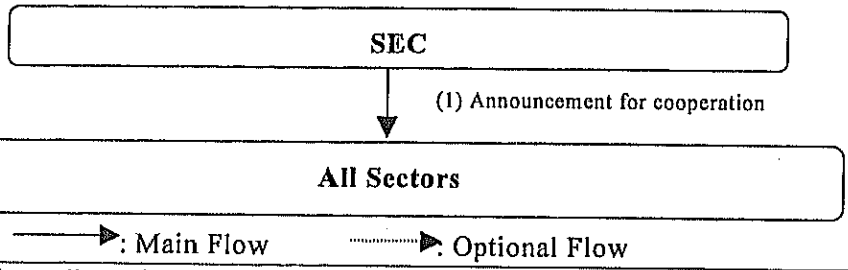
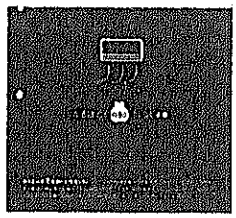
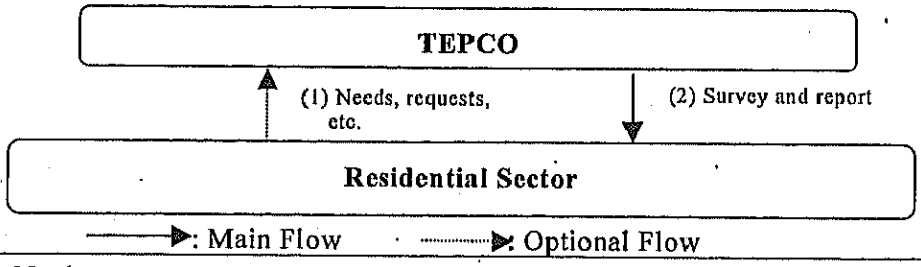
(2) Concept Paper for KSA

<table>
<tr><td>Program</td><td colspan="4">Announcement of Daily Demand and Supply Forecast</td></tr>
<tr><td>Players</td><td colspan="2">Executing Agency:
SEC</td><td colspan="2">Target:
All Sectors</td></tr>
<tr><td>Concept</td><td colspan="4">(Concept)
- Announcement of balance of demand and capacity every day
- Request of cooperation for energy conservation
- Announcement of instruction for how to reduce energy consumption</td></tr>
<tr><td>Workflow</td><td colspan="4"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="4">- At first, dissemination strategy should be established including the Denki Forecast. It is one of contents of the dissemination programs.
- To make know widely, media (TV or radio) should be used.</td></tr>
<tr><td rowspan="5">Possibility to adopt the scheme for KSA</td><td>Evaluation Criteria</td><td>Level 1</td><td>Level 2</td><td>Level 3</td></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>Middle</td><td>Short</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>Many</td><td>Several</td><td>Few</td></tr>
<tr><td>Effect on EC</td><td>Small</td><td>Fare</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">This is effective method in case of emergency of power supply. In other words, it might be not effective in non-emergency time.</td></tr>
</table>

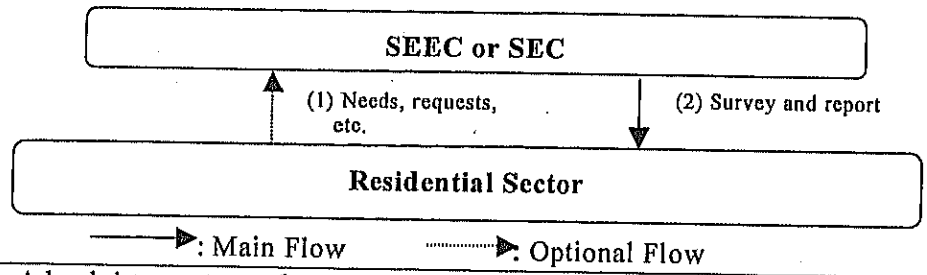
5. Instruction Booklet and Lifestyle Laboratory Report (by Utility)

(1) Japan's Sample

<table>
<tr><td>Program</td><td colspan="2">Instruction Booklet and Lifestyle Laboratory Report (by Utility)</td></tr>
<tr><td>Players</td><td>Executing Agency:
TEPCO</td><td>Target:
Residential Sector</td></tr>
<tr><td>Overview</td><td colspan="2">(Instruction Booklet (TEPCO Shoene Nattoku Book))
- Instruction for efficiently use of household appliances
- How to use Air-conditioner, Refrigerator, Lamp, TV, Rice cooker, Washing machine, Cleaning machine, Waiting power, etc.
- Laboratory test result and calculation sheet for electricity bill are also included in the book.
- Explanation of tariff option is also included.
 

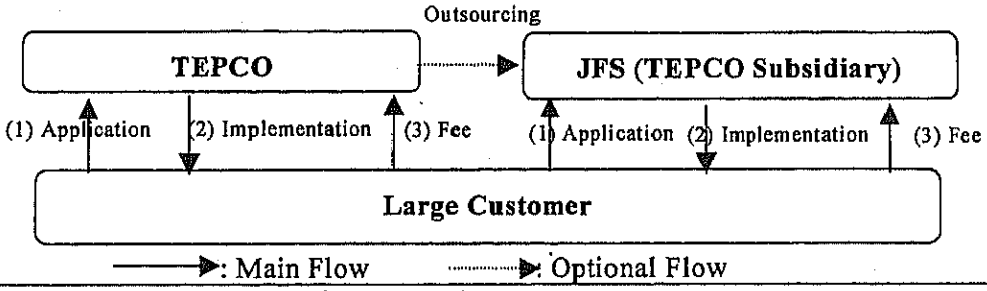
(Lifestyle Laboratory Report)
- Q&A regarding how to efficiently use of household appliances is summered in the reports.
- Frequent questions are collected from customers and then laboratory test themes are decided.
- Laboratory tests are conducted in TEPCO R&D center.
- The various reports are prepared, for example, "Air-conditioner", "Refrigerator", "Lamp", "Washing Machine", "Cleaning Machine".
 
  </td></tr>
<tr><td>Workflow</td><td colspan="2">  </td></tr>
<tr><td>Record and effect</td><td colspan="2">- No data</td></tr>
<tr><td>Key points for success</td><td colspan="2">- Various EC measures are complied in one instruction booklet so that it may be easy to read.
- Themes of laboratory tests are selected based on needs or request of people.</td></tr>
</table>

(2) Concept Paper for KSA

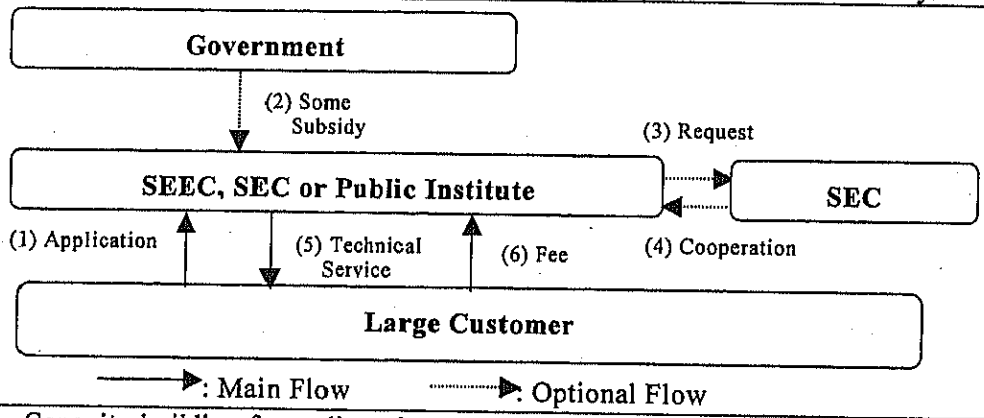
<table>
<tr><td>Program</td><td colspan="4">Instruction Booklet and Lifestyle Laboratory Report (by Utility)</td></tr>
<tr><td>Players</td><td colspan="2">Executing Agency:
SEEC or SEC</td><td colspan="2">Target:
Residential Sector</td></tr>
<tr><td>Concept</td><td colspan="4">(Current Situation in KSA)
- Instruction has been already prepared by KSA. However, it seems to be difficult for people or not complied in 1 booklet.
(Recommendation for Improvement)
- Various EC measures how to efficiently use household appliances should be complied in 1 booklet.
- Needs or requests of people regarding household appliances should be also reflected in the booklet. Those information can be collected from questionnaire survey)
- Laboratory test is effective because numerical value can be indicated.</td></tr>
<tr><td>Workflow</td><td colspan="4"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="4">- A book is easy to read.
- Laboratory test gives a reality for each EC measure.</td></tr>
<tr><td rowspan="5">Possibility to adopt the scheme for KSA</td><td>Evaluation Criteria</td><td>Level 1</td><td>Level 2</td><td>Level 3</td></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>[Middle]</td><td>Short</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>Many</td><td>Several</td><td>[Few]</td></tr>
<tr><td>Effect on EC</td><td>Small</td><td>[Fare]</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">For EC promotion in the residential sector, such instruction book is a basic measure. Instruction booklet should be updated for further improvement.
If KSA adopts Labeling System, such laboratory test skill can be utilized for the standardization of test method.</td></tr>
</table>

6. Consulting Service for Energy Conservation and ESCO Business

(1) Japan's Sample

Program	Consulting Service for Energy Conservation and ESCO Business	
Players	Executing Agency: TEPCO	Target: (i) (ii) Large Customers
Overview	(Objective) TEPCO provides technical service for industrial and commercial sector targeting large customers. Such technical service is managed by TEPCO or TEPCO subsidiary (ESCO) on the business base. Now such technical service is one of the major EC businesses in Japan. ECCJ also provides a similar service without fee, but it covers only basic survey. (Major Contents of Technical Service) - Energy Audit Service (basic survey, detailed survey and recommendation) - Assistance of making "Energy Audit Report" for clients - ESCO business (performance guarantee contract for EC project) - Management of Energy Center, etc. (Implementing Body) - TEPCO - Japan Facility Solutions (JFS) which is TEPCO subsidiary ESCO	
Workflow		
Record and effect	(JFS Business Record as of Nov. 2005) - Assistance for Energy Audit Report: 31 - Energy Audit Service: 20 - Construction of all electrified house: 9 - ESCO projects: 50 - Energy Center project: 1	
Key points for success	- Reliability to TEPCO from customers helps such business. - Subsidy for ESCO project assists the ESCO business. - When necessary, specific technology expert is outsourced from other consultign firm.	

(2) Concept Paper for KSA

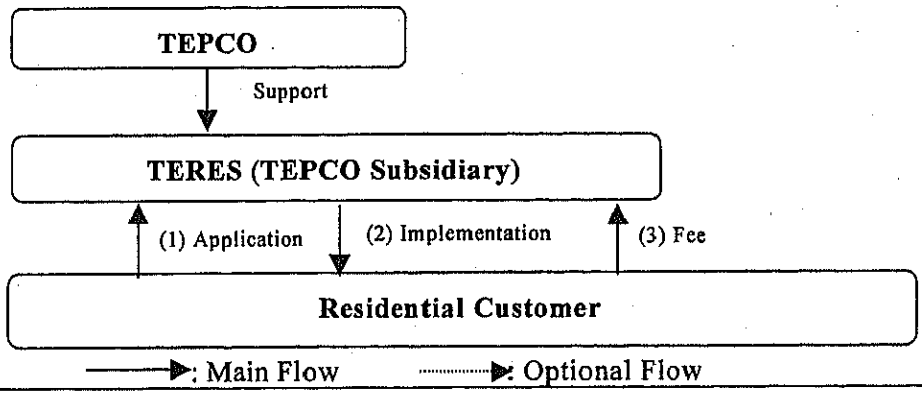
<table>
<tr><td>Program</td><td colspan="3">Consulting Service for Energy Conservation and ESCO Business</td></tr>
<tr><td>Players</td><td>Executing Agency:
SEEC, SEC or Public Institute</td><td colspan="2">Target:
(i) (ii) Large Customer</td></tr>
<tr><td>Concept</td><td colspan="3">(Consideration)
- To promote energy conservation, such technical service is necessary.
- It is discussion point whether this consulting service is provided by business base or non-business base.
- Non-business base (or business base with subsidy) seems to be better at first. Because awareness of factory and business sector is now not so intensive.
- ESCO business (performance guarantee contact) seems to be difficult now. Because tariff is not so high compared with investment cost of ESCO.
(Expected Executing Agency)
- SEEC, SEC or Public Institute might be possible.
- SEC assistance seems to be needed for such activities. Because they have potential experts in architecture and electric facility, and much information and data for customers.
(Subsidy)
- If non-business base is chosen, 100% subsidy is necessary.
- Even though business base is chosen, some subsidy seems to be necessary.</td></tr>
<tr><td>Workflow</td><td colspan="3"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="3">- Capacity building for auditors is necessary.
- Demarcation between "free charge service" and "business base" should be considered.
- After recommendation, a project owner normally meets a financial problem. Financial scheme should be considered together with such technical service.</td></tr>
<tr><td>Possibility to adopt the scheme for KSA</td><td colspan="3"><table>
<tr><th>Evaluation Criteria</th><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>[Middle]</td><td>Short</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>Many</td><td>Several</td><td>[Few]</td></tr>
<tr><td>Effect on EC</td><td>Small</td><td>[Fare]</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">From the long-term view, such audit skill is crucial needed in spite of business or non-business. Capacity building for executing agency is needed at first. A building sector is easier than industrial sector because common facilities are used in buildings. On the other hand, industrial sector normally needs a specific technology and skill.</td></tr>
</table></td></tr>
</table>

7. Energy Conservation Consulting Service for Residential Sector

(1) Japan's Sample

<table>
<tr><td>Program</td><td colspan="2">Energy Conservation Consulting Service for Residential Sector</td></tr>
<tr><td>Players</td><td>Executing Agency:
TEPCO Subsidiary</td><td>Target:
Residential Sector</td></tr>
<tr><td>Overview</td><td colspan="2">(Objective)
TEPCO HQ provides general information for EC way and EC equipment by instruction book to improve awareness. However, some people wishes to know specific energy saving method for their houses. In order to meet such demand, TEPCO provides technical services as a business base.

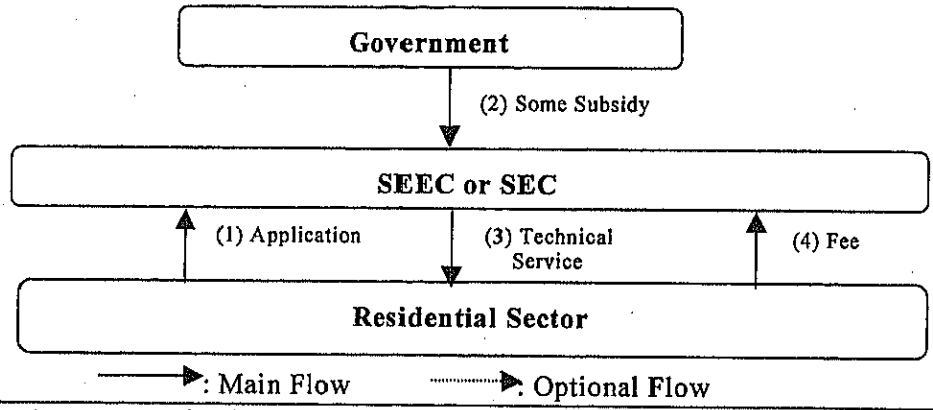
(Major Contents of Technical Service)
- Load survey for the whole house, for each equipment, for each circuit, and recommendation
- Sales of EC goods (watthour indicator for household appliances, tool for cutting waiting power, reflecting panel in florescent lamp, etc.)
- Dispatching teacher for EC seminar, etc.

(Implementing Body)
- Tokyo Energy Research (TRES) which is TEPCO subsidiary for residential sector consultant.</td></tr>
<tr><td>Workflow</td><td colspan="2"> 
</td></tr>
<tr><td>Record and effect</td><td colspan="2">(TERES Record)
- Various Load survey: 113 houses/stores
- Basic energy use survey and recommendation: 2,250 houses</td></tr>
<tr><td>Key points for success</td><td colspan="2">- Reliability to TEPCO from customers helps such business.</td></tr>
</table>

(2) Concept Paper for KSA

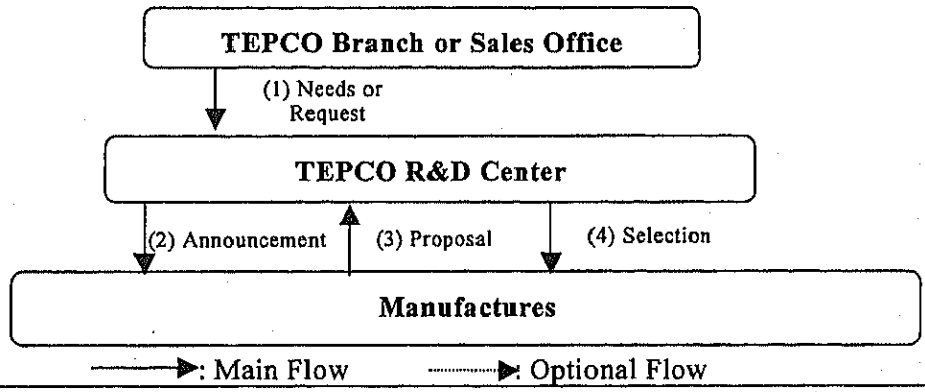
<table>
<tr><td>Program</td><td colspan="4">Energy Conservation Consulting Service for Residential Sector</td></tr>
<tr><td>Players</td><td colspan="2">Executing Agency:
SEEC or SEC</td><td colspan="2">Target:
Residential Sector</td></tr>
<tr><td>Concept</td><td colspan="4">(Consideration)
- Business base with subsidy seems to be better at first. If 100% grant is provided for the services, a customer might lose a concern about the result.
- Some subsidy seems to be necessary because electricity rate of KSA is not so high and customer's benefit is also small compared with the service cost.

(Expected Executing Agency)
- SEEC or SEC is expected.

(Expected Services)
- Load survey for house and each household appliance
- Questionnaire survey to know EC practices
- Analysis of relation between load data and EC practices
- Recommendation
- Continuous monitoring after the service by a record of electricity bill</td></tr>
<tr><td>Workflow</td><td colspan="4"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="4">- A customer should pay some money for the service in order to make a strong concern.
- However, some subsidy seems to be necessary to give incentive for applicants.</td></tr>
<tr><td rowspan="5">Possibility to adopt the scheme for KSA</td><td>Evaluation Criteria</td><td>Level 1</td><td>Level 2</td><td>Level 3</td></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>Middle</td><td>Short</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>Many</td><td>Several</td><td>Few</td></tr>
<tr><td>Effect on EC</td><td>Small</td><td>Fare</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">It expects small effect on EC. However, from the long-term view, such activities will encourage EC awareness. This scheme can be established easier.</td></tr>
</table>

8. Joint Development of Energy Conservation Equipment and Household Appliances

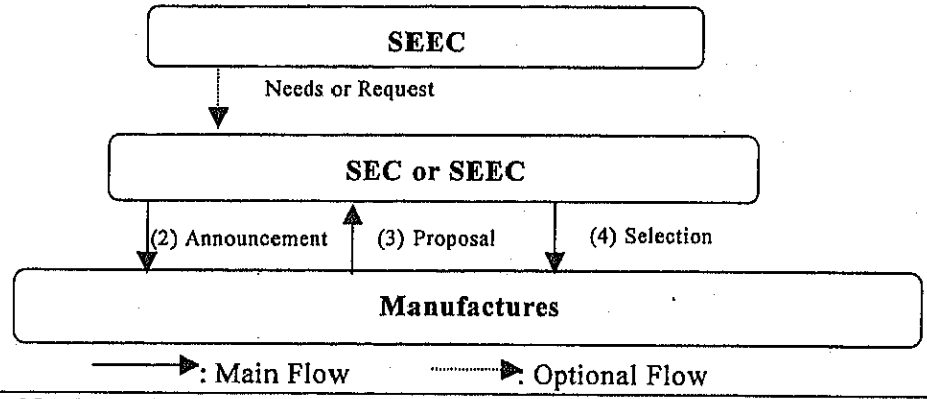
(1) Japan's Sample

<table>
<tr><td>Program</td><td colspan="2">Joint Development of Energy Conservation Equipment and Household Appliances</td></tr>
<tr><td>Players</td><td>Executing Agency:
TEPCO R&D Center</td><td>Target:
Manufactures
(Final Target: All Sectors)</td></tr>
<tr><td>Overview</td><td colspan="2">(Objective)
TEPCO has much information for needs and request for various equipment or household appliances. Because customers sometimes ask questions or make claims for such appliances to TEPCO. So TEPCO and manufactures jointly develop equipment or household appliances.
(Procedure)
- R&D center of power utility collects needs and requests from customers through branch offices and sales offices.
- R&D center selects themes for development of equipment and appliances form such needs and requests.
- R&D center (or Headquarters) announces joint development of selected themes to manufacturers.
- Some manufacturers propose joint development by theme and makes a selection.
- R&D center and manufacturers jointly develop energy conservation equipment or appliances.
(Expected Equipment and Appliances)
- HVAC system, Ice storage system, Hot water server, IH system, etc.
(Implementing Body)
- TEPCO R&D Center together with manufacture</td></tr>
<tr><td>Workflow</td><td colspan="2"> 
</td></tr>
<tr><td>Record and effect</td><td colspan="2">(Development Record)
- Air-cooled chiller unit (Capacity=160kW, COP=3.7) in 2004 with Hitachi
- Water-cooled screw type chiller (Capacity 528kW, COP=5.6) in 2003 with KOBELCO
- Ice storage package unit with Sanyo
- ECO-Cute (electric hot water server), Cocking or washing machine, etc.</td></tr>
<tr><td>Key points for success</td><td colspan="2">- Needs and requests are collected in TEPCO R&D Center.
- Manufacture wishes to obtain an endorsement by neutral agency such as power utility.</td></tr>
</table>

(2) Concept Paper for KSA

<table>
<tr><td>Program</td><td colspan="4">Joint Development of Energy Conservation Equipment and Household Appliances</td></tr>
<tr><td>Players</td><td colspan="2">Executing Agency:
SEC or SEEC</td><td colspan="2">Target:
Manufactures</td></tr>
<tr><td>Concept</td><td colspan="4">(Consideration)
- Such R&D scheme has normally another objective, that is, promotion of local product. It should be focused on local product development first.
- When a public R&D development scheme is established (as mentioned in 3.3), this private scheme (done by private power utility and manufacture) might be redundant.
- Needs and request for development should be collected and reflected on development strategy.

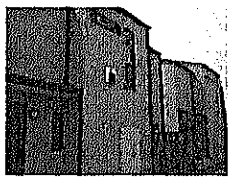
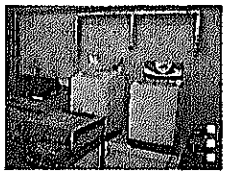
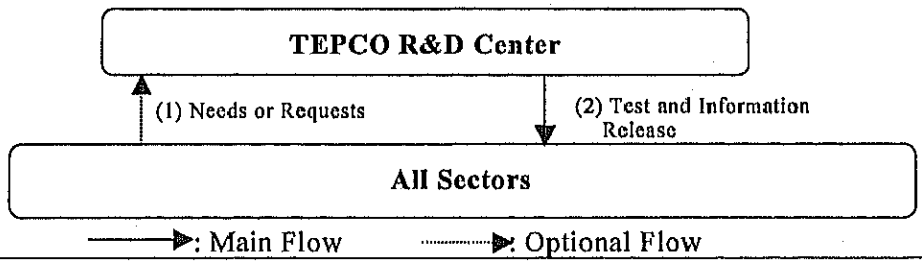
(Expected Executing Agency)
- SEC or SEEC

(Expected Field to be developed)
- Local product (if any)
- Product which needs some modification</td></tr>
<tr><td>Workflow</td><td colspan="4"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="4">- Needs and request from customers should be reflected on development strategy.</td></tr>
<tr><td rowspan="5">Possibility to adopt the scheme for KSA</td><td>Evaluation Criteria</td><td>Level 1</td><td>Level 2</td><td>Level 3</td></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>Middle</td><td>Short</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>Many</td><td>Several</td><td>Few</td></tr>
<tr><td>Effect on EC</td><td>Small</td><td>Fare</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">It might be overlapped to public R&D development scheme.</td></tr>
</table>

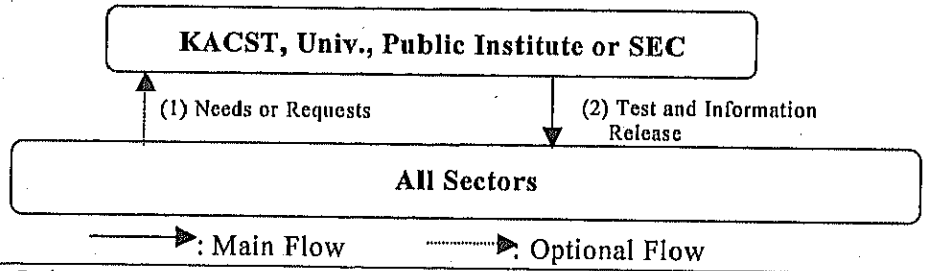
9. Laboratory Testing for Performance Check

(1) Japan's Sample

<table>
<tr><td>Program</td><td colspan="2">Laboratory Testing for Performance Check</td></tr>
<tr><td>Players</td><td>Executing Agency:
TEPCO R&D Center</td><td>Target:
All Sectors</td></tr>
<tr><td>Overview</td><td colspan="2">(Objective)
TEPCO R&D Center has a laboratory test group for promotion of joint development with manufactures, and performance evaluation of household appliances (12 types) to make a recommendation for efficient use. The test site is located in TEPCO R&D Center.

(Laboratory Test Field)
- Air-conditioning system and thermal storage system
 
Indoor Unit Test (Sample)
- Twin house (house performance test)
 
Twin houses
- Household Appliances
 
Test for Washing Machine</td></tr>
<tr><td>Workflow</td><td colspan="2">  </td></tr>
<tr><td>Record and effect</td><td colspan="2">- Information Release (Lyfestyle Laboratory Report, Ginza Museum, Instruction Book, etc.)
- Making Reports for 5 themes conducted by "Twin Houses"</td></tr>
<tr><td>Key points for success</td><td colspan="2">- Needs and requests are collected in TEPCO R&D Center.
- Feedback the information to the customer and collect further needs</td></tr>
</table>

(2) Concept Paper for KSA

Program	Laboratory Testing for Performance Check	
Players	Executing Agency: KACST, Univ., Public Institute or SEC	Target: All Sectors
Concept	(Consideration) A laboratory can check a performance of equipment. It can check equipment performance (COP, demand power, consumption, etc.), obtain a knowledge of more efficient use (like TEPCO Lifestyle Laboratory Report), and test for some modification of foreign product for Saudi Arabian style, etc. Themes to be tested can be collected from needs survey of customers. (Requirement) - Establishment of standard test methods (ISO, JIS, etc.) for each equipment - Test equipment matching the standard - Test skill using such test equipment (Expected Executing Agency) - KACST, Univ., Public Institute or SEC	
Workflow		
Key points for success	- Laboratory equipment should be prepared for larger consumption equipment such as air-conditioner, lamp, refrigerator, etc. - Needs and request from customers should be reflected on laboratory test. - If a test standard is established, consensus and cooperation of industry association are necessary. It is better to start easier test such as lamp test.	

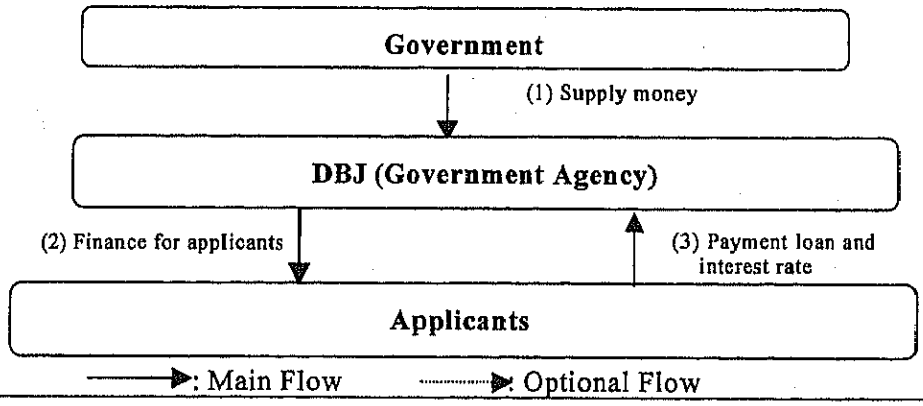
Possibility to adopt the scheme for KSA

Evaluation Criteria	Level 1	Level 2	Level 3
Duration for design, consensus, and finalization	Long	[Middle]	Short
No. of concerned agencies and stakeholders	[Many]	Several	Few
Effect on EC	Small	[Fare]	Large
Comments	Laboratory is required to prove EC effect of electrical equipment. Test skill and the standard will be required for "Labeling System" as well. However, establishment of test standard might take a long time to make consensus of industry association.		

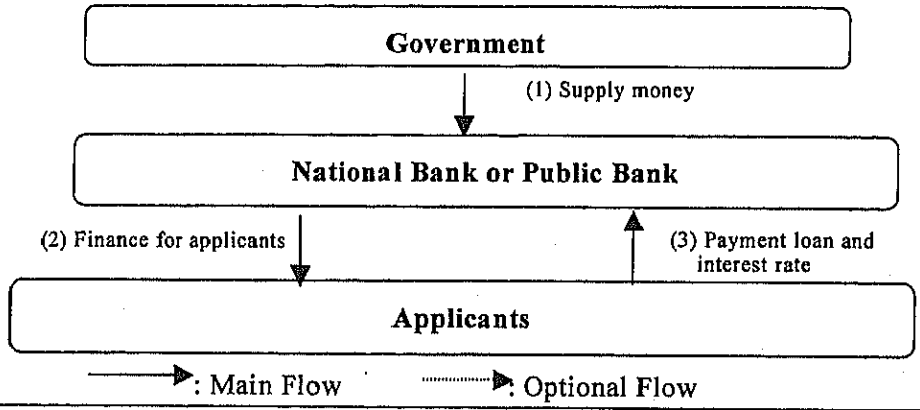
Low Priority Measure

1. Preferable Interest Rate Loan for Energy Conservation Project

(1) Japan's Sample

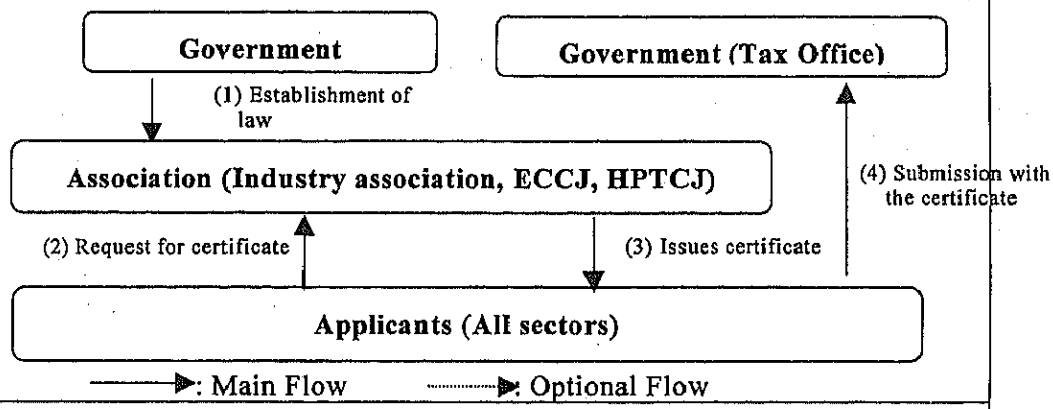
Program	Preferable Interest Rate Loan for Energy Conservation Project	
Players	Executing Agency: Development Bank of Japan (Government Agency)	Target: Industrial and Commercial Sector
Overview	(Target Project) - General energy conservation projects - Energy-saving promotion projects for the industrial sector - Energy-saving promotion projects for buildings - Electric power load leveling projects (Qualification) - Improvement rate: 10 % for the commercial sector, 20 % for the industrial sector (Terms of Condition) - Financing rate: 50 % - Interest rates and payment periods are decided by the project feature. (Government Support) - Supply money to the Bank from the Government	
Workflow		
Record and effect	Not disclosed	
Key points for success	- Appraisal capacity of the Bank is needed. - Low and long-term condition is needed.	

(2) Concept Paper for KSA

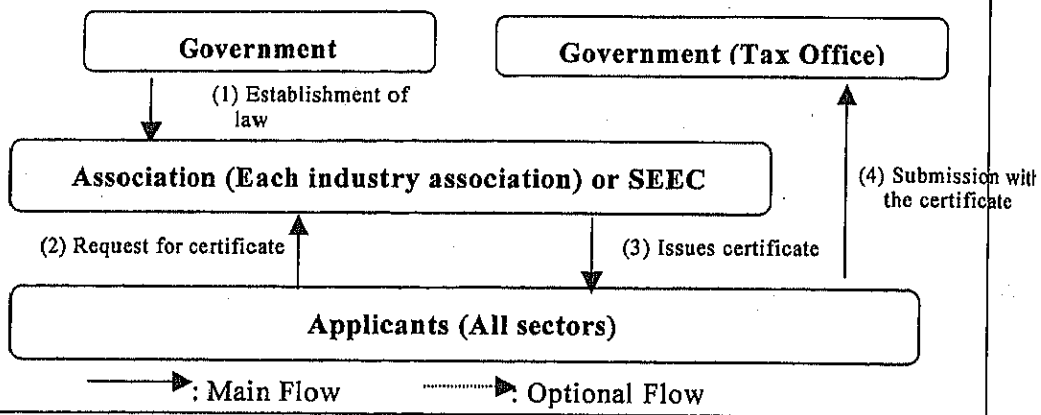
<table>
<tr><td>Program</td><td colspan="4">Preferable Interest Rate Loan for Energy Conservation Project</td></tr>
<tr><td>Players</td><td colspan="2">Executing Agency:
Government Bank</td><td colspan="2">Target:
Industrial and Commercial Sector</td></tr>
<tr><td>Concept</td><td colspan="4">(Target Field)
- EC project
- EC equipment installation
(Executing Agency)
- A Government Bank or public banks should be an executing agency.
- A government support might be necessary for replenishing for low interest rate</td></tr>
<tr><td>Workflow</td><td colspan="4"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="4">- Appraisal capacity building is necessary for the Bank staff
- Needs survey is necessary before starting the scheme.</td></tr>
<tr><td rowspan="5">Possibility to adopt the scheme for KSA</td><td>Evaluation Criteria</td><td>Level 1</td><td>Level 2</td><td>Level 3</td></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>Middle</td><td>Short</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>Many</td><td>Several</td><td>Few</td></tr>
<tr><td>Effect on EC</td><td>Small</td><td>Fare</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">Credibility for EC project is necessary to lend money. The Bank staff has to have appraisal capacity for EC projects. Capacity building for the staff is necessary.</td></tr>
</table>

2. Tax Incentive to Install Energy Conservation Equipment

(1) Japan's Sample

Program	Tax Incentive to Install Energy Conservation Equipment	
Players	Executing Agency: METI and Association	Target: All Sectors
Overview	(Target Technology: Total 69 type equipment) - Factory process equipment for energy efficiency - Installation of energy efficiency equipment (Air-conditioner, lamp, transformer, window, etc.) - Load leveling equipment (Gas air-conditioner, thermal storage system) - Renewable energy, etc. (Incentive) - Tax exemption from corporate tax, equivalent to 7% of the equipment acquisition cost - Or, special depreciation of 30% of the equipment acquisition cost in the year of acquisition, in addition to ordinary depreciation (Certification) - Association (Industry association, ECCJ, HPTCJ, etc.) issues a certificate - Evaluation criteria (minimum scale, COP, etc.) should be established.	
Workflow		
Record and effect	Not disclosed	
Key points for success	- To issue a certificate, evaluation standard is established and open to the public. - To simplify the work of certification, various associations from each sector can appraise the application form submitted by applicants.	

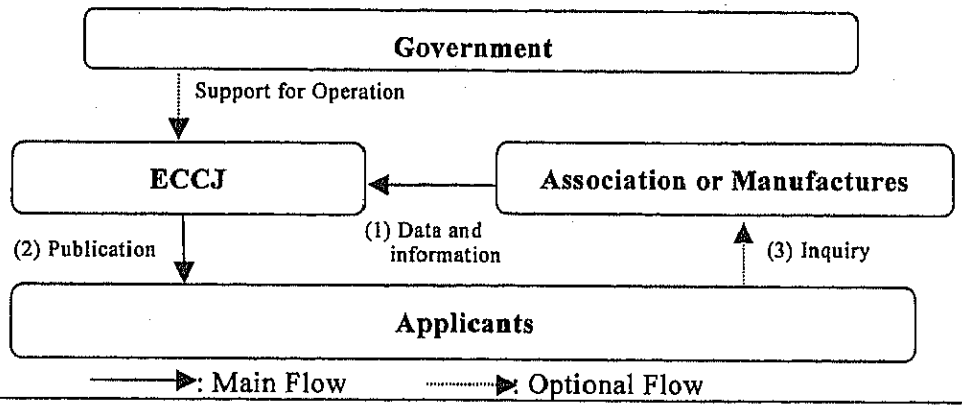
(2) Concept Paper for KSA

Program	Tax Incentive to Install Energy Conservation Equipment	
Players	Executing Agency: Association or SEEC	Target: Industry, Commercial, Residential and Agriculture Sectors
Concept	(Target Technology) - Installation of EC equipment (Incentive) - Tax exemption from corporate tax - Tax exemption from import tax (Certification) - Association (Industry association) issues a certificate	
Workflow		
Key points for success	- To issue a certificate, evaluation standard is established and open to the public. - Association's cooperation is necessary for planning and operation.	

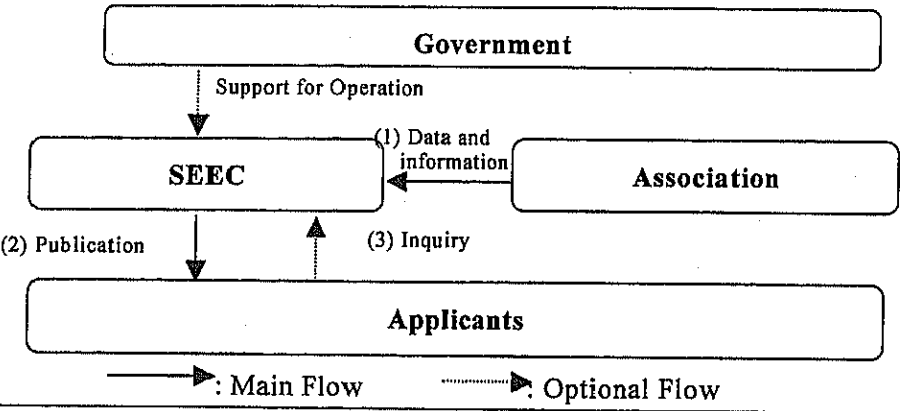
Possibility to adopt the scheme for KSA	Evaluation Criteria	Level 1	Level 2	Level 3
	Duration for design, consensus, and finalization	[Long]	Middle	Short
	No. of concerned agencies and stakeholders	[Many]	Several	Few
	Effect on EC	Small	Fare	[Large]
	Comments	It seems to have a large impact for EC. However, arrangement with MOF and industry association is necessary.		

3. Information Release of Energy Conservation Equipment

(1) Japan's Sample

<table>
<tr><td>Program</td><td colspan="2">Information Release of Energy Conservation Equipment</td></tr>
<tr><td>Players</td><td>Executing Agency:
ECCJ</td><td>Target:
All Sectors</td></tr>
<tr><td>Overview</td><td colspan="2">(Household Appliances)
- Target is air-conditioner, TV, refrigerator, lamp, hot water server, etc.
- Contents of information covers name of manufacture, COP in catalogue, evaluation of labeling system, expected annual expense, etc.
- Website or booklet is available.
(Equipment for Industrial and Commercial Sector)
- Target is air-conditioner, cogeneration, transformer, boiler, elevator, etc.
- Contents of information is just a linkage to supplier and manufactures through website. (no specific data in the ECCJ Website)
(Data Collection)
- ECCJ collects above data from association or manufactures and complies the database.</td></tr>
<tr><td>Workflow</td><td colspan="2"> 
</td></tr>
<tr><td>Record and effect</td><td colspan="2">- No data</td></tr>
<tr><td>Key points for success</td><td colspan="2">- Making database of household appliances is not so difficult because the "Labeling System" which indicates product performance can be utilizes.
- The test method in the Labeling System is standardized by JIS. So data reliability is secured to some extent.
- Periodical updating data and website is required.</td></tr>
</table>

(2) Concept Paper for KSA

<table>
<tr><td>Program</td><td colspan="2">Information Release of Energy Conservation Equipment</td></tr>
<tr><td>Players</td><td>Executing Agency:
SEEC</td><td>Target:
Industrial, Commercial and Residential Sectors</td></tr>
<tr><td>Concept</td><td colspan="2">(Target EC Equipment)
- Target should be focused on frequent use appliances such as air-conditioner, TV, refrigerator, lamp, hot water server, etc.
- To compare under same condition, standard test methods are adopted for each appliances.
- Association or supplier should be cooperated for database.</td></tr>
<tr><td>Workflow</td><td colspan="2"> 
</td></tr>
<tr><td>Key points for success</td><td colspan="2">- Labeling system or test standard is required for indication of performance.
- Catalogue data is not comparable, because of different test method.
- Fair and proper comparison is necessary among manufactures.</td></tr>
<tr><td>Possibility to adopt the scheme for KSA</td><td colspan="2"><table>
<tr><th>Evaluation Criteria</th><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td>Duration for design, consensus, and finalization</td><td>Long</td><td>Middle</td><td>[Short]</td></tr>
<tr><td>No. of concerned agencies and stakeholders</td><td>[Many]</td><td>Several</td><td>Few</td></tr>
<tr><td>Effect on EC</td><td>[Small]</td><td>Fare</td><td>Large</td></tr>
<tr><td>Comments</td><td colspan="3">If the Labeling System can be established, it will be one part of the Labeling System.</td></tr>
</table></td></tr>
</table>

付属資料 4

ミニプロジェクト実施結果

CONTENT

1. Energy Conservation Model House

1.1 Purpose and Outline of the Project

(1) Purpose of the project

Residential sector is the largest consumer of electricity in KSA. More than 50% of electricity is used by residential sector according to studies.[1] Also these studies show the large use originates mostly from use of air conditioners (AC). Population growth in this country is high enough to make house electricity use a heavy burden for social energy supply, if the sector continues to consume electricity at present rate.

This problem needs to be tackled in various ways. Incentives for the energy efficient electrical appliances, specially ACs, and EC awareness promotion are two important issues.

At the same time, improvement of EC performance of house building itself is crucial. Hot climate and cheap energy cost make use of AC inevitable in modern lifestyle, and result in large electricity consumption. Nevertheless, our local survey (APPENDIX-1) showed that present EC capability of houses is very low.

The purpose of this project was to propose a possible (with available technology) model case of energy conserving house design in Riyadh, through discussions and studies with local professionals.

(2) Outline of the Project

1) Through our 2nd and 3rd mission, workshops were held and studies were made in order to collect information and opinions on conditions surrounding KSA houses.

2) Through 3rd and 4th mission, interim proposal design was presented at workshops and evaluation methods were investigated.

3) At the 5th and 6th mission, electricity use simulation result was presented in workshops. Also future improvement of the model house was discussed.

1.2 Study of Local Conditions

(1) Housing Districts and Blocks in Riyadh

Riyadh's city plan is based on the master plan designed by Greek architect/urban planner Konstantinos Apostolos Doxiadis (Figure AP4-1.1). In this plan, existing old road network was interwoven into large grid pattern and highway network, which allowed city expansion with the use of cars.

Residential block serves as a unit component of this pattern. On block perimeter facing main streets are commercial buildings. Inside block are series of detached houses (Figure AP4-1.2). Blocks in Riyadh lean towards Makah direction by 25° degrees from latitude line.

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[1] Electric Power Consumption in KAU", Dr. Badr A. Habeebullah, King Abdulaziz University 2008

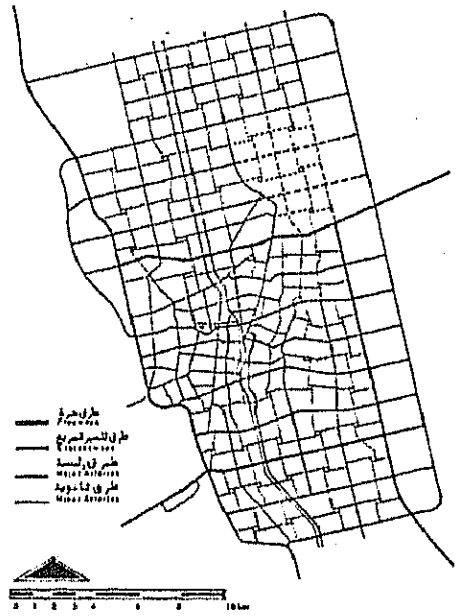


Figure AP4-1.1 1972 Riyadh City Plan

(source: Riyadh Architecture in One Hundred Years)

Figure AP4-1.2 Residential Block in Riyadh

Riyadh has four residential districts; northern, southern, eastern and western. The city is expanding towards all these directions with new residential block developments.

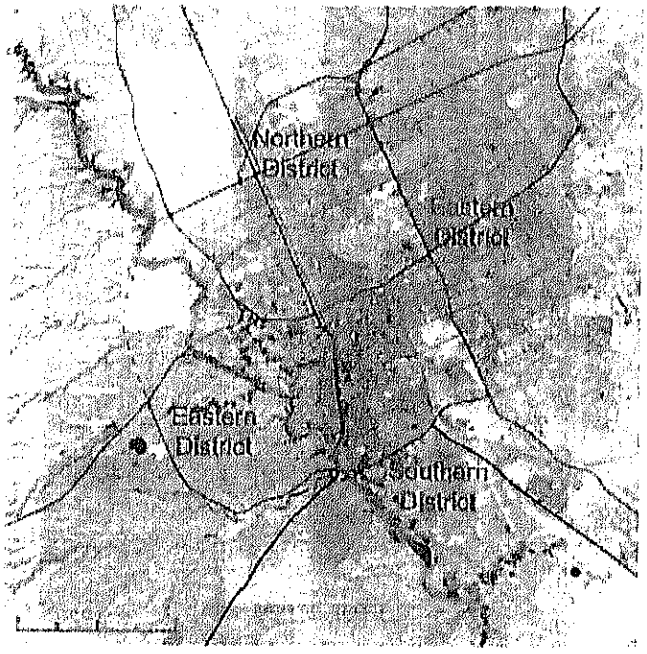


Figure AP4-1.3 Residential Districts

(map source: Google Earth)

Since this expansion is almost a uniform phenomenon in site condition, model house should be supposed to stand in this typical type of residential district.

(2) Climate and Heat Gain from the Sun

1) Climate and Insolation

Situated in hot-arid climate region, Riyadh temperature stays high in most of the year. According to our survey, average use of ACs for cooling extends 7.5 months. (APPENDIX 1)

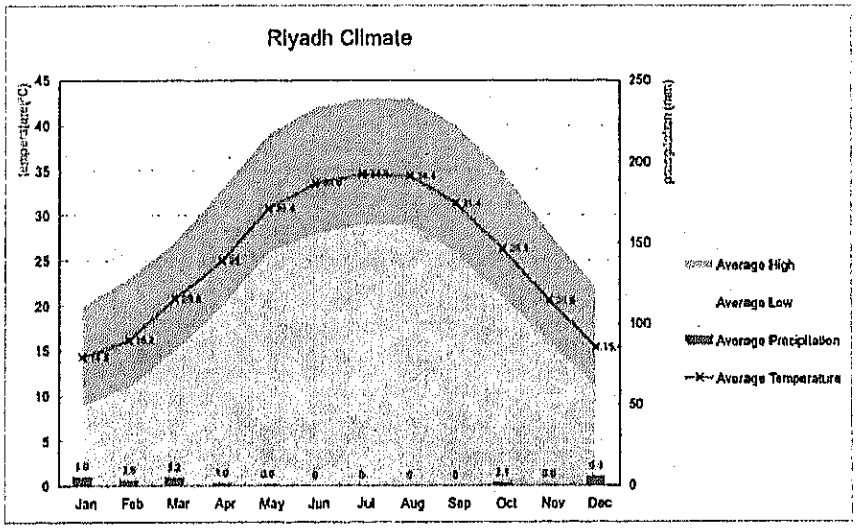


Figure AP4-1.4 Riyadh Temperature and Precipitation (source: Climate Design Data 2005)

Insolation duration is also long in desert climate Riyadh. Significance of direct sun radiation as heat load factor is far greater compared to other hot regions with more unclear skies. Figure AP4-1.5, 6 and 7 are graphs of average direct solar radiation on roof and walls in January, April and July.

As shown, roof acts as main recipient of solar heat eradiation especially in summer (insolation duration is taken into account). Some measure for tackling roof heat gain needs to be included in model house design.

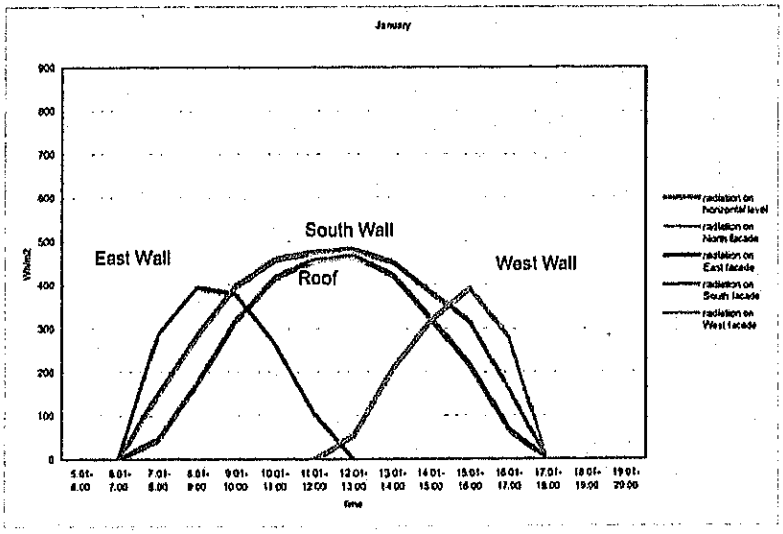


Figure AP4-1.5 Average Direct Solar Radiation on Roof and Walls in January (Wh/m^2)

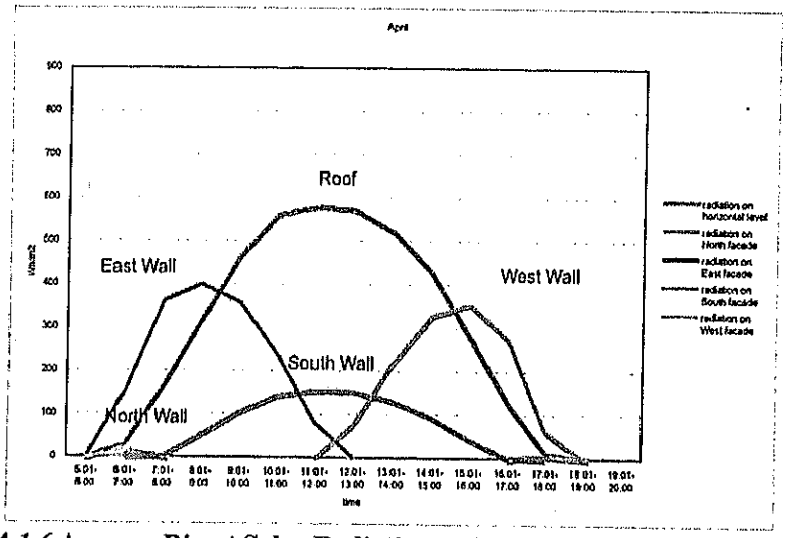


Figure AP4-1.6 Average Direct Solar Radiation on Roof and Walls in April (Wh/m^2)

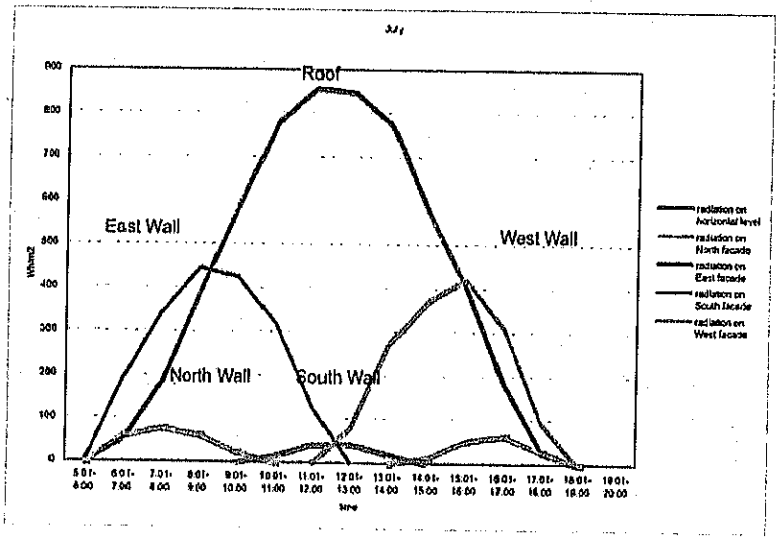


Figure AP4-1.7 Average Direct Solar Radiation on Roof and Walls in July (Wh/m^2)

2) Relation between House Configuration and Heat Gain from the Sun

We calculated heat gain from direct sun radiation for different house floor numbers and shapes (in July, Table AP4-1.1). Shape of house (square or rectangular) makes small difference in heat gain (E-W long house receives 5% less heat than N-S long house). Difference between 2 and 3 stories house is significant. 3 stories with less roof area receives 25% less radiation heat than 2 stories house.

Table AP4-1.1 House Configuration and Solar Heat Gain in July

(Comparison of 800m^2 total floor area house)

Floors	Footprint	Building Envelope Area (m^2)	Heat Gain from Direct Radiation (kW•day)
2	Square	976	2912
	N-S Long	990	2986
	E-W Long	990	2873
3	Square	972	2307
	N-S Long	990	2398
	E-W Long	990	2256

(3) Local House Structure, Material and Construction

1) Structure

Figure AP4-1.8 through 10 illustrate how local houses are built.

i) Concrete columns, beams and slabs with reinforcing steal rods are cast at site.

ii) Walls are filled with concrete blocks (in Riyadh. Hollow bricks are used in Jeddah).

iii) Window openings are made with short beams on upper sides.

On this structure, windows are fixed and exterior/interior finishing is done.

This type of structure is common not only to detached houses, but also to apartments or commercial buildings of almost any size.

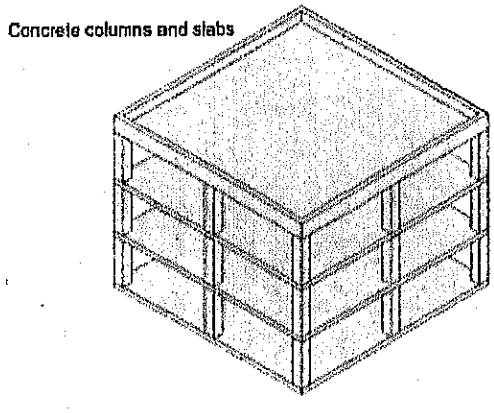


Figure AP4-1.8

Concrete Columns, Beams and Slabs – i)

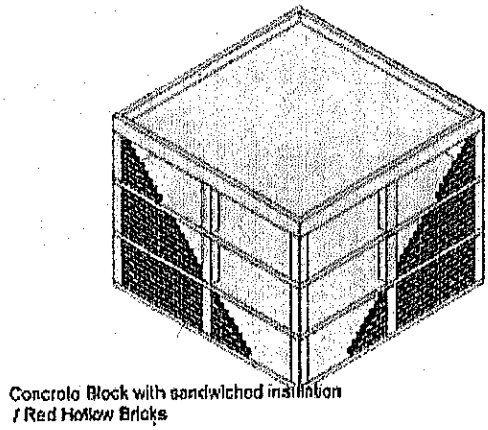


Figure AP4-1.9

Infill Concrete Blocks – ii)

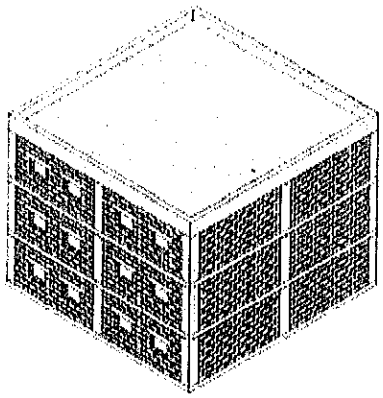


Figure AP4-1.10 Window Openings – iii)

Compared to masonry structure with adobes that were traditionally used in the region, concrete frame has more structural strength. Still, large area of wall with no steal reinforcement is questionable quality even in area with no earthquakes.

2) Material and Construction

i) Structure

As mentioned, concrete is widely used in KSA. Raw material of cement, clay and limestone, are available in domestic area.

ii) Wall, Roof and Insulation

Below two pictures are common products used at house construction sites in Riyadh.

Concrete block on the left has expanded polystyrene as central layer for thermal insulation purpose. Hollow red brick on the right is mainly used and cast in roof slabs in order to lessen slab weight.

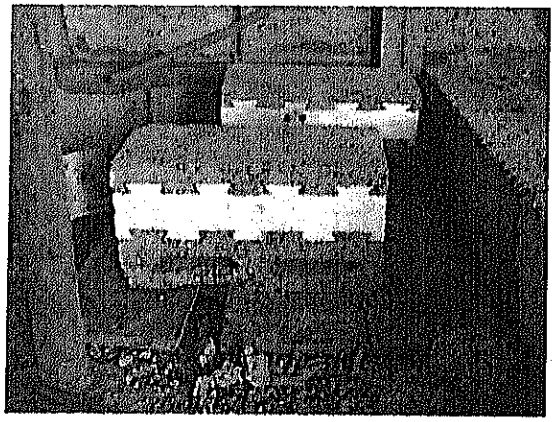


Figure AP4-1.11 Concrete Block with Sandwiched Insulation (Expanded Polystyrene)

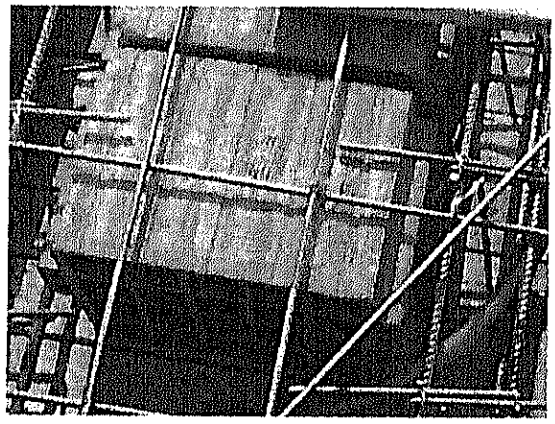


Figure AP4-1.12 Hollow Red Brick

(© Yoshitake Ishii)

Picture below is a typical outlook of detached house during construction. As the picture indicates, use of sandwiched concrete blocks has two problems concerning insulation performance.

A. Insulation is not complete or continuous, because considerable area of concrete wall directly face outside and has no insulation.

B. Use of sandwiched block cannot be examined from outlook. There is a possibility that usual blocks with no insulation material are used even if contractor claims proper use.

Figure AP4-1.13 House Construction Site

(© Yoshitake Ishii)

Also above picture suggests that complicated or irregular shape of house, which is often favored in KSA makes insulation as continuous layer of building very difficult or imperfect.

Picture below shows how hollow bricks are cast in a concrete slab. Although some people believe these bricks act as thermal insulators, effect is very little or none, since brick layer is not continuous. They may be actually acting as thermal storage, not conducting heat instantly, but emitting gradually during nighttime.

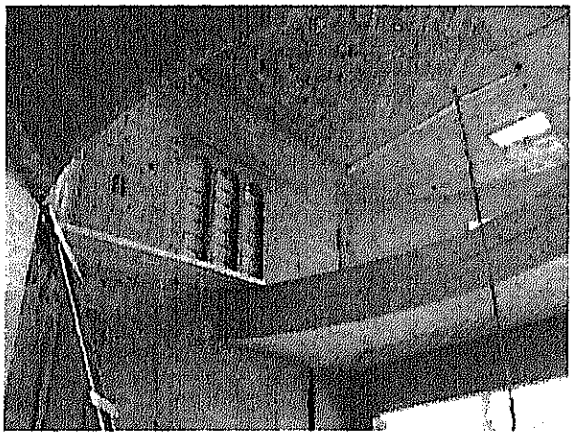


Figure AP4-1.14 Bricks used in a Slab

(© Yoshitake Ishii)

iii) Finishing

Exterior and interior wall/ceiling finishing is done usually by plastering. Stones and ceramic tiles are also used. Interior floor is covered with carpets, stones or ceramic tiles.

(4) Lifestyle and House Composition

According to our survey (APPENDIX 1), detached houses in KSA are very large. Average total floor area is above 1,000m^2. Median is 650 m^2. Site area and family members are also large. In this project, 800m^2 floor area in 800m^2 site is supposed for a model house.

High walls usually surround a house site for privacy. Garden between walls and house is vegetated with

trees, but maintenance of vegetation requires water (thus energy) and environmental contribution of scarce vegetation is limited.

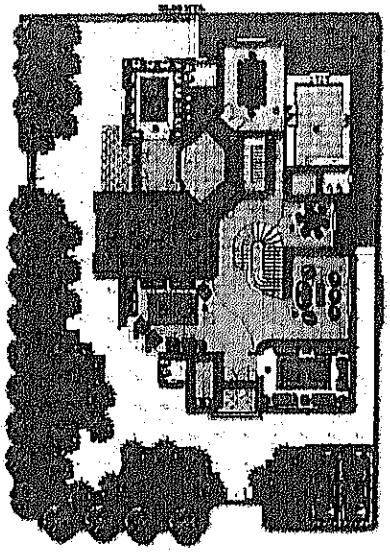


Figure AP4-1.15 Typical House with 800m^2 Floor area and 800m^2 Site Area

Interior space is composed following Islamic tradition and practice. Most significant character is clear separation between social (male) zone and family (family and female) zone. Each zone has own entrance (often gates on street are also separate).

Social zone contains majilis (meeting room) and dining room. Kitchen is placed next to dining room. Family zone contains women's majilis and rooms for family use. Bedrooms (large and many) are placed upstairs and accessed from family area. They are often equipped with own bathrooms or kitchenettes. Figures below show composition of typical ground and 1st floor level.

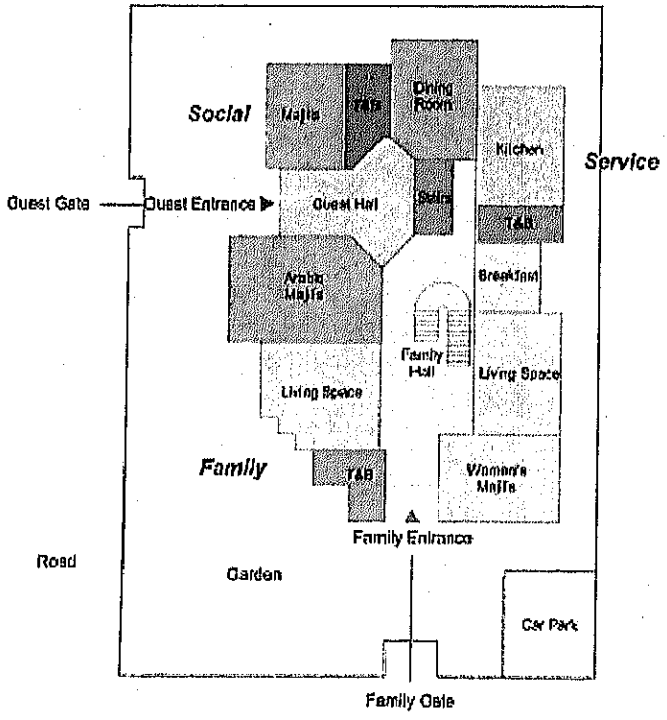


Figure AP4-1.16 Ground Floor Plan

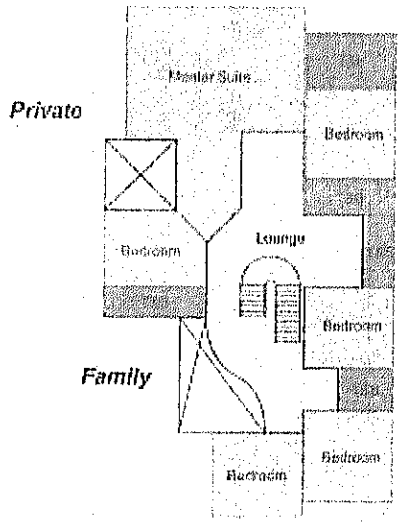


Figure AP4-1.17 Ground Floor Plan

In this composition, family zone acts as "heart of a house" connecting different zones with most activity. It means family zone is the primary area of energy consumption in a house. When we look at its placement, size and shape, issues concerning energy conservation can be realized;

A. Family zone has limited area of windows for natural light. It consumes lighting electricity.

B. It has large volume connecting many rooms. Air conditioning of entire space consumes large energy.

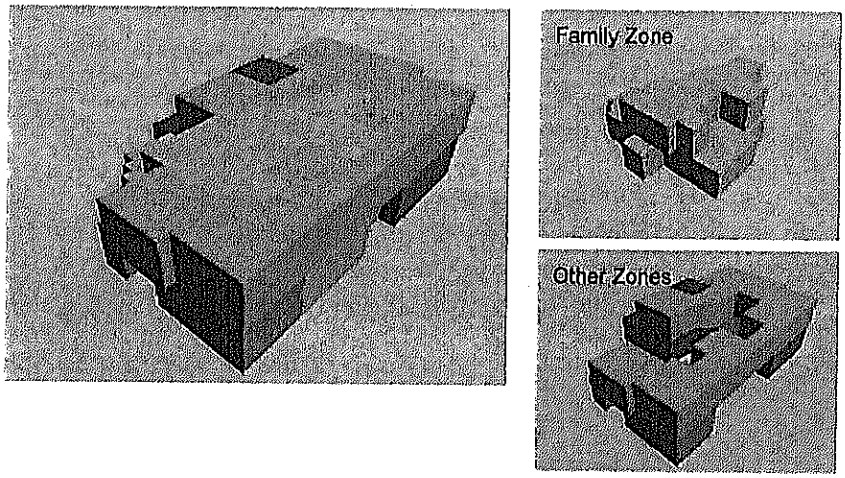


Figure AP4-1.18 Family Zone and Other Zones of a House

Our electricity use measurement study (APPENDIX 2.4) showed that nighttime use even after sleep is large in a residence. This should come from use of ACs in bedrooms. Room temperature probably continues to be high, by the emission of heat stored in building during daytime.

1.3 Model House Proposal

(1) Issues and Proposals

Through the study, major issues to be tackled as below, were clarified in designing energy conservation model house in Riyadh.

1. High outside temperature
2. Large direct solar heat gain especially on the roof
3. Incomplete insulation caused by building material and irregular house shape
4. Dark central family zone that requires lighting and AC energy
5. Large AC energy consumption in bedrooms
6. Garden with little contribution for residential environment

Table below shows proposal measures corresponding to these important issues.

Table AP4-1.2 Major Issues and Proposals for Model House Design

	Issues	Proposal
1.	High outside temperature	Insulation with air space and extruded polystyrene
2.	Large direct solar heat gain especially on the roof	3 stories house with less roof area Louvers above roof
3.	Incomplete insulation caused by building material and irregular house shape	Insulation cast with concrete Simple house form
4.	Dark central family zone that requires lighting and AC energy	'Light Well' with natural light Separable family zone
5.	Large AC energy consumption in bedrooms	Inside + Outside insulation for bedrooms
6.	Garden with little contribution for residential environment	'Common Green Passage' with dense trees

(2) Model House Structure

Model house proposes use of cast-at-site concrete not only for structural frame, but also for exterior walls. One reason is structural reliability compared to blocks with no steal reinforcement. The other and EC related reason is, casting of wall concrete together with building frames enables outside insulation layer coherent to structural walls.

In Japanese concrete houses, insulation material (usually extruded polystyrene) is often placed along outside formworks when casting concrete (Figure 2-1.19). Coherence of insulation material and building frame ensures high insulation performance.

Outside insulation protects building frame from storing thermal energy (heat). Thus building will emit little heat towards interior, if insulation layer is completed properly.

Another advantage of this method is visibility of insulation in construction. House owner or construction supervisor can easily inspect if insulation is properly installed.

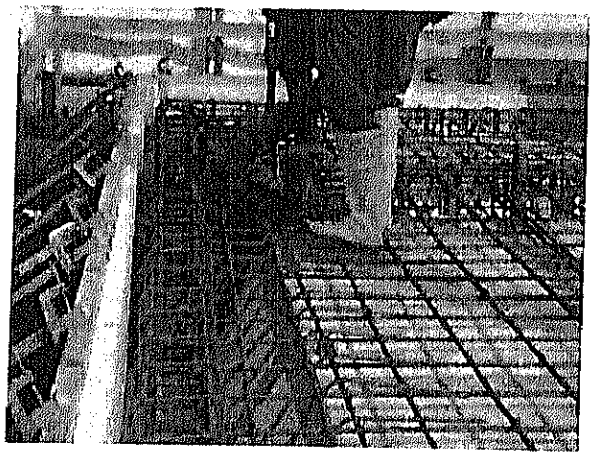


Figure AP4-1.19 Casting of Concrete with Insulation in Japan

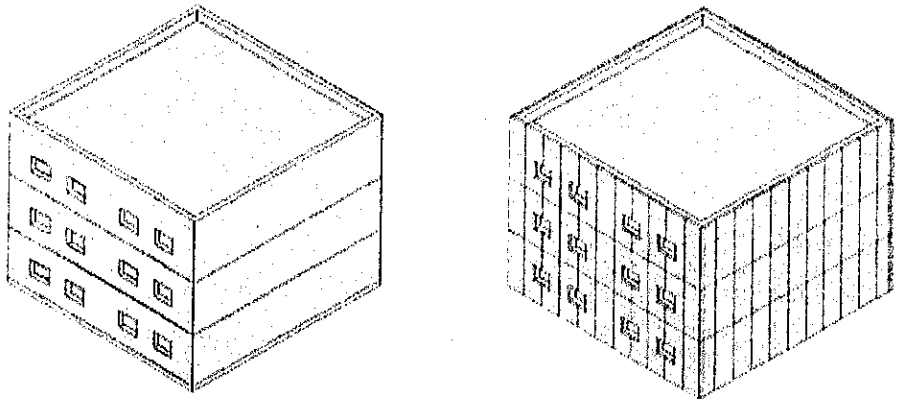


Figure AP4-1.20 Model House Structure 1 – Cast Concrete Walls and Insulation

Insulated building envelope is covered with outer wall with air space in between. This outer wall needs to be strong and can be made with concrete blocks. Or lighter extruded cement panel, which is easier for installation with less thermal conductivity (0.44 W/mK) than concrete blocks (0.53W/mk), is a possibility (Figure AP4-1.21). Presently it is not a common product in KSA as building material, but necessary resources are available domestically for production.

Exterior finishing can be made in whatever way on these outer walls.

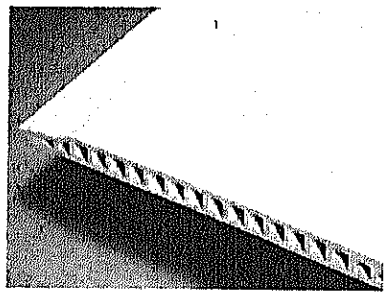


Figure AP4-1.21 Extruded Cement Panel

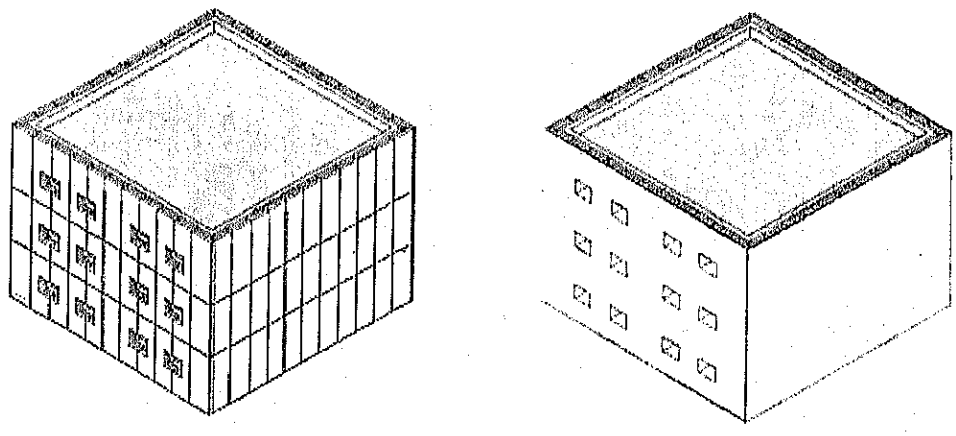


Figure AP4-1.22 Model House Structure 2 – Outer Wall and Finishing

(3) Model House Composition

For restricting heat gain from direct sun radiation and ensure compete insulation, model house is designed in 3 stories, square simple form.

At the center connecting 3 floors is 'Light Well' which brings bounced (thus with less heat) natural light into interior of the house (Figure AP4-1.23).

3 floors are attributed to;

A. Ground floor for social and service zone

B. 1st floor for family zone

C. 2nd floor for private zone (bedrooms).

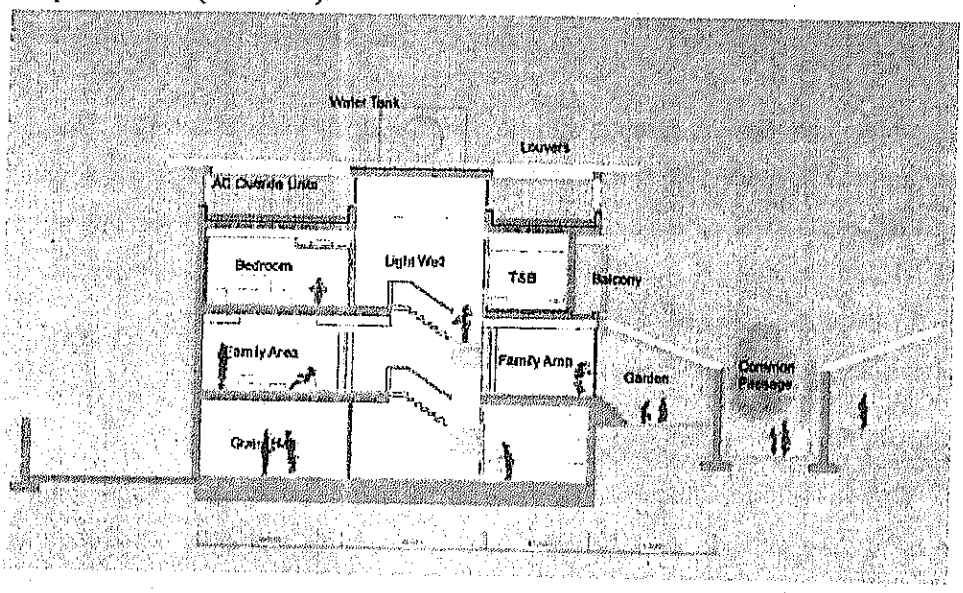
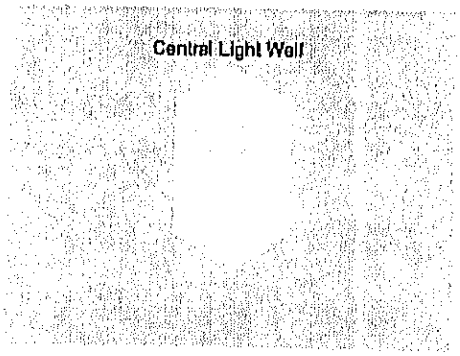
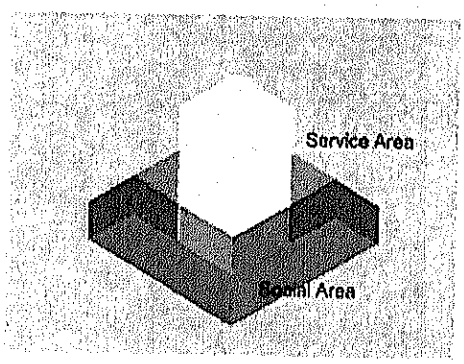
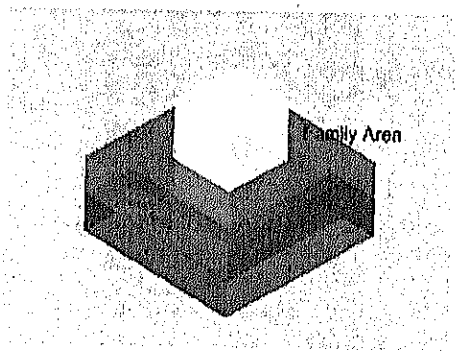


Figure AP4.1-23 Model House Section







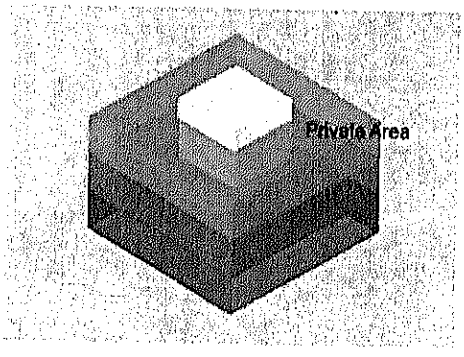


Figure AP4.1-24 Model House Composition

Family area on the 1st floor is approached from outside stairs. Family garden is also placed on 1st floor level at backside of the house. This upgrading requires landfill and excavated soil for foundation is used for this purpose. Re-use of excavated soil at site contributes to reduction of total energy consumption for construction.

As a result, ground floor rooms are placed as half underground. This also contributes to AC energy use reduction, since building envelope area exposing to outside air reduces.

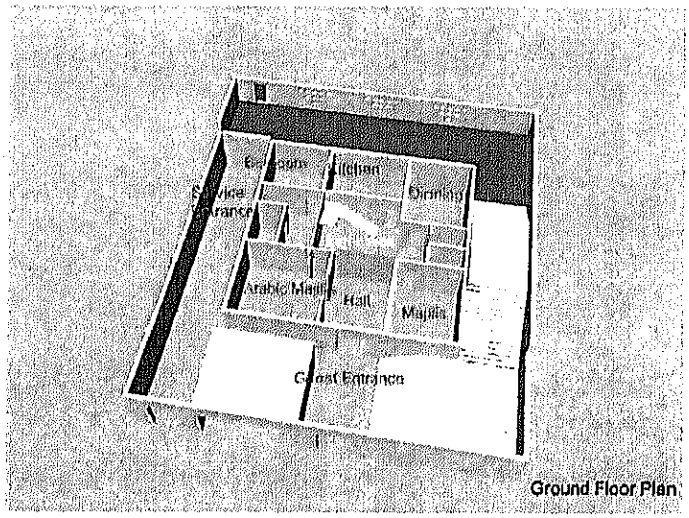


Figure AP4-1.25 Ground Floor Plan

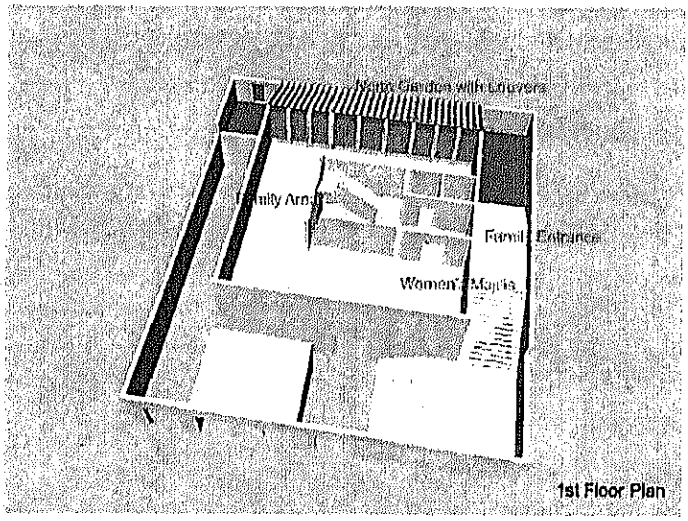


Figure AP4-1.26 1st Floor Plan

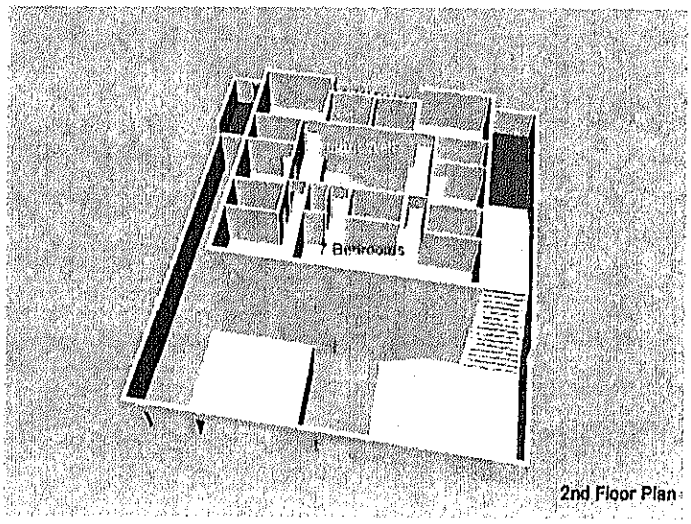


Figure AP4-1.27 2nd Floor Plan

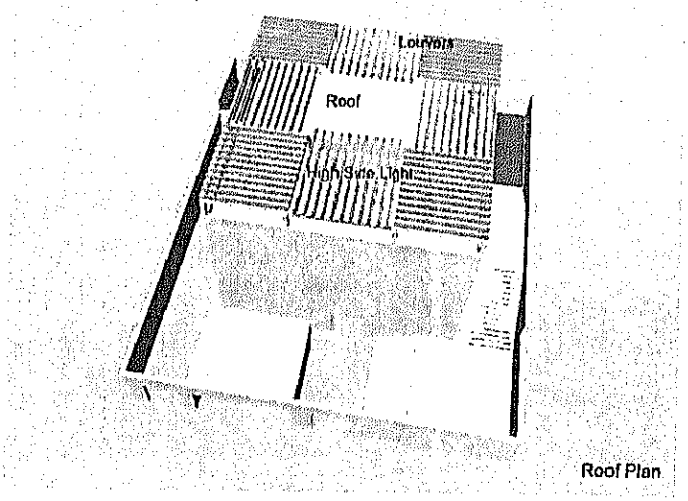


Figure AP4-1.28 Roof Plan

(4) Model House Detail – Insulation

1) Wall

Airspace between outer covering and insulation layer permits heated air to naturally ventilate and reduces heat load on walls (thus interior).

Extruded polystyrene board (XPS) has lower thermal conductivity (0.025W/mK) and more compressive strength (35N/cm^2), compared to expanded polystyrene board (EPS, 0.035-0.04W/mK, 15-30N/cm^2). Although XPS is not common in present KSA construction market, raw material is available domestically.

If extruded cement panels are used for covering, total thickness of the wall including finishing is approximately 40cm.

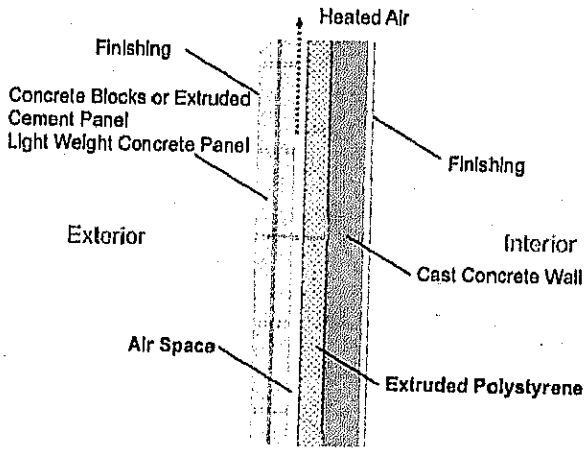


Figure AP4-1.29 Wall Detail

2) Roof

In order to reduce direct radiation of the sun, louvers are placed over the roof. Shadows made by louvers also give more preferable operation conditions for AC outside units. Outer insulation layer is over waterproof membrane. In addition, bedrooms are equipped with inner insulation.

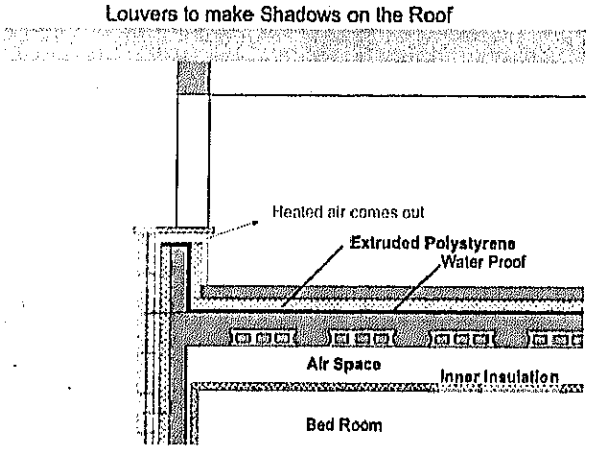


Figure AP4-1.30 Roof Detail

3) Windows

Double pane low-emittance glass is supposed for all windows of the model house. Window area is limited in each room except living room that faces private garden and has large window area on this side.

In the model house, windows for each private room are designed as plural small opening, rather than single one. The reason for this design is;

A. Plural small windows let less sun radiation inside than single window with same area, because window perimeter makes shadow area.

B. They protect privacy more effectively.

C. In each room users can enjoy change and reflection of lights created by many windows.

Drawings below show exterior images of the model house. Louvers are also intended to give changing arabesque geometric patterns on walls.

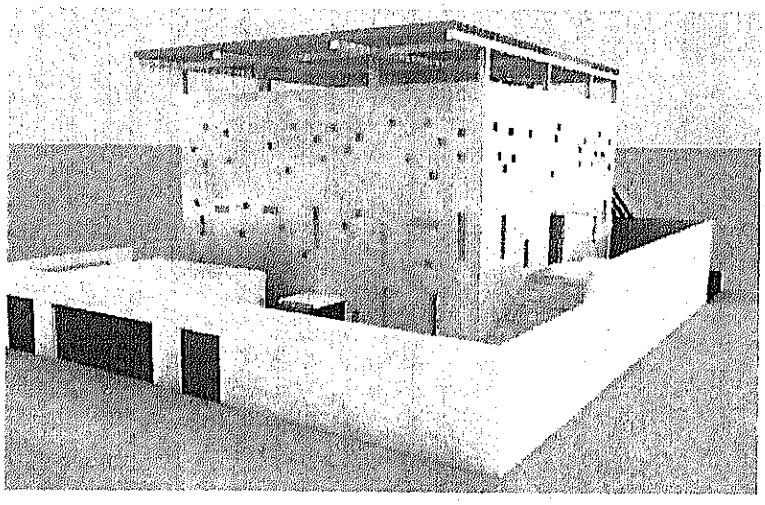


Figure AP4-1.31
Exterior Image -1

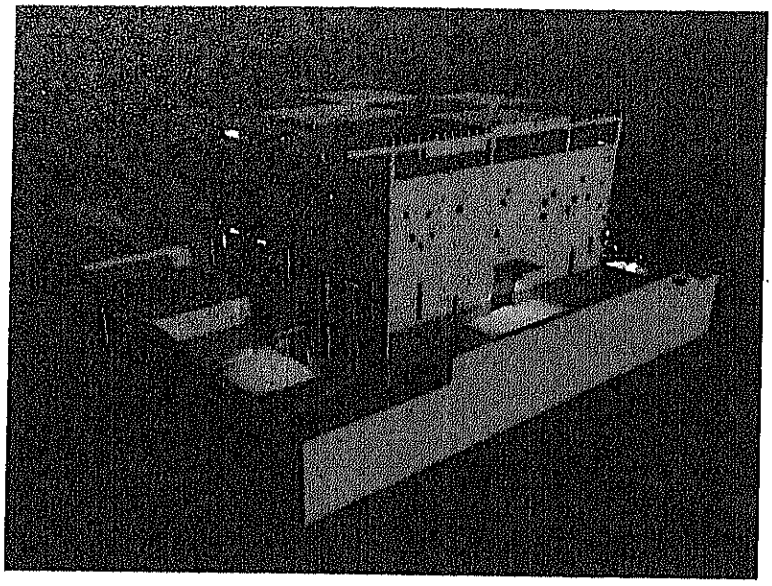


Figure AP4-1.32

Exterior Image -2

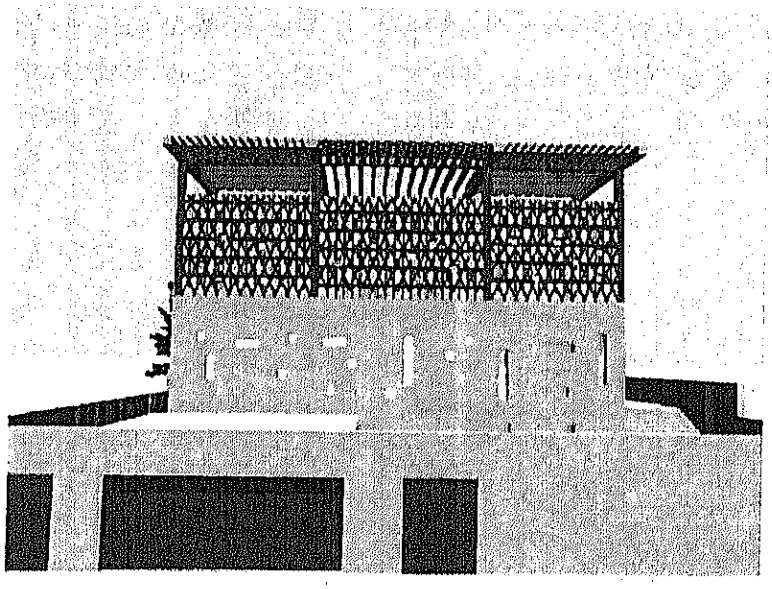


Figure AP4-1.33

Exterior Image -3

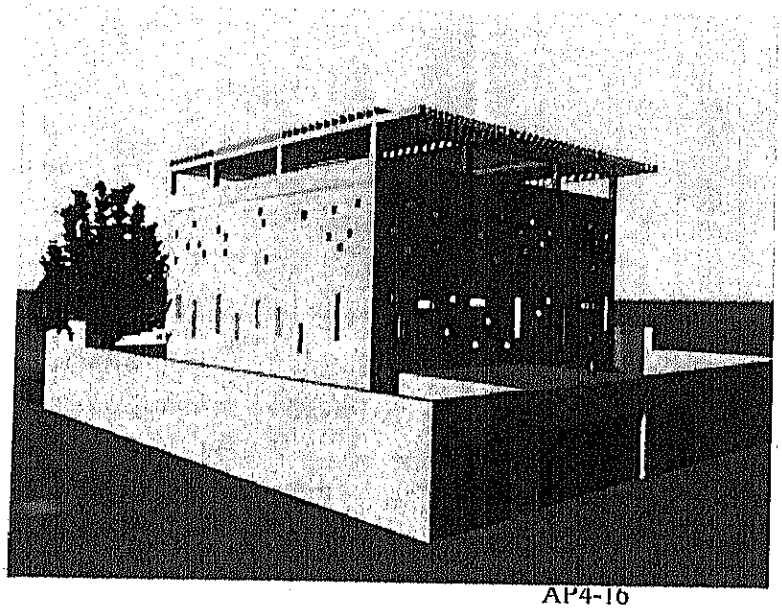


Figure AP4-1.34

Exterior Image -4

(4) Environmental Contribution to Neighboring Area

In summertime Riyadh, daytime temperature is so high that staying outside can be harmful especially for children and elders. Towards evening, families gather in central gardens to enjoy cooler temperature. On the other hand, it is difficult to find public outdoor area with families or people taking walks in residential districts.

In this respect, Jeddah is different from Riyadh, although having similar temperature, with regional parks used by neighbors. Jeddah's humidity and closeness to the sea probably are more favorable for plants' growth and human outdoor activities.

Still, lack of accessible outdoor area in residential districts can lead to not direct but serious problem concerning energy conservation in Riyadh, which is fomenting in dependence on motor movements.

Model house design proposes one possibility of tackling this problem. Trees are gathered on backside of the house. If same site design is adopted to aligning neighbor houses, district will possess continuous green belt placed like a valley between rows of houses. Concentrated green can result more comfort, microclimate, than scattered one.

If residential block is designed in such a manner, 'common green passage' for pedestrian walk is possible as shown in below drawing. Recycle use of water for plants will become more effective in such a residential block.

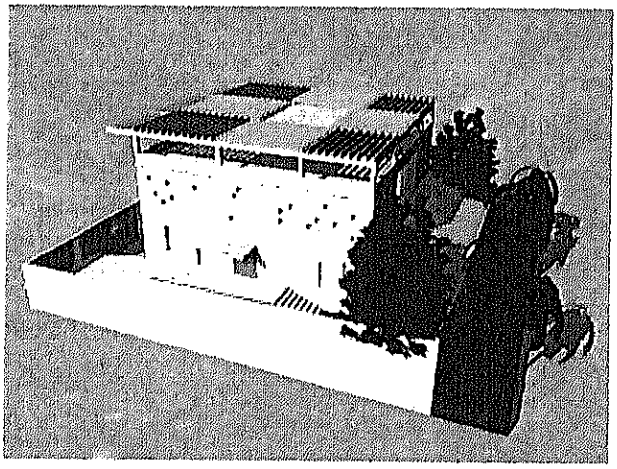


Figure AP4-1.35 Trees Behind House

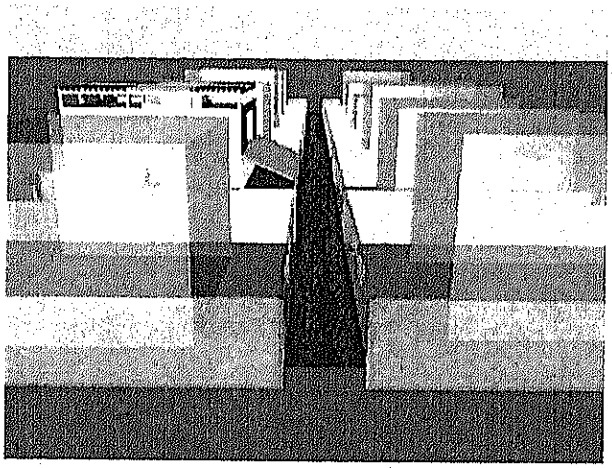


Figure AP4-1.36 Common Green Passage

1.4 Energy Efficiency Simulation

Computational simulations of the model house were carried out at Kato–Ooka Laboratory, Institute of Industrial Science (I.I.S.), University of Tokyo.

(1) AC Load Simulation

1) Analysis Outline

AC Load Simulation is calculation of air conditioning load of model house and comparing cases, in their peak and throughout a year. This calculation leads to estimation of required AC capacity and electricity energy to maintain used rooms in certain temperature condition.

A. Analysis Tool

Two simulation programs, TRNSYS and COMIS are used in coupling manner for calculation. Below diagram illustrates flow of calculation.

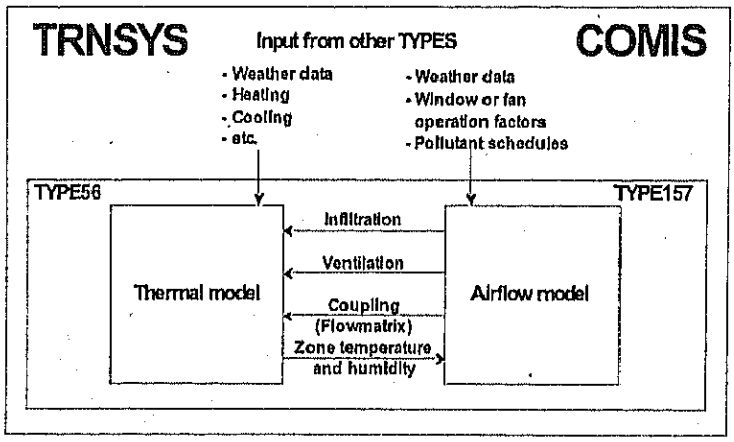


Figure AP4-1.37 Coupling of TRNSYS and COMIS

B. Simulated Cases

Three cases were simulated and compared. Below table shows conditions of each case. Note that simulations were made supposing the same plan/section condition.

Table AP4-1.3 Three Simulated Cases

	Insulation	Window	Ventilation	Roof Louver
Case 0	No Insulation	Single Common Glass	No Heat Exchange	No
Case 1	Conventional Insulation[2]	Single Common Glass	No Heat Exchange	No
Case 2	Proposed Insulation	Double Low-E Glass	With Heat Exchange[3]	Roof Lover

[2] 1 Conventional Insulation means use of sandwiched concrete blocks.
[3] Case 3 is equipped with heat exchanger, which transfers heat between exhausting and intake air.

C. Analysis Condition

C-1 Simplification for Modeling

Following simplification of 3D model house data were made, in order to enable smooth calculation.

1. Floor plans were simplified, for example non air-conditioned rooms were omitted from modeling.
2. Multiple small windows on one wall of a room were treated as one window of summed area.
3. Leaking of air to outside was not considered.
4. Two living spaces were treated as one space.
5. Glass wall between light-well and living space was omitted.

C-2 Cooling/Heating, Ventilation Condition

The models were simulated in such a way that ACs run to keep used rooms' temperature between 22°C and 24°C degrees. Humidity control was not taken into account.

Mechanical ventilation operated to exchange half of room volume in one hour.

C-3 Room Use

Each room use schedule and occupancy were input as below figures.

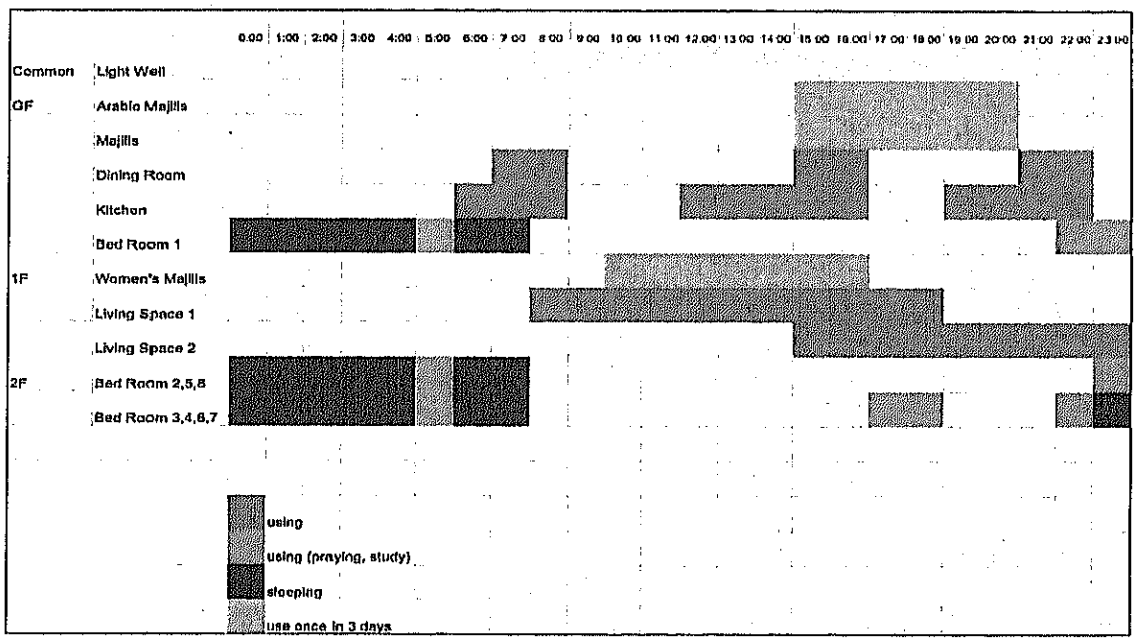


Figure AP4-1.38 Room Use Schedule

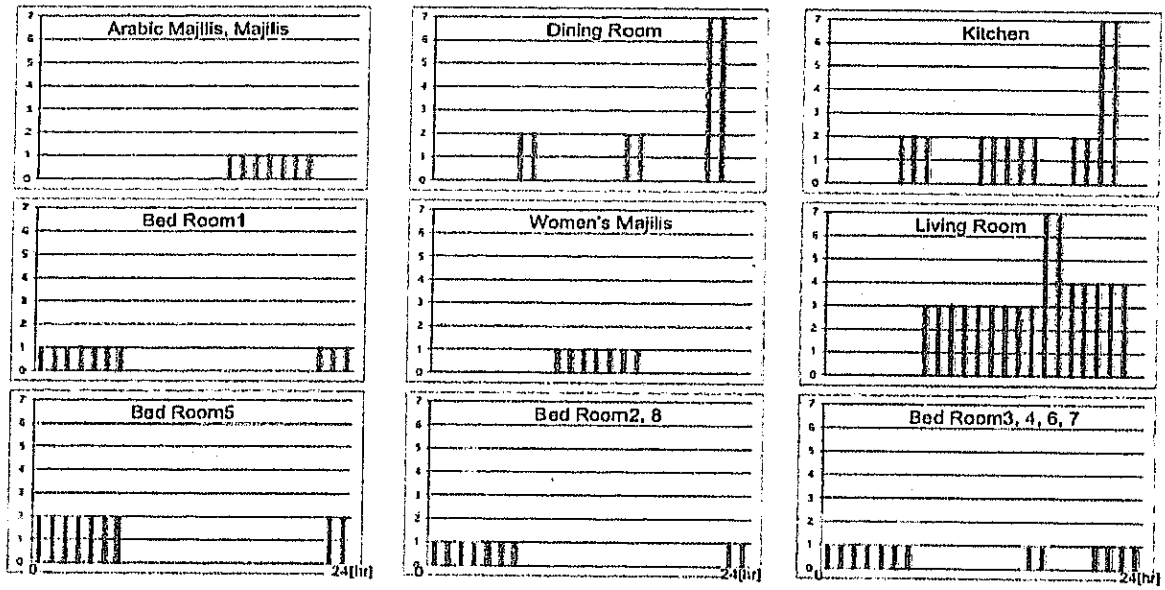


Figure AP4-1.39 Occupancy of Each Room

C-4 Interior Heat Emission

Heat emission from appliances, as well as human bodies, was taken into consideration. Figure below shows schedule of this emission (W).

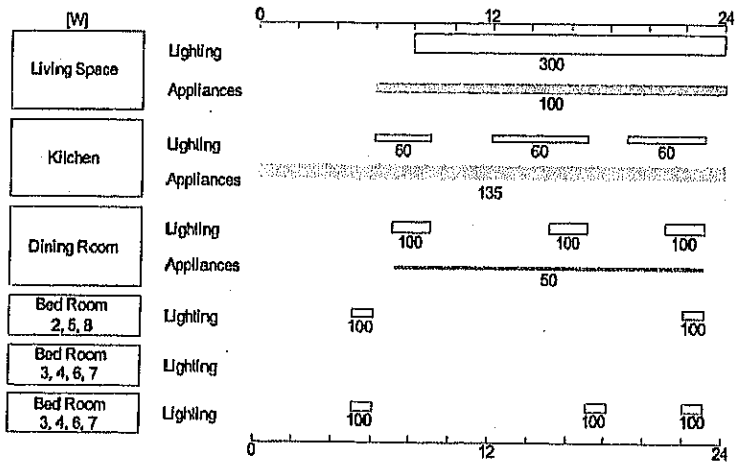


Figure AP4-1.40 Heat Emission from Electrical Appliances

C-5 Simulation Example

Two graphs below illustrate how simulation runs.

Figure AP4-1.41 is cooling load change in the living room on July 28th (hottest day). As the room starts to be used, AC also starts to operate and keeps the room temperature below 24°C degrees.

Whereas in Figure AP4-1.42, which is the same graph for bedroom 5, AC runs while the room is used for sleeping.

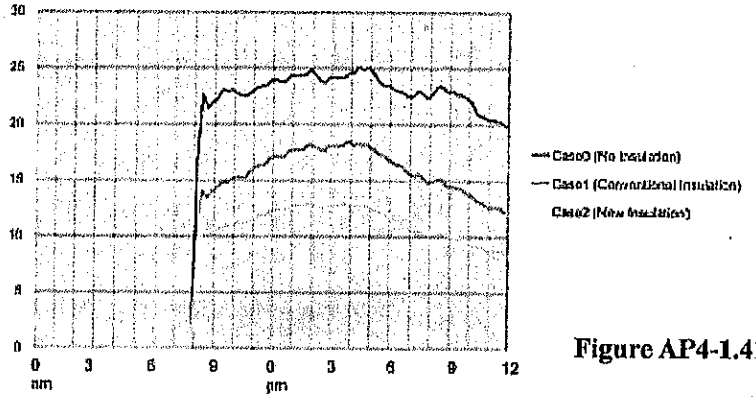


Figure AP4-1.41 Cooling Load in Living Room on July 28th

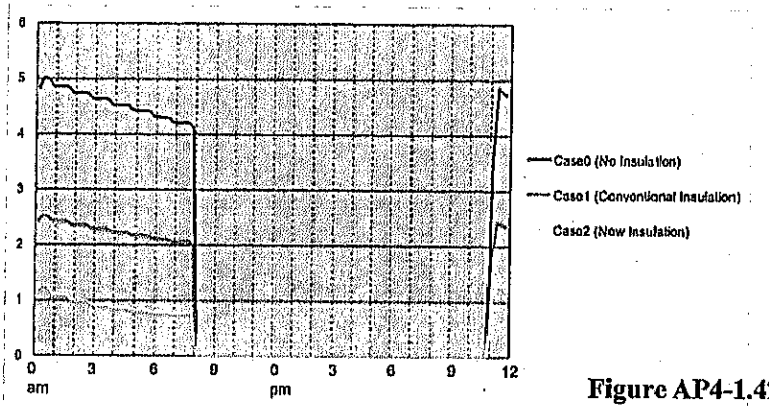


Figure AP4-1.42 Cooling Load in Bedroom 5 on July 28th

2) Simulation Result

Graph below shows peak cooling load in a year, which is in the afternoon of July 28th, in all living spaces. Each peak load decides necessary AC cooling capacity for each room. Better insulation (Case 1 and 2) reduces installing AC capacities. This leads not only to lower initial cost of ACs, but also to more energy efficient operation of ACs with power closer to rating power.

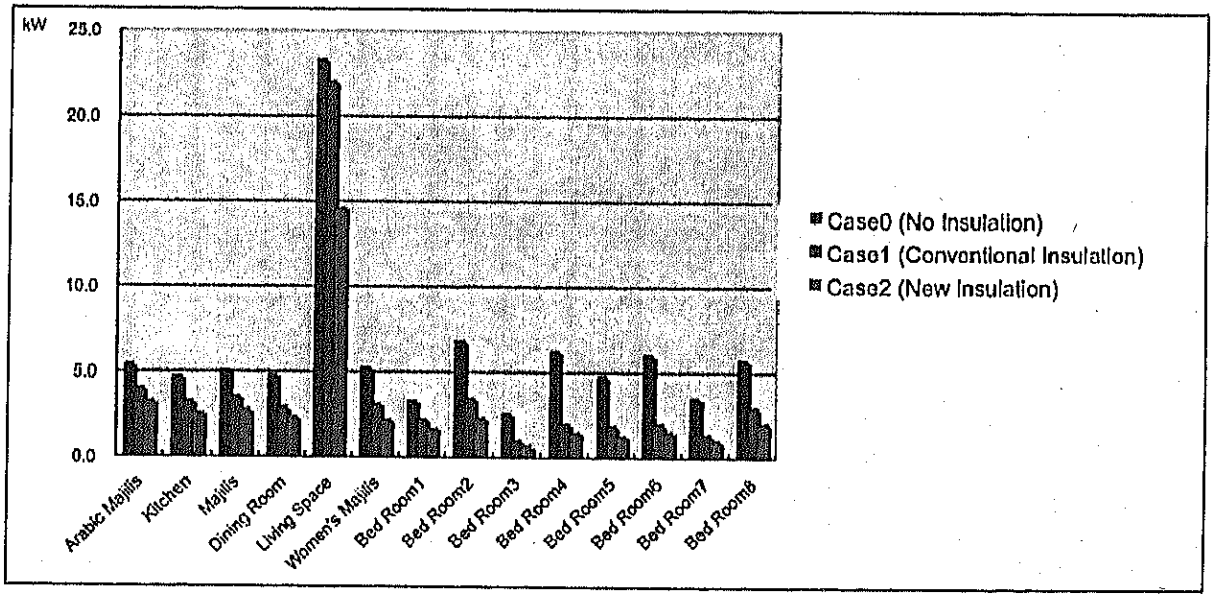


Figure AP4-1.43 Peak Cooling Load [kW] in Each Room on July 28th

Next graph shows annual cooling load required to keep set room temperature for each room. Case 1 and 2 can reduce annual load in every room, compared to Case 0. Their effects are large in 2nd floor bedrooms. In other words, bedrooms suffer largely from bad air condition if insulation is not properly installed.

Case 2's effect is prominent in the living room. Contribution of double pane low-E glass should be the major reason, because the living room has large window area. Including Case 2, living room heat load is far greater than other rooms. Room size, intensive use and adjacency to outside should be the causes.

Considering frequent use and heat emission, annual kitchen heat load is not so large. This is possibly because the kitchen is placed half underground.

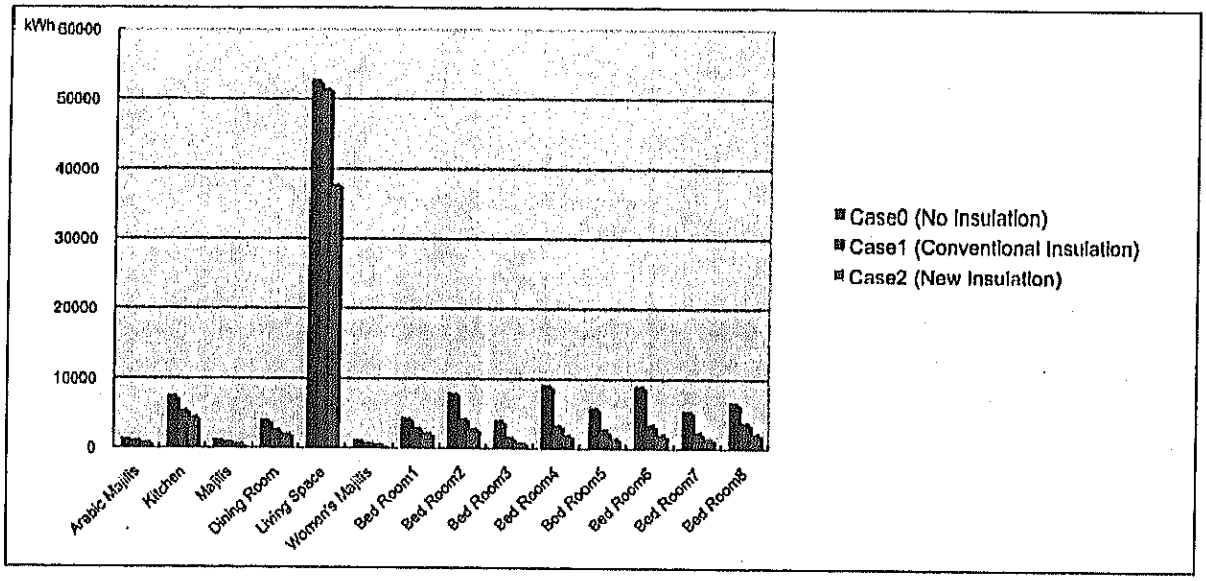


Figure AP4-1.44 Total Annual Cooling Load [kWh] for Each Room

Next graph shows change of monthly cooling load in whole house. Because simulation runs mechanically, Case 1 and 2 experiences cooling load in winter to counter interior heat emission.

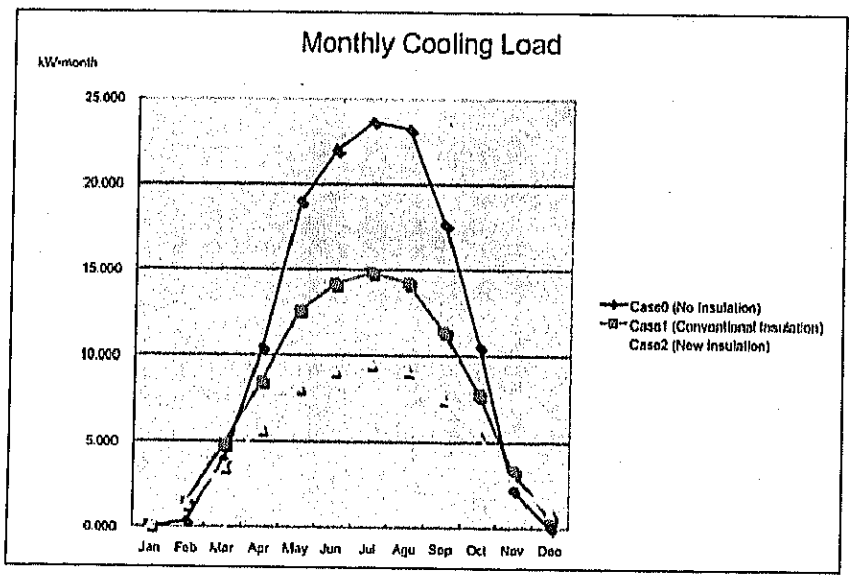


Figure AP4-1.45 Monthly Cooling Load [kWmonth] for All House

Two graphs below show peak and annual load for heating. Effects of Case 1 and 2 are large, but the scale is different from cooling.

Noteworthy result is Case 2 requires almost 0 energy for heating.

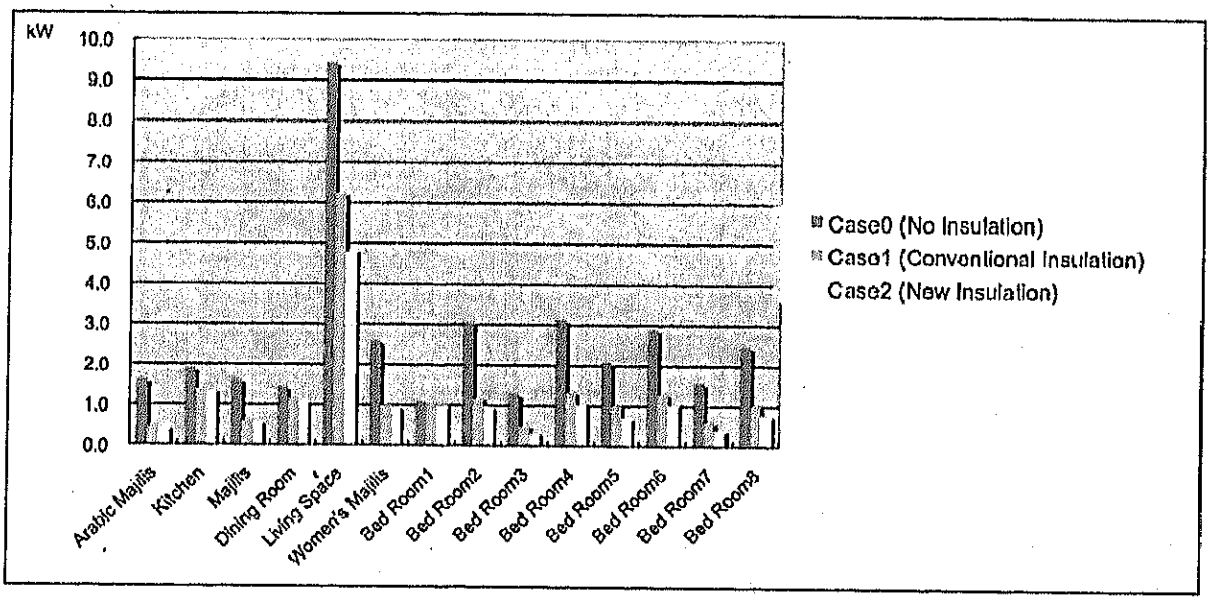


Figure AP4-1.46 Peak Heating Load [kW] in Each Room on January 17th

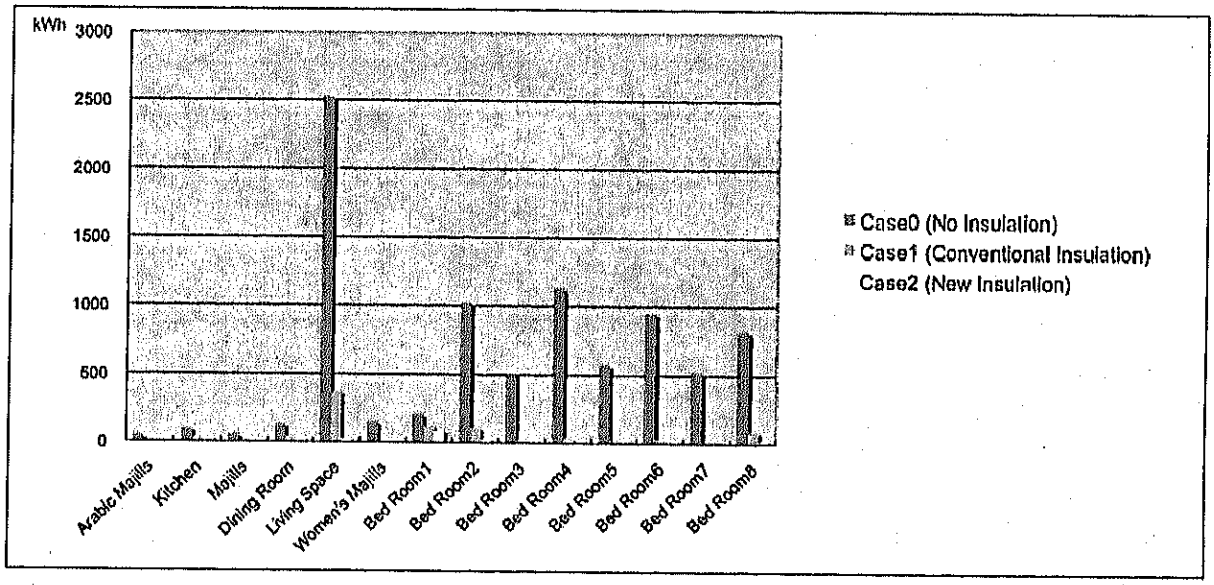


Figure AP4-1.47 Total Annual Heating Load [kWh] for Each Room

Table below shows annual air conditioning load and calculated electricity use and cost for countering load in each case. Since ACs operate with heat-pump mechanism, required electricity is less than the load. In this calculation, COP (coefficient of performance) is supposed as 2 (=6.826 in EER). Cost of electricity is set as 15 halala/kWh.

Compared to Case 0, Case 2 (model house) AC load (electricity use) is less than half. It is 72% of case 1. Although Case 2 shows EC advantage to case 0 and 1, it is important to note here that the simulation was made for the same plan/section condition. Also for Case 1, sandwiched block insulation was supposed to cover fully and continuous for the sake of modeling, which is not the case in conventional construction.

Table AP4-1.4 Annual AC, Electricity Use and AC Cost in Three Cases -1

	Case 0	Case 1	Case 2
Annual Cooling Load [kWh]	120,893	87,342	63,481
Annual Heating Load [kWh]	8,698	922	260
Annual AC Load [kWh]	129,591	88,264	63,741
Electricity Use for AC [kWh]	64,796	44,132	31,871
Cost for AC [SR]	9,719	6,620	4,781

Next table is a rough but not too favoring amendment considering these points.

Case 0' is supposed to be 2 stories house with the same total floor area. Case 1' is the same building as Case 2, but incompleteness of insulation is taken into consideration.

Table AP4-1.5 Annual AC, Electricity Use and AC Cost in Three Cases -2

	Case 0'	Case 1'	Case 2
Annual AC Load [kWh]	162,000	109,000	63,741
Electricity Use for AC [kWh]	81,000	54,500	31,871
Cost for AC [SR]	12,150	8,175	4,781

This table suggests that model house consumes 40% of AC energy compared to conventional house with no insulation. It consumes 60% compared to house with good insulation in market.

At the same time it is important to remember even model house AC energy use is very large. Electricity tariff in KSA is almost 1/5 of Japan. If it were in Japan, model house need to pay 662 thousand yen per year for air conditioning.

3) Comfort in Bedrooms

Room air temperature is not equal to human sensible temperature. Humidity, air movement and radiation are other related elements. In a summer room, if temperature of walls, windows or ceiling is high, radiation brings discomfort for occupants.

Graph below shows change of ceiling temperature on July 28th in bedroom 5. In Case 0, ceiling temperature stays at 32 - 33°C through the day. This will lead to excessive setting/use of AC even if air temperature is kept at 24°C during occupancy. Whereas in Case 2, ceiling temperature stays at 25 - 27°C through the day.

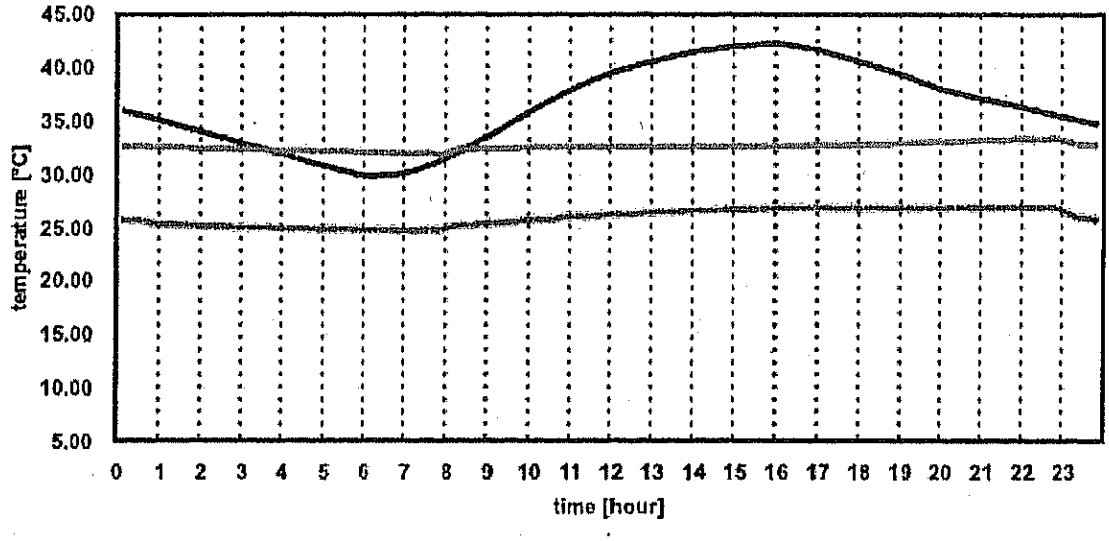


Figure AP4-1.48 Ceiling Temperature of Bedroom 5 on July 28th

Next graph shows same room's ceiling temperature change through one year. Model house bedroom ceiling is kept at steady temperature and gives more comfort, because of careful roof insulation.

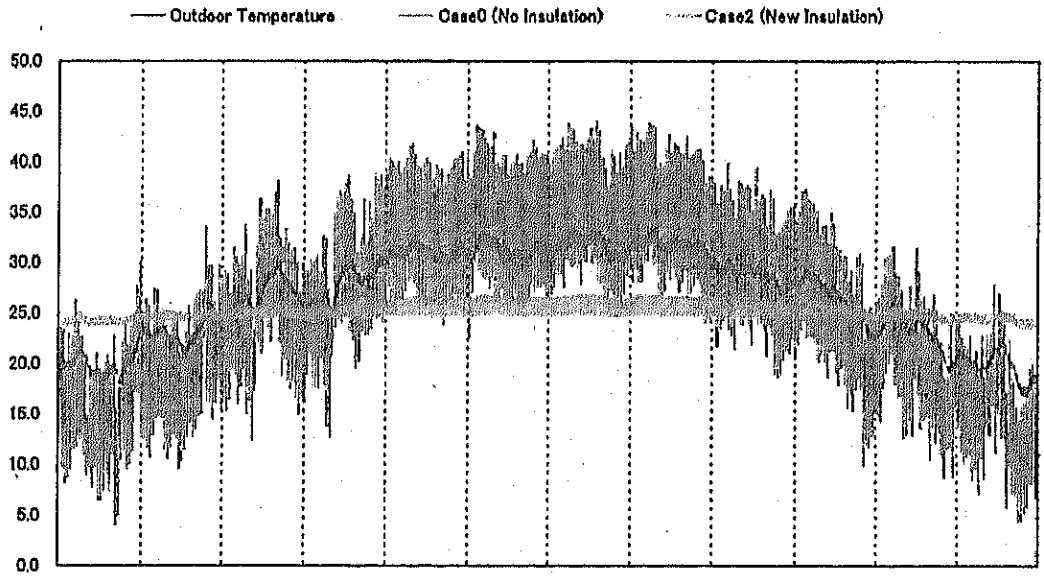


Figure AP4-1.49 Ceiling Temperature of Bedroom 5 over One Year

(2) Computational Fluid Dynamics Simulation

1) Analysis Outline

In order to visualize temperature condition for different cases, CFD (computational fluid dynamics) simulation was conducted. Below diagram and table illustrate calculation flow and condition of this simulation.

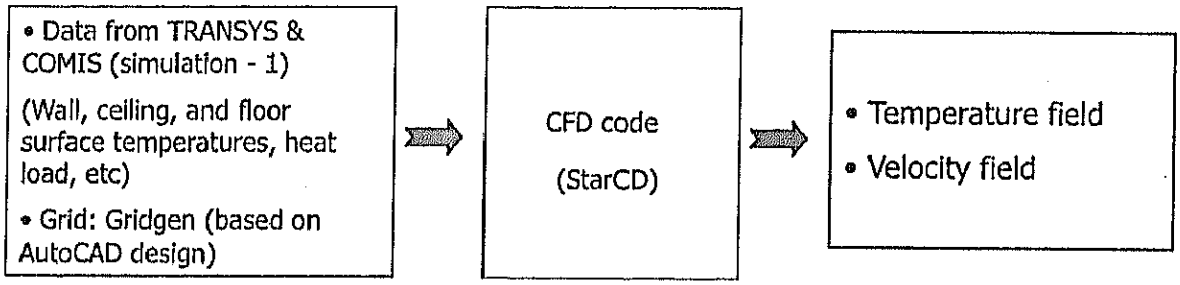


Figure AP4-1.50 Calculation Flow of CFD Simulation

Table AP4-1.6 Calculation Condition Detail of CFD Simulation

CFD Model	K-epsilon / high Reynolds number
Algorithm	SIMPLE
Grid arrangement	Unstructured Non-staggered (415,775 tetrahedral cells)
Momentum and transport equation	Upwind differencing scheme
Turbulent intensity at inlet boundaries	0.1%
Turbulent length scale at inlet boundaries	0.1 m

Figures below show allocation of AC units and outlet direction input in the simulation.

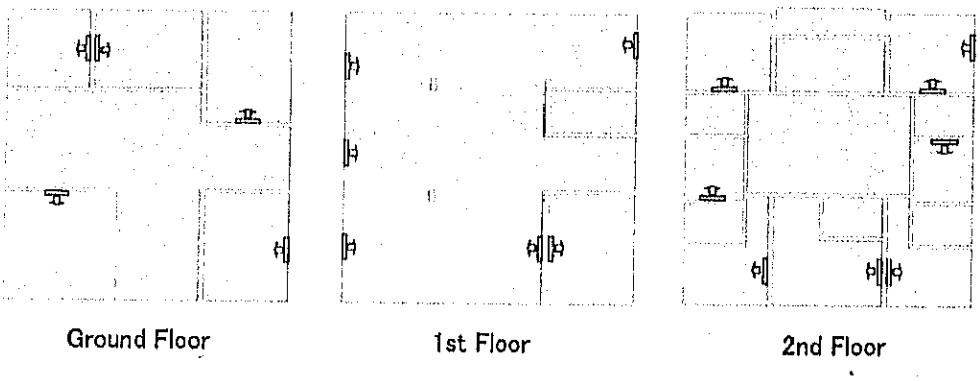


Figure AP4-1.51 Allocation of AC Units

2) Simulation Result

Figure below is visualization of interior temperature at 5pm on July 28th (sectional drawing). At this time bedrooms on top floor are not used and ACs are stopping. In Case 0, bedroom temperature exceeds 30°C degrees. In Case 2, it is 26 to 28°C.

High room temperature in absence can be experienced when room starts to be used. This discomfort easily leads to continuous operation of ACs even while absence, which is a common practice in KSA.

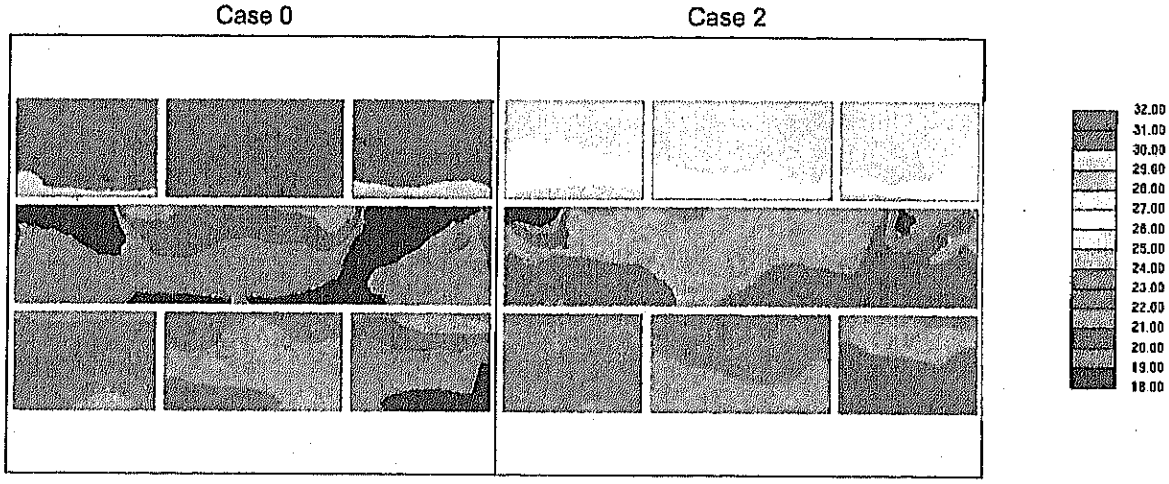


Figure AP4-1.52 Sectional Temperature Field in Summer

Next figure shows horizontal temperature field of 1st floor (living room). Case 0's dark blue area is below 19°C degrees. This means in houses with no/bad insulation, some area of rooms become excessively cold (or warm) and waste energy for air conditioning.

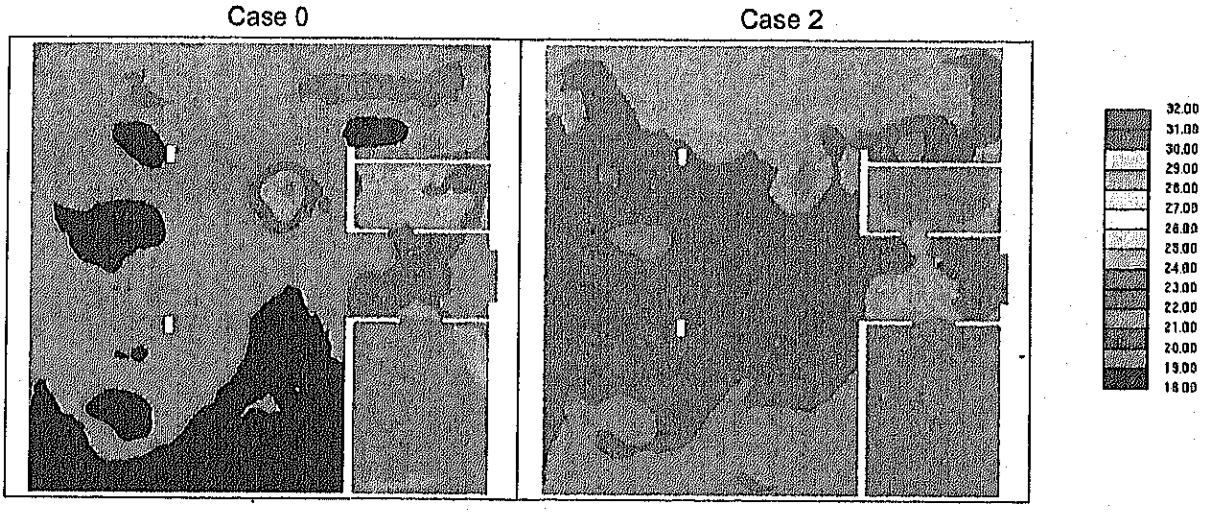


Figure AP4-1.53 Horizontal Temperature Field (1st Floor) in Summer