Kuwait’s Strategy for Energy Efficiency and R&D Roadmap – Country Report

ESCWA Workshop on “Technical & Economic Aspects for Developing Energy Efficiency (EE) investment projects” and Energy Group Meeting (EGM) on EE
Tunis, Tunisia, September 24-26, 2012

Saad Al Jandal, PhD.
The Energy Group
Building & Energy Technologies Department (BET)
Kuwait’s Strategy for Energy Efficiency and R&D Roadmap – Country Report

Presentation Outline

▶ Research Areas
▶ EE & Technology R&D approach
▶ Background of EE R&D program activities
▶ Looking Forwards Remarks
Research Areas

- **Innovative & Renewable Energy Resources;** Technology evaluation and system implementation;

- **Energy Efficiency and Implementation;** Sustainable building and green approach; energy conservation measures and development of practice codes.

- **Energy Planning and Policy Measures;** Long-term energy planning policy studies and national scenario development.
Kuwait Energy System

Energy Resources

(Oil & LNG)

Power Stations & Oil Refineries

Energy Conversion

End-Users Sect., Electricity & LPG

End

Start
Kuwait electric power

- Kuwait electricity consumption (2007):
  ~ 50 TWh/a, peak demand 9 GW continued rapid increase foreseen.
- Coping with rising demand strains MEW power system beyond limits.
- Major investments are foreseen for new generation capacity and in upgrading grid, including the 1200 MW GCC interconnection.
- Air conditioning is main driver in growth of electricity consumption.
- Kuwait has an abundant solar resource with a good time-correlation with the air conditioning demand.
Current Kuwait Energy Mix & Distributions

- **Fuel Consumption in Power & Water Production (Eqv. Kbbi):**
  - 21% (5713)
  - 17% (1812)
  - 61% (16670)
  - 3% (687)

- **Electrical Consumption per Sector (GWh):**
  - Residential
  - Industrial
  - Commercial
  - Others

- **Thermal Energy Consumption in Power & Water Production (BBTU):**
  - 27% (29450)
  - 1% (1184)
  - 0.5% (172)

- **Gas Oil:**
  - 29% (105,4)

- **Natural Gas:**
  - 44% (162,5)
  - 27% (99,1)

- **Heavy fuel:**
  - 44% (162,5)
  - 27% (99,1)

- **Crude Oil:**
  - 44% (162,5)
  - 27% (99,1)

- **Petroleum:**
  - 61% (16670)

- **Transportation:**
  - 17% (1812)
- Load >8 GW for only 900 hrs
- 1,000 MW additional capacity needed for about 1000 hours
- Less than 10% of the total installed capacity for this 1 GW
- Expensive kWh’s!
- In Kuwait both Solar and wind energy outputs are optimum in these peak period
Kuwait Current Energy Scenario - Primary Energy Consumption

Petrochemical industries and Air-conditioning are the major consumers with a share of over 27%; over 20.9% goes for air-conditioning.
Energy Conservation Program in Kuwait

**Vision**

- Avoid traditional fossil fuel generation capacity and grid extension through combination of:
  - Energy conservation measures (improved building codes).
  - Implementation of sustainable approaches in power generation (improved DSM & Energy mix) in urban areas.
  - Adapt viable energy technologies (peak shifting - cold storage, district cooling & renewable resources).
- Put Kuwait in forefront in adapting innovative power generation, conservation codes and DSM technologies.
CHALLENGE

“To reduce per capita energy consumption without impacting the quality of life, by providing innovative knowledge-based energy efficiency approaches”

20-YEAR VISION

“will have local and international recognition for its innovative solutions in energy resources and efficiency technology applications”
THRUSTS

- Understanding the feasibility of energy generation and efficiency in Kuwait conditions.
- Transferring efficient energy generation technologies and systems.
- Research and development of efficient energy generation systems.
Challenge and Solutions of Energy Efficiency Technologies Program

- Energy Efficiency Design & Contraction – New Buildings
- Incorporation of Sustainable Features – New Buildings
- Incorporation of Sustainable Features – District level
- Indoor Environmental Quality
- New & Existing Building Control & Operation
- Existing Building Performance
- Industrial Energy Efficiency Techs.
- Power Generation Efficiency and Enhancement

- Building Envelop and Environment
- Industry
- Power Generation
- Energy Efficiency Techs.

- Reduction in Primary Energy Demand & Electricity Consumption
PROGRAM PRINCIPLE DESCRIPTION

- **Delivery Mechanism**
  - Performance Guidelines
  - Integrated Team Approach
  - Design S/W & Database

- **Technology Emphasis**
  - Alternative Technologies
  - Demonstration Designs
  - Smart Buildings
  - Sustainable Practices

- **Program Financing**
  - Life-cycle Analysis
  - Alternative Financial Mechanism

- **Operations**
  - Performance Assurance
Main driver electricity growth

Max. daily power load (MW)

Max. daily temperature (°C)

Max. daily power load
Max. daily temperature

Challenges & Problems

- Electricity consumptions remains highly intensive, specifically in Buildings.
- Delay in implantation and enforcement of some of energy conservation measures in the codes.
- Lack of incentives to promote the use of efficient cooling and lighting equipment.
- No subsidies or cash incentives for energy efficient products to reduce energy consumption.
- Too much of over estimation or sizing of A/C equipment.
- No progress in the application of thermal storage and district cooling systems.
- Poor power plants maintenance & delay in new stations construction.
Recommended energy conservation measures

Must be viable cost effectiveness and can further reduce the energy demand of the building;

- Floor insulation,
- Increase in basic measure,
- Use of shading devices,
- Use of efficient lighting and appliances,
- Improved building design, Use of efficient A/C systems,
- Use of energy recovery systems,

- Alternative U-values for walls and roofs. Basis for building peak load calculations
  - Design conditions: 24 °C IT, 46 °C OT, 28 °C WB
  - Acceptable methods of calculations.
Building Energy Code of Practice R&D
Energy Conservation Applications
CASE STUDIES Development

Architectural Design Considerations

Lighting Design Considerations

Thermal Transmission
(Bridging Bridges & Columns)
Buildings energy conservation guidelines and codes of practice

Building components
- Wall & Roofs
- Windows & Glazing
- Ventilation & Infiltration

HVAC equipment
- Window type A/C
- Air-cooled type A/C
- Water-cooled type A/C

HVAC applications & controls
- Peak Cooling load W/m²
- Lighting W/m²

Demand Side Management DSM
- Load auditing & conservation
- Building design
- Efficient devices
- Efficient controls
- Load management
  - Peak shaving
  - Load shifting
  - Time-of-use
  - District cooling

Building construction

Window type A/C

Air-cooled type A/C

Water-cooled type A/C
1983 codes are documented in the following publications:

- (MEW / R-1) Regulations for electrical installations.
- (MEW/R-2) Procedures for approval of electrical and A/C drawings and connection of power supply for construction and buildings projects.
- (MEW/R-3) Electrical load form and explanatory notes.
- (MEW / R-4) Regulations for testing of electrical installations before connection of power supply.
- (MEW / R-5) General guidelines for energy conservation in buildings.
- (MEW/R-6) Code of practice for energy conservation in buildings and appendices.
- (MEW / R-7) Rules and regulations for design of A/C system and equipment.
- (MEW/R-8) Rules and regulations for handing over engineering services (electrical and mechanical) to the maintenance authority.
- (MEW / S-1) General specifications for electrical installations.
Building Energy Code of Practice in Kuwait

The 1983 code was developed by MEW, MPW and KISR:
- Applicable to all new and retrofitted buildings of all types.

The code covers electrical installations:
- Regulations including their operations energy and conservation measures in buildings.

Basic energy conservation requirements:
- limits A/C peak power (Watt) per unit area (m²) for air- and water-cooled A/C systems as well as lighting for:
  - Residential buildings.
  - Commercial buildings (including office, shops, mosques, schools ... etc.).
قرار وزاري رقم (9) لسنة 2010، نافذ من تاريخ 1 فبراير 2010.
<table>
<thead>
<tr>
<th>Type of Application for Building per end-use sector</th>
<th>Peak load requirements for Air–conditioning (w/m²)</th>
<th>Peak load requirements for Internal lighting (w/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air Cooled Units</td>
<td>Water Cooled units</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single residence</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>Multiple family residence</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>Commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offices</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Shops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. With no electrical equipment</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>ii. With electrical equipment</td>
<td>90 + heat gen.</td>
<td>60+heat gen.</td>
</tr>
<tr>
<td>iii. Shopping centers</td>
<td>80</td>
<td>56</td>
</tr>
<tr>
<td>iv. Supermarkets with basement</td>
<td>80</td>
<td>56</td>
</tr>
<tr>
<td>Institutional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massjeds (mosques)</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>School classrooms</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>Theaters &amp; community halls</td>
<td>145</td>
<td>100</td>
</tr>
<tr>
<td>Special installations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial sheds, warehouses, factories, workshops ... etc.</td>
<td>Minimum EC requirements with no peak load (w/m²) criterion is applied.</td>
<td></td>
</tr>
</tbody>
</table>

*KISR report (1986 & 2010)*
The Energy Conservation Code of Practice (MEW / R-6)

Minimum required energy conservation measures.

- Wall and roof insulation
- glazing (WWR).
- Ventilation requirements:
  - Residential buildings at 1 AC/hr,
  - All other buildings adhere to ASHREA Handbook of Fundamentals,
  - Use of cooling recovery units.

- Air infiltration control:
  - Exterior walls, Windows and doors, Building entrances.
- Use of efficient A/C systems:
  - PUFs are 2 and 1.4 kW/RT at design conditions,
  - Air vs water-cooled systems.
Scopes of the Old and the Revised Versions of Kuwait’s Code of Practice for Energy Conservation.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Thermal insulation of walls and roofs excluded columns and beams.</td>
<td>❖ Thermal insulation of exposed columns and beams is to be made mandatory. (7.2.1)</td>
<td></td>
</tr>
<tr>
<td>❖ A common glazing-to-wall area ratio was specified regardless of building class.</td>
<td>❖ Maximum glazing-to-wall area ratios are specified for each class of glazing. (7.2.2 Table 8)</td>
<td></td>
</tr>
<tr>
<td>❖ Three-dimensional thermal bridging due to window frames was not considered.</td>
<td>❖ Thermal breaks for window frames are mandatory to prevent thermal bridging. (7.2.2)</td>
<td></td>
</tr>
<tr>
<td>❖ Limits for U-value, SHGC and visible transmittance for windows were not specified.</td>
<td>❖ Acceptable ranges of U-values, SHGC and visible transmittance for whole window assemblies are specified for different types of glazing. (7.2.2 Table 8)</td>
<td></td>
</tr>
<tr>
<td>❖ One set of design weather conditions was specified for the entire state of Kuwait.</td>
<td>❖ Separate design weather conditions are defined for Kuwait’s coastal and interior zones. (4.2 Tables 3 &amp; 4)</td>
<td></td>
</tr>
<tr>
<td>❖ Application of water-cooled A/C systems was mandatory for capacities higher than 1,000 RT.</td>
<td>❖ The capacity for mandatory use of water-cooled A/C systems is reduced to 500 RT for interior areas while 1,000 RT for coastal areas to be continued. (8.2)</td>
<td></td>
</tr>
<tr>
<td>❖ ASHRAE’s 1979 standard ventilation rate of 5 CFM/person was used.</td>
<td>❖ The higher of ASHRAE’s latest ventilation rate of 20 CFM/person or 0.5 ACH + exhaust air is used. (7.3)</td>
<td></td>
</tr>
</tbody>
</table>
### Scopes of the Old and the Revised Versions of Kuwait’s Code of Practice for Energy Conservation (Cont.)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>❖ Application of thermal storage systems was not considered.</td>
<td>❖ Cool storage systems are mandatory for buildings with partial occupancy. (8.5)</td>
</tr>
<tr>
<td>❖ Thermal insulation of exposed floors was not considered.</td>
<td>❖ Thermal insulation for exposed floors with R-value of 10 is mandatory. (7.2.1)</td>
</tr>
<tr>
<td>❖ No rigorous analysis on the application of cooling recovery units (CRUs) was made.</td>
<td>❖ Use of CRUs for recoverable exhaust air of more than 940 L/s, taking into account weather zone and building type, is mandatory. (8.3)</td>
</tr>
<tr>
<td>❖ Application of programmable thermostats for A/C control was not considered.</td>
<td>❖ Clear recommendations for the application of programmable thermostats, including recommended pre-cooling levels. (8.4)</td>
</tr>
<tr>
<td>❖ No rigorous analysis on the application of variable speed drives (VSDs) was made</td>
<td>❖ Use of VSDs in cooling tower are mandatory for all sizes and locations. (8.9)</td>
</tr>
<tr>
<td>❖ Application of seawater for condenser cooling was not considered</td>
<td>❖ Use of seawater for condenser cooling for W/C plants of 5,000 RT or more is mandatory for coastal zone.</td>
</tr>
</tbody>
</table>
Looking forwards

- Developments of a Comprehensive energy strategy; interaction with policy makers and stakeholders thru a road-map for technology implementation, regulatory guidelines, awareness campaigns and application incentive schemes.

- Research Development and Demonstration; sets a road-map for technology evaluation and implementation thru reference demonstration projects.

- Establishment a Center of Excellence; know-how transfer and training thru state-of-art laboratory testing facilities to support government / private sectors in implementation projects.
Concluding Remarks

- Kuwait remains an Energy-intensive country among the other countries in the region.
- Need to continue enforcing energy conversion and energy efficiency in all types of buildings.
- Need to enforce implementing optimal operation strategies in cooling systems and EC in all air-conditioned buildings.
- Need to offer incentives to promote use of efficient appliances, A/C and lighting systems.
- Need to apply load-shifting technologies, e.g., thermal storage and district cooling systems.
- Need to design sustainable buildings, with Solar and passive systems.