controls in air-conditioned buildings can save appreciable amounts of energy annually. Commercially available programmable thermostats provide simple, trouble-free temperature offset control and switching off the air circulating fan for energy conservation, particularly in buildings with only part-day occupancy, such as: commercial offices, diwaniyas, community centers, mosques, clinics, schools, public offices, banks, game and sports centers, gymnasiums, clubs etc. Use of programmable thermostats is mandatory for buildings with part-day occupancy with a recommended offset of 5°C together with switching off of air-circulating fans during the non-occupancy period.

Use of Partial Cool Storage. Use of partial cool storage (sensible or latent) is mandatory for buildings with part-day occupancy and chilled water systems serving building peak loads of 100 RT and above. Some examples of buildings with part-day occupancy are: commercial offices, community centers, schools, public offices, banks, games and sports centers, gymnasiums, clubs etc.

Fenestration. Minimum glazing requirements: Minimum requirements for glazing quality such as U-value and SHGC are given in relation of window-to-wall ratio in Table 4. All windows should have a thermal break between metallic frame and glazing.

Table 4. Minimum Requirement for Glazing Quality in Relation to Window-to-Wall Ratio**

Glazing Type	SHGC***	Tv***	U-Value (W/m^2C)	Window to wall Ratio			
				East	West	South	North
6-mm single-clear	0.721	0.8	6.21	≤5	≤5	≤5	≤5
6-mm single-reflective	0.314-0.371	0.16-0.27	6.41-6.44	6-10	5-10	5-10	5-10
6-mm double-tinted	0.36-0.40	0.3-0.57	3.42-3.44	11-15	10	10	11-15
6-mm double-reflective	0.245	0.228	3.38	16-50	10-45	10-45	16-50
6-mm double-spectrally selective**	0.356	0.565	1.71	51-100	45-75	45-75	51-100

*An exterior pane of spectrally selective low-e coating on clear glass and an interior pane of clear glass with an Argon gas filled cavity.

** Based on combined cooling and lighting at 15:00 h.

*** SHGC and Tv are solar heat gain coefficient and visible light transmittance coefficient, respectively.

KISR Vision to Promote for Energy Efficiency in the Society

Some techniques can be used to promote for energy efficiency in the society. Some of these techniques are listed below:

Assign Dedicated Fund. This strategy envisages allocation of special funds for procurement and installation of energy efficient and cost-effective equipment and appliances such as use of compact fluorescent lambs (CFLs) in place of incandescent lamps or retrofitting of air-handling units with variable speed drives (VSDs). Availability of such a fund facilitates government agencies to deploy proven systems and technologies without facing procedural delay and bureaucratic hurdles. Some examples of such funds around the world are: Energy Efficient Fund, India, Energy Efficiency Credit Fund, Hungary, and Energy Special Account, South Korea (Painuly et al, 2002).

Provide Technical support. Facility managers and their assistants in many government agencies may not have experience with proven cost effective technologies, including use of cost free-energy efficient operation strategies. As a result they perceive these technologies to be unreliable and fear performance uncertainties. For example, Time-of-Day Control (TDC) and Pre Closing Treatment (PCT) for air-conditioning systems are excellent options to reduce the peak load demand for the government and institutional buildings, most of which have part-day-occupancy (Al-Ragom, 2005). These operational strategies can be implemented using available building automation system (BAS). Technical support provided to facility managers through demonstration projects and on site audits can help in building confidence in terms of reliability and performance of these technologies.

Demonstration Programs. Site visits by facilities managers from government, institutional, and commercial agencies and engineers from service companies and consultant offices to locations where energy efficient systems are installed and functioning can be used to enhance awareness about the impact of utilizing more energy efficient systems.

In addition, the government of the State of Kuwait is soon going to impose standard and codes for all mechanical and electrical equipments imported from outside or locally manufactured. This action will definitely enhance the efficiency of these equipments and therefore reduce both the energy consumption and peak load demand in the nation.

Conclusion

Science and technology have played a major role in the development of human civilization, as is clearly evidenced by its great effect on a variety of aspects of life in today's world. KISR plays a significant role in implementing applied research concepts in the State of Kuwait. Energy policy is a high concern in the State officials where the Code of Practice for Air-conditioning buildings was implemented since 1983. The total estimated benefit is around KD2.25 billions until 2005 due to the implementation of this code. The paper illustrated some features of the revised Code of Practice such as: using Time-of-Day-Control for energy savings, utilization of partial energy storage, and fenestration specifications. In addition, the paper discussed KISR vision to promote energy efficiency in the nation such as: assigned dedicated fund, provide technical support, demonstration programs, and the government action to impose standard and codes on the mechanical and electrical equipments.

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