## Program

| | |
|---|---|
| 0900 | Registration |
| 0930 | Welcome by A/Prof Lee Siew Eang<br>Head, Energy Sustainability Unit |
| 0945 | Introduction of Project 64 & 68 by Mr. Kristian Eriksen, PMU, EAEF-EU Project |
| 1000 | Seminar Paper 1: From International Approach to ASEAN Targets - The Development of a Business Model for Building Energy Performance Services: Dr Mervi Himanen ( VTT Finland ) |
| 1030 | Tea Break |
| 1100 | Seminar Paper 2: Development of Public Sector Energy Performance Contracting: Mr Tan Kok Kwang ( National Environment Agency ) |
| 1130 | Seminar Paper 3: Development of Measurement & Verification Guidelines for Singapore: Ms Li Shuo ( ESU ) |
| 1200 | Seminar Paper 4 : Energy Performance Contracting – An ESCO's perspective: Mr Richard A. Uy ( G-Energy Philippines Inc.) |
| 1230 | Lunch Break |
| 1400 | Seminar Paper 5: Energy Smart Tool - Mr Sun Hansong ( ESU ) |
| 1430 | Seminar Paper 6: Preparing for Energy Smart Office Awards – Experiences from the 8 Energy Smart Offices: Dr Priyadarsini Rajagopalan M. T ( ESU ) |
| 1500 | Seminar Paper 7: Industrial Building Energy Benchmarking :Ms Chia Yen Ling ( ESU ) |
| 1530 | Tea Break |
| 1600 | Tutorial on the use of Energy Smart Tool – Mr Sun Hansong & Ms Chia Yen Ling ( ESU ) |
| 1700 | End of Seminar |

## Objective & Background

***"You cannot manage what you do not measure"***

Jack Welch
Former CEO of General Electric

On 1st Feb 2005, two EU Grants have been awarded by the EC-ASEAN Energy Facility Programme, through the support of the ASEAN Centre for Energy (ACE). A total of €395,212 was awarded and the projects encompass a period of 23 months. These projects are led by ESU of NUS. The project team members include Belgian Building Research Institute (BBRI), the International Network for Information on Ventilation and Energy Performance (INIVE-EEIG), France's Centre Scientifique et Technique du Batiment (CSTB), IEN Consultants from Denmark and the Malaysia Centre for Energy. These two projects are:

- Development of a Business Model for Building Energy Performance Services in the ASEAN Region ( Project No : 64-2003 )
- Development of a Comprehensive Database for Building Energy Performance Benchmarking in the ASEAN Region ( Project No: 68-2003 )

At the seminar, detailed information on both projects will be presented by a panel of researchers and industry players. The seminar hopes to gather valuable feedback from participants especially in the final development of energy performance model and guidelines that will significantly reduce energy services business cost, enhance energy services procurement know-how, and develop professionalism within the energy services sector as a whole for Singapore and the regions.

## Key Speakers

**Dr Mervi Himanen** is a Senior Research Scientist with the National Technical Research Centre of Finland (VTT Finland) . She is currently an Academic Visitor with the Department of Building , School of Design and Environment.

**Mr Tan Kok Kwang** is an Executive Engineer (Energy Conservation) of the Resource Conservation Department, National Environment Agency. His Department spearheads the promotion of energy retrofitting projects among public and private sector buildings as part of the National Economy Drive.

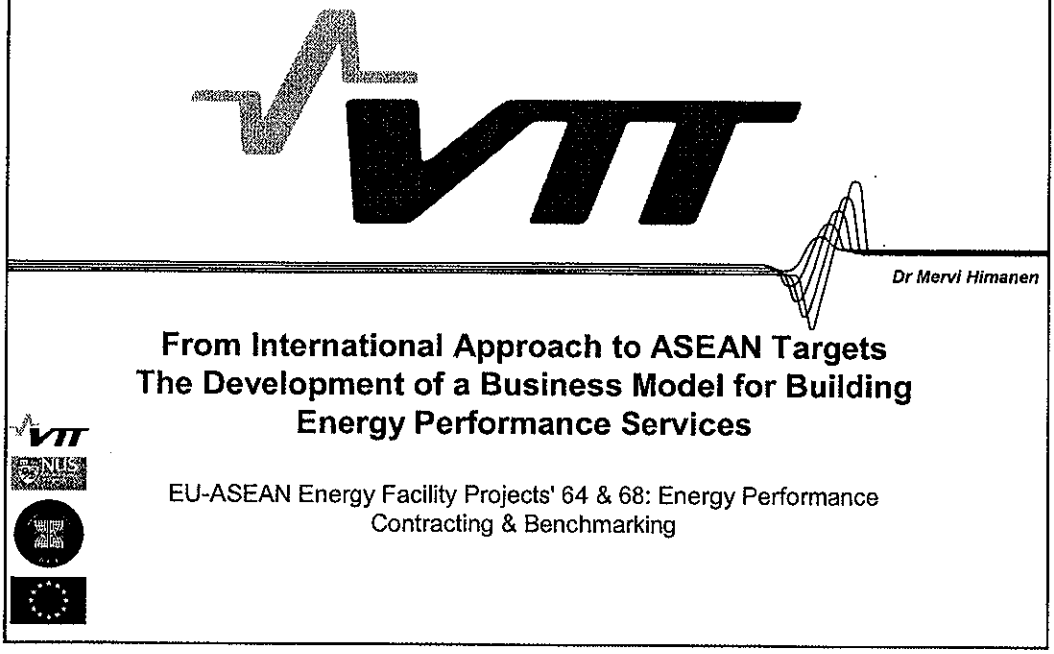
**Ms Li Shuo** is a Research Assistant with the Energy Sustainability Unit who is the Project Leader for Project 64. She received her B.Eng. in HVAC from Beijing Institute of Civil Engineering and Architecture, China in 2000 and MSc in Building Science from the National University of Singapore in 2004.

**Mr Richard A. Uy** is the Director of G-Energy Philippines Inc. His company, a subsidiary of G-Energy Global Singapore, which is a recognized energy consultant firm has been involved in the energy and system performance for clients in Philippines. He has numerous experiences in Performance contracting projects in Philippines and is also the Director of Energy Management Association of Philippines (ENMAP).

**Dr Priyadarsini Rajagopalan** is a Research Fellow with Energy Sustainability Unit who is responsible for the development and implementation of the NEA's Energy Smart Building Labeling Programme. She has recently completed her PhD in Building Science from the Department of Building, National University of Singapore.

**Ms Chia Yen Ling** is a Research Assistant with the Energy Sustainability Unit. Ms Chia is the leading researcher for a JTC (Jurong Town Cooperation) funded project on benchmarking industrial building energy performance. She received her BSc. in Real Estate in 2002 and MSc in Building Science in 2003 both from the National University of Singapore.

**Mr Sun Hansong** is a Research Assistant with the Energy Sustainability Unit who is the Project Leader for Project 68. He received his MSc. in Building Science from the National University of Singapore in 2004 and B.Eng in heating, ventilation and air-conditioning (HVAC), Honors graduate from the Tianjin University, China in 2000.




# Co-operating projects

- The EU funded projects at the National University of Singapore: Development of a Business Model for Building Energy Performance Services in the ASEAN region (EC-ASEAN project 64) and Development of a Comprehensive Database for Building Energy Performance Benchmarking in the ASEAN region (EC-ASEAN project 68) (www.esu.com.sg),
- The EU research project the Eurocontract, European Platform for the promotion of Energy Performance Contracting,
- Future Life-Cycle Building Services, CUBENet (www.sisailmatieto.com/cubenet/) the CUBE Technology Programme of Tekes, the National Technology Agency (http://www.tekes.fi/english/programmes/cube/).
- IEA (International Energy Agency, www.iea.org), Annex 46, Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)

Dr Mervi Himanen

EUROCONTRACT
GUARANTEED ENERGY PERFORMANCE

# Aims of projects

- To provide aggregated current know-how on EPC, Energy Performance Contracting
- To provide key factors for success (experiences of projects implemented, case examples...)
- To build a European Platform on Energy Contracting (build a network for actors and a feedback loop between actors..)
- To build and increase capacity of market actors (transparency, risk minimising, trust..)
- To provide model documents and adapted procedures on EPC (...for different local conditions and legal frameworks..)
- To provide quality guidelines.
- Further developing new approaches in innovative energy services and financing schemes (e.g. linking measures to facility management or leasing applications)
- Prepare for more local implementation of EPC. Only more projects that are implemented under different framework conditions will help to trigger the potential that is possible




*Dr Mervi Himanen*

CUBENet

# Aims of projects



- The CUBENet project is to develop new life-cycle service concepts for building services and automation industry. The aim is to move the focus from technical system oriented building service supply into the service related and demand driven facility service during the entire building life span.
- Such services could be for example agreeded indoor circumstance or on ecology measures, guaranteed energy efficiency, etc.
- In the future, life-cycle building services will serve the needs of the clients of the branch with cost- and energy efficient service products, which guarantee technological reliability and smooth business functioning during the entire life-cycle of buildings.

- The objectives of IAE Annex 46:
- To provide tools and guidelines for decisionmakers and energy managers, performance contractors and designers to identify energy conservation opportunities in Government buildings and to improve the working environment of Government buildings through energy-efficient retrofitting projects. Although the focus of this Annex is on Government buildings, many results can be applied to similar private sector buildings.
- To support decisionmakers in evaluating the efficiency and acceptance of available concepts.
- To promote energy- and cost-efficient retrofit measures by providing successful examples.
- To find improved ways of using Energy Performance Contracts (ESPCs) for Government buildings retrofit measures.




*Dr Mervi Himanen*

# Research Teams

- The research team consists of experts in building services, and asset and facilities management.

The research partners are Helsinki University of Technology (www.hut.fi), VTT (www.vtt.fi) and Motiva (www.motiva.fi).

- Eurocontract
- IAE Annex 46

coordinated by Alexander Zhivov, US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory, 2902 Newmark Drive, Champaign, Illinois

participants from USA, Canada, Denmark, Finland,France, Germany, Italy, Poland, Russia, Slovakia, UK, USA

- Researchers, officers and professionals from various organizations of Singapore, Malaysia and Europe are working closely in the project team:

as a coordinator the Centre for Total Building Performance, Department of Building, National University of Singapore, Singapore (www.ctbp.bdg.nus.edu.sg),

as partners Malaysia Energy Centre (PTM), Kuala Lumpur, Malaysia (www.ptm.org.my); IEN Consultants, Virum, Denmark, Davis Langdon & Seah Asia Pacific (DLS), Singapore (www.davislangdon-uk.com/), the International Network for Information on Ventilation (INIVE), Brussels, Belgium represented by the CSTP from France (www.cstb.fr) and the National and Kapodistrian University of Athens Greece (www.uoa.gr/).



# Aims of the projects, EC-ASEAN

- The EC-ASEAN, Project 64 is developed for the purpose of developing a framework model for the procurement, financing, measurement and evaluation, and verification of energy retrofitting projects for the ASEAN region. The expected deliveries of the project mainly include an ASEAN Building Performance model for commercial buildings based on existing systems developed in Europe and elsewhere, energy services procurement template in terms of procedure and documentation and project financing and management documentation.

- The EC-ASEAN, Project 68 is developed for the purpose of establishing a comprehensive, reliable and independent benchmarking database of energy consumption and efficiency in commercial buildings for the ASEAN region. The deliveries of the project mainly include an internet based energy benchmarking system accessible by all users, methodology of benchmarking development to serve as guide for extension to other parts of ASEAN, and a building energy performance classification system, paving the way for building energy labelling. Project term: Feb 2005 to Dec 2006.

# Aims of projects

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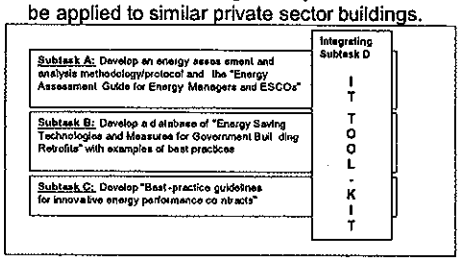
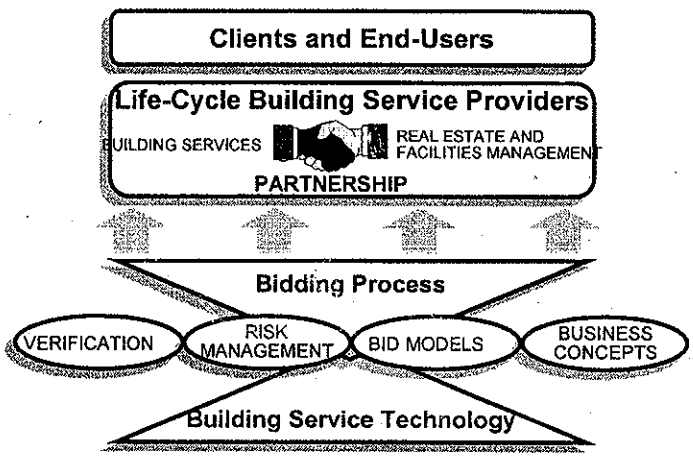



Dr Mervi Himanen

# Future Life Cycle Building Services




Dr Mervi Himanen

## Findings of CUBENet
### Acknowledgements


- Mika Vuolle HUT, Helsinki University of Technology
- Juha-Matti Junnonen HUT
- Jarek Kurnitsky HUT
- Pertti Koski Motiva Oy
- Ismo Heimonen VTT
- Tapani Ryynänen VTT
- Jorma Pietiläinen VTT






## Life-Cycle Concept of Building Services

- Service is what energy gives me!
- Building services make the building life-cycle energy effective

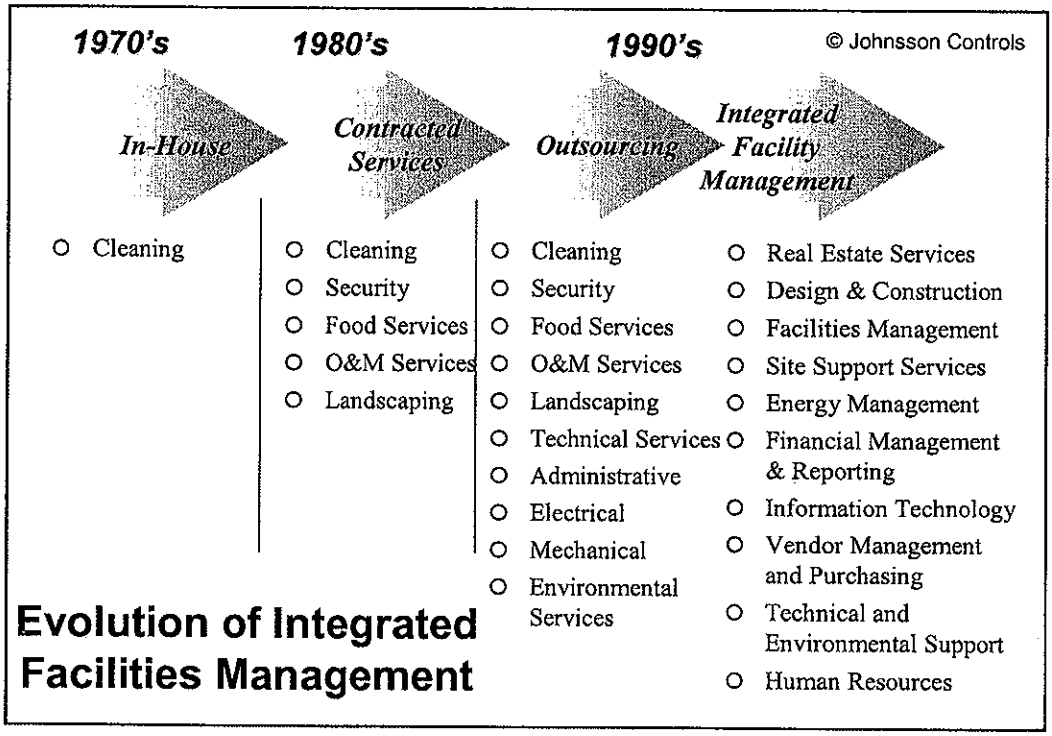
BEST PRACTISE

- Minimum concept: management of system and equipment choices with the life-cycle costs calculation
- Maximum concept: design, contracting, evolution and integrated facilities management of the whole building and the outdoor area

THEORY

- What are service type building services? No definition






## Growth of customer relationships into partnerships

- **From customer service to real partnership:**
- **A new operational approach is emerging that is based on customer relationships and the idea that in addition to offering good service, it is also necessary to forge co-operation in the form of a partnership between the customer and the supplier**
- **As the service component becomes an essential part of core business, the traditional value hierarchy in the sector will be transformed**

*Hyvän elämän puitteet*
KIINTEISTÖ- JA RAKENNUSALA

## Examples of Life-Cycle Concepts of Building Services

- Guaranteed Indoor Air Qualifications
- Guaranteed Energy Efficiency
- Usability of Spaces

Qualitative requirements and response times justify the fee of the provided service or obligate to sanctions in unsuccesful operation = service level agreement

Realisation of the sanctions needs the end-user activity

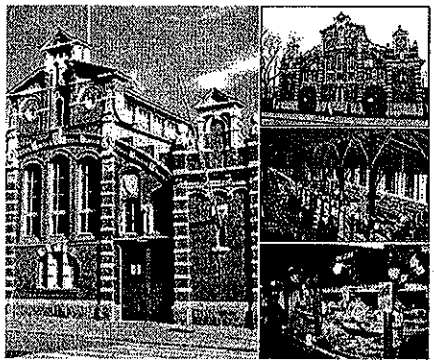



## Some Idenfied Problems of Life-Cycle Concepts of Building Services

- The co-operation with facilities management essential
- However, the role of building services unclear
- No common language between provider and client of the service descriptions (fees) and service level requirements (complains and sactions)
- The service provider reports on the energy consumptions and building environmental quality (problematic quality control)



Space 16 950 m³
Heat energy consumption in 2000 –2002 between 61.3-66.4 kWh/m3.
Energy Audit: calculated heating energy share 34 %, air conditioning 40 % and warm domestic water 26 %.
Consumption of electricity in 2000 –2002 between 34.7-36.9 kWh/m3.
Water consumption in 2000 – 2002 between 327-335 l/m³.



On agreed pay back period:
Reduction of the district heating power
Limitation if the water consumption of the water and sewerage fittings
Renovation of the control units of air conditioning heating units
Heat recovery system installation into the air conditioning system
Changes in the control of illumination

## Market Hall in City of Turku

**Eerikinkatu 16, 20100 Turku**

ESCO

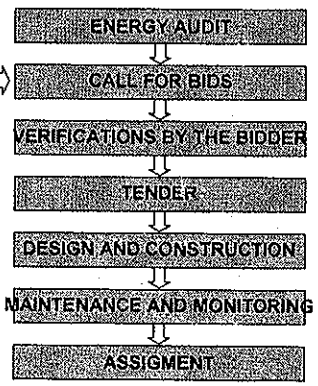
Retrofitting of Building Service Systems: when there is no municipal money available to invest or no will to invest

# Phases of the ESCO process in Turku

- Use of ESCO concept started in 1994
- Since then 6-7 ESCO projects per year

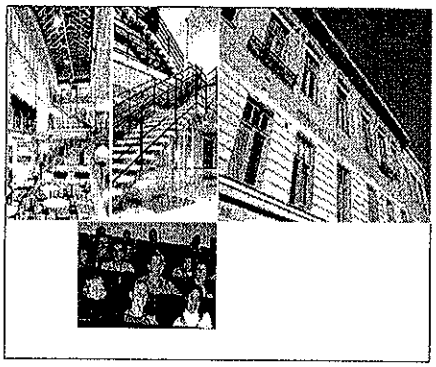
Energy consumption during 3-4 last years
Presettings and controls
Report of consumption
Investment and saving calculations

Energy Audit report
As built documentation
Targeted savings




*Dr Mervi Himanen*

Space 98 900 m³
Heat energy consumption in 2000 –2002 between 50.0-57.1kWh/m3.
Energy Audit: calculated heating energy share 29 %, air conditioning 64 % and warm domestic water 7 %.
Consumption of electricity in 2000 –2002 between 17.2-18.1.kWh/m3.
Water consumption in 2000 – 2002 between 66-78 l/m³.



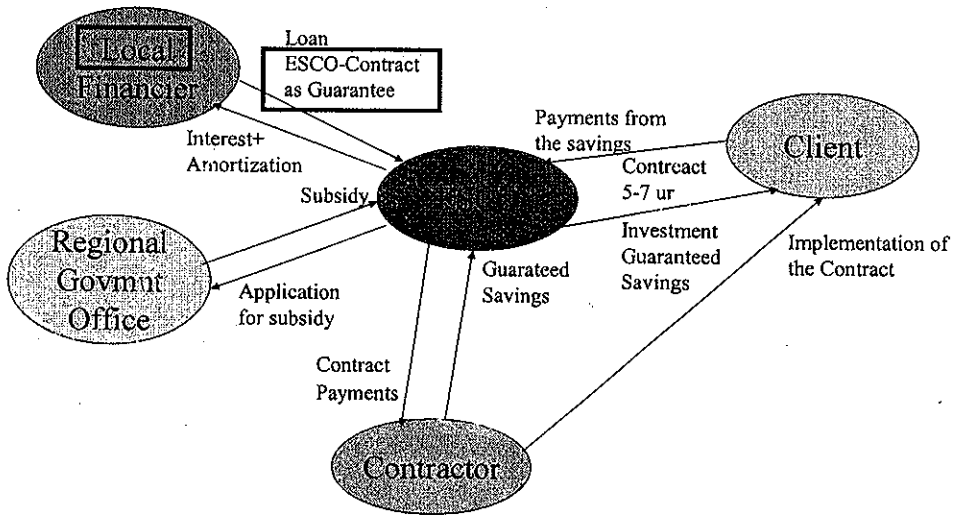
On agreed pay back period:
Change of the heating control timing
Reduction of the running times of the air conditioning units
Change of the control practise
The setting of the radiator network
Change of the presetting of the air conditioning unit
Installation of periodicly running heating pumps
Renovation of heat recovery
Change of the control of the block heaters

**Turku Polytechnic**
**Sepänkatu 3, 20700 Turku**

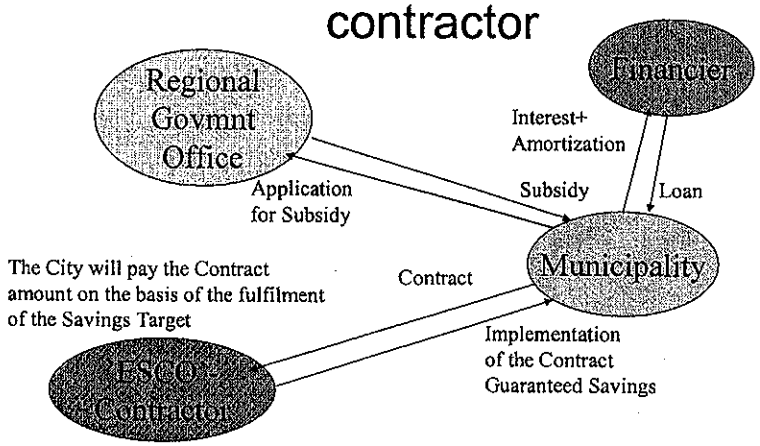
## ESCO

Retrofitting of Building Service Systems: when there is no municipal money available to invest or no will to invest

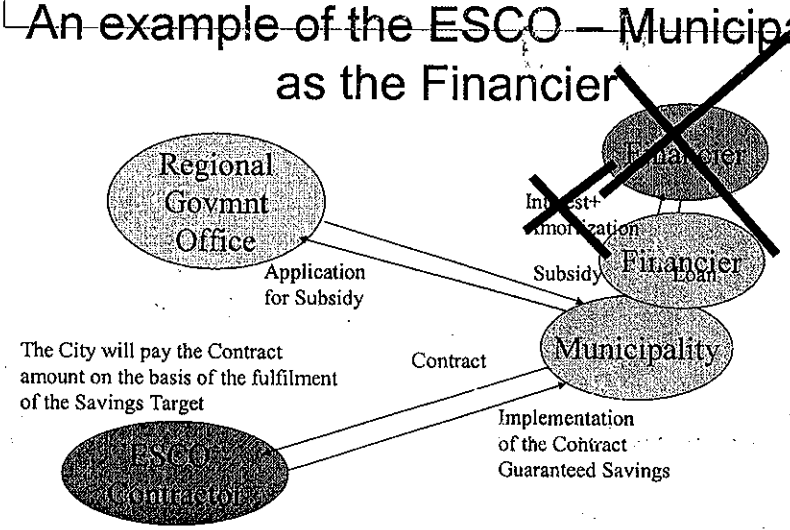
## ESCO Conventional Financing Model
## ESCO for Municipalities



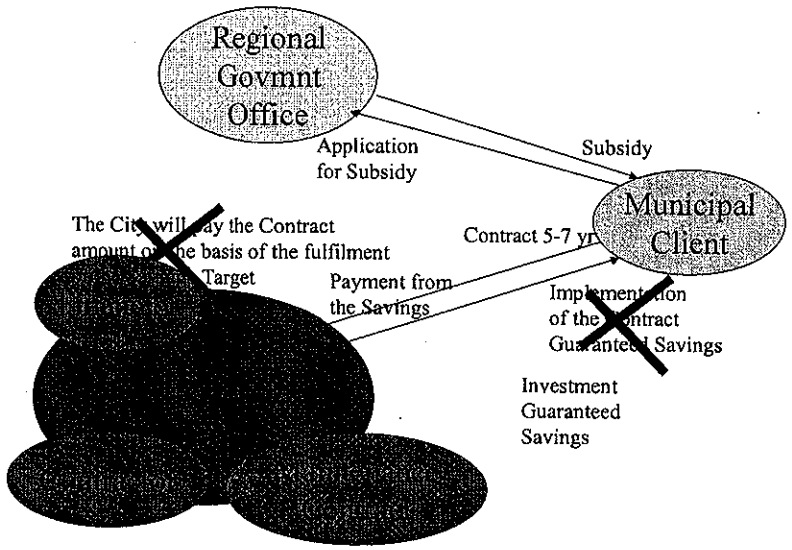
## ESCO with the Municipality as the Financier and ESCO as contractor




## An example of the ESCO – Municipality as the Financier

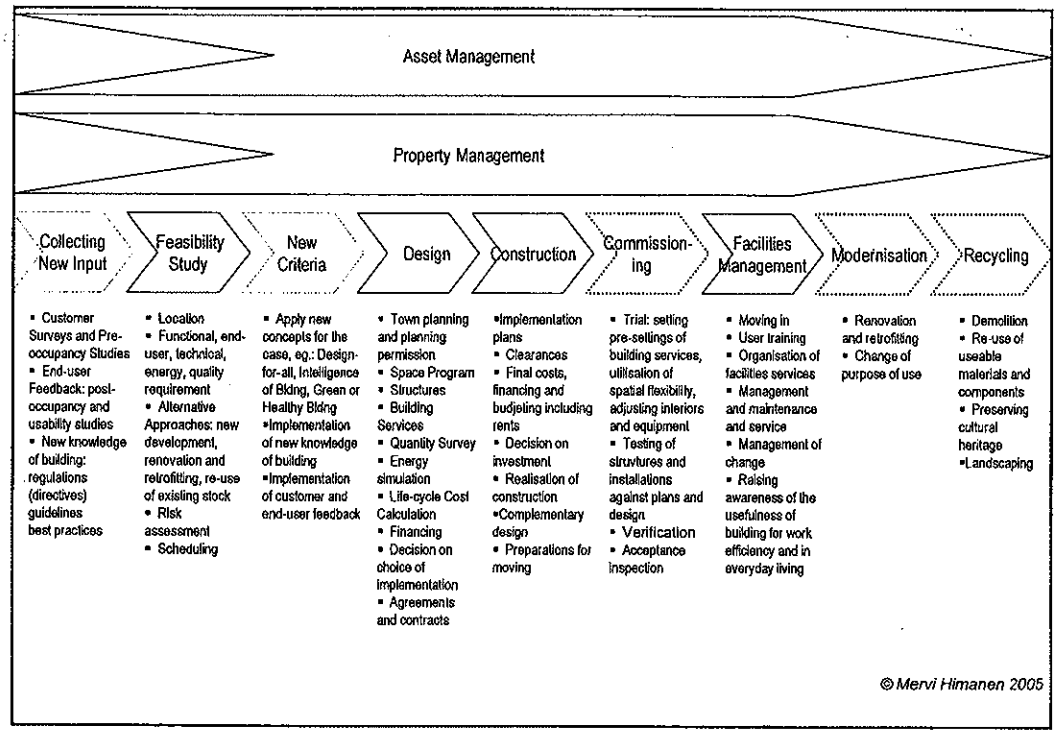


## Another example of municipal ESCO




## Development of ESCOs

- The procurement of the ESCOs are carried out without any unified procedure and thus instructions for procurement phase are needed
- The neutrality of the contractors, in the case of larger consortiums behind the ESCO, is a problem if the trust between the client and the ESCO is not as strong as it is in the city of Turku
- The new legislation on public procurements works for making contracts more transparent and more open to competition
- However, unified instruction for best practises are lacking and in need
- A problem with the business of ESCOs in Finland is the lack of competitive providers for larger projects
- The markets have not developed enough for a larger number for bigger players and smaller providers have not enough service assortment for larger tenders
- In municipalities, the political decision making is sometimes a problem while the municipal technical professionals have made their best for profitable solutions but the councillors making the decisions on investments are not necessarily aware of the latest technology and cannot trust on it


Asset Management
Property Management
Collecting New Input
Feasibility Study
New Criteria
Design
Construction
Commission-ing
Facilities Management
Modernisation
Recycling
▪ Customer Surveys and Pre-occupancy Studies
▪ End-user Feedback: post-occupancy and usability studies
▪ New knowledge of building: regulations (directives) guidelines best practices
▪ Location
▪ Functional, end-user, technical, energy, quality requirement
▪ Alternative Approaches: new development, renovation and retrofitting, re-use of existing stock
▪ Risk assessment
▪ Scheduling
▪ Apply new concepts for the case, eg.: Design-for-all, Intelligence of Bldng, Green or Healthy Bldng
▪Implementation of new knowledge of building
▪Implementation of customer and end-user feedback
▪ Town planning and planning permission
▪ Space Program
▪ Structures
▪ Building Services
▪ Quantity Survey
▪ Energy simulation
▪ Life-cycle Cost Calculation
▪ Financing
▪ Decision on choice of implementation
▪ Agreements and contracts
▪Implementation plans
▪ Clearances
▪ Final costs, financing and budjeting including rents
▪ Decision on investment
▪ Realisation of construction
▪Complementary design
▪ Preparations for moving
▪ Trial: setting pre-settings of building services, utilisation of spatial flexibility, adjusting interiors and equipment
▪ Testing of struvtures and installations against plans and design
▪ Verification
▪ Acceptance inspection
▪ Moving in
▪ User training
▪ Organisation of facilities services
▪ Management and maintenance and service
▪ Management of change
▪ Raising awareness of the usefulness of building for work efficiency and in everyday living
▪ Renovation and retrofitting
▪ Change of purpose of use
▪ Demolition
▪ Re-use of useable materials and components
▪ Preserving cultural heritage
▪Landscaping
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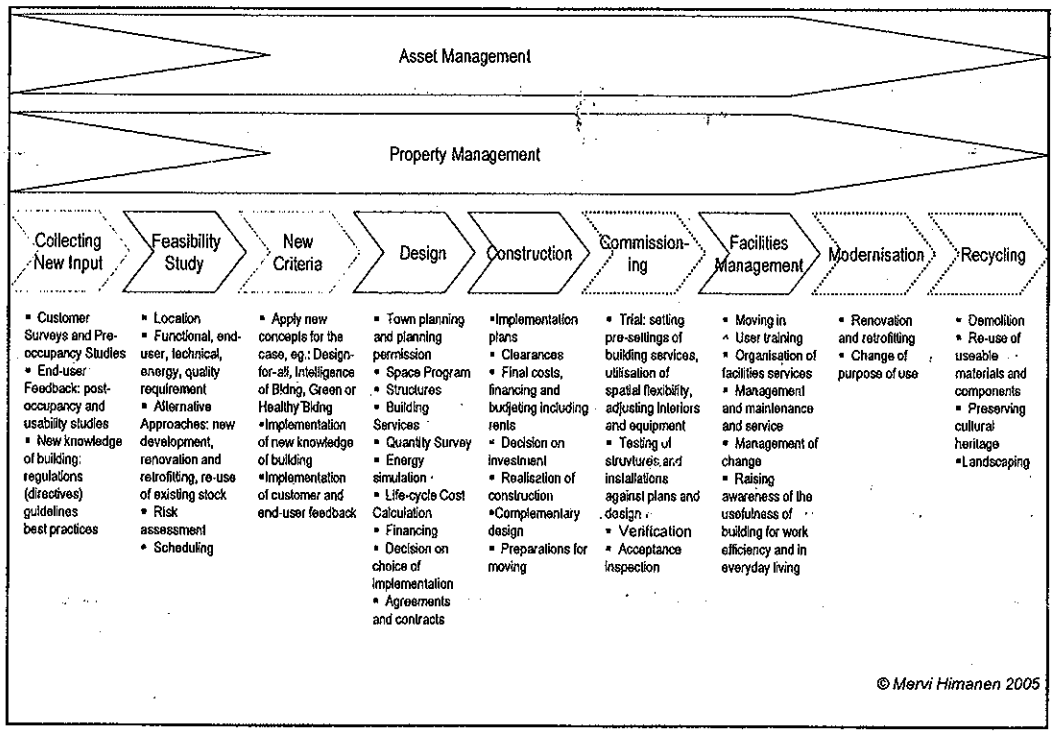
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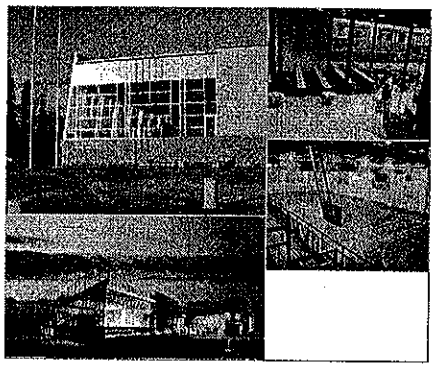


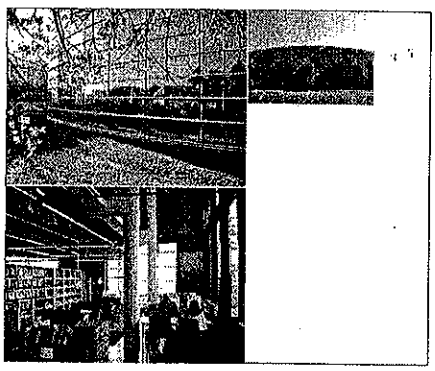
Finished 2003
On the behalf of the building services the requirements for the usability are compared to the design values: room temperature between +/- 1 °C, illumination intensity +/- 10 %, water temperature +/- 5 °C.
Response times for the reparations are in use.
If the the space is not in use due to partial lackings the fee is not paid and the sanctions will occur

## Kuninkaantie High School and Swimming Hall Kaivomestari

**Kaivomestarinkatu 2, 02070 City of Espoo**

Private Public Partnership agreement for 25 years, assignment of the property in the shape as good as new

English consultancy in contracting, several sustainable solutions



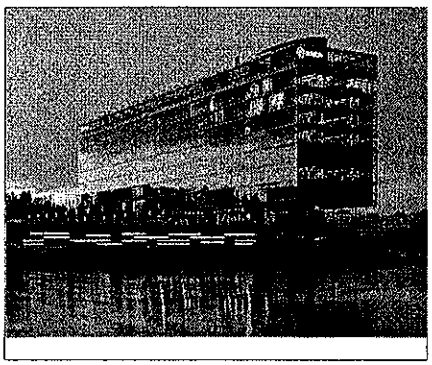
Finished 2000
Service provider responsible for half of the exceeds or belows. The energy guarantee for five years. The energy provider and the client develop the building continuesly. The contract is changed according to changes.
The interest rate for the life-cycle cost calculations 6 %.

## Helsinki University / Viikki Infocentre

**Viiklnkaari 11, 00014 Helsinki University**

A Special project based on a competition of the energy efficient solutions; the double glass facade being the most important implementation (a passive system)

Finished 2001
Space 18900 m² and 90500 m³ for 1000 occupants, washable glass surface 43200 m²

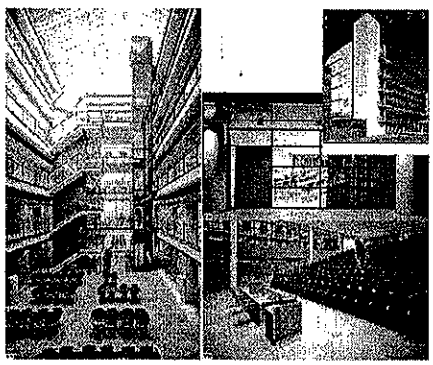


The energy consumption only 30 % of the annual nominal energy consumption, despite the use of glass in Northern climate.
Use of pasive solar energy for heating via the facade, taking advange of the air inlets from North in Summer and from South in Winter, control of illumination after the amount of natural light.
Sophiticated building automation system.

## The Radiolinja Building in Espoo

**Keilaranta**

Successful use of the active double glass facade

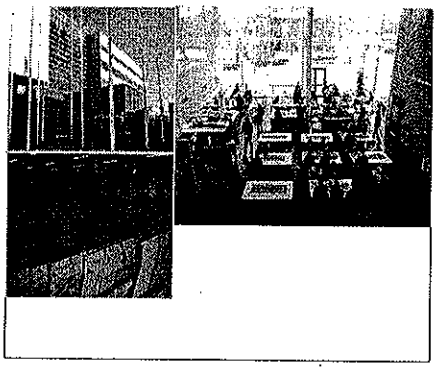


## Helsinki University / Biomedicum

**Haartmaninkatu 8, 00290 Helsinki**

A Sophisticated Management of Buildings

To know how much illumination, computing and building services use energy, comparison of calculations agains the measured consumptions
Effect of recommendations and regulations to energy efficiency

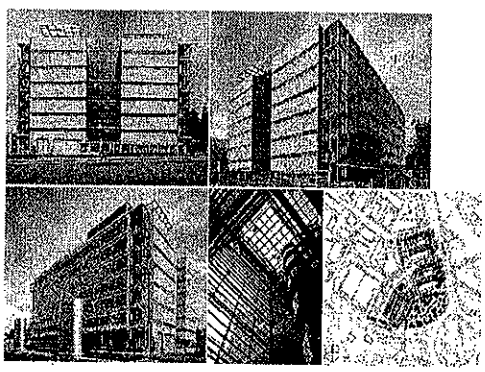


## City of Jyväskylä, IT-Dynamo

**Piippukatu 2, 40100 Jyväskylä**

Energy Simulation Project for Commissioning

Life-cycle costs calculations on the use of frequency converters, ventilation of the glass roof entrance hall with opening windows (space reserve for curatins), heating alternatives for the parking hall; warm, half warm or cold, the design criteria of cooling power for enabling flexibility, indoor air inlet alternatives, heating of the ramp leading to the parking hall in winter, the use of low preassure air conditioning system (Swegonin Eric®).



Finished 2003, Targets for the district heating consumption and the electricity consumption of the parking hall, checking three times a year, contract time three years.

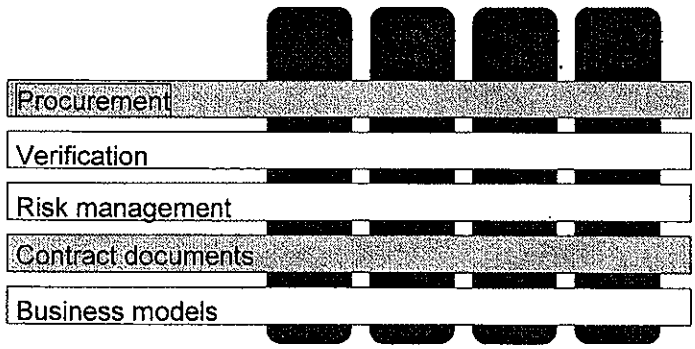
## Office in Pitäjänmäki, Novo Oy Pitäjänmäen toimitalo

**Karvaamokuja 2 C, Helsinki**

Target of the owner to have buildings of Energy Efficient Life Cycle

CUBENet

## *Future Life Cycle Building Services*






## Procurement

- The design and the contracting merge into one discipline enabling
  - more "buildable" innovative and energy-effective solutions
  - maintenance costs count in the design of alternative solutions
  - the contractor is more motivated to design and use of new technology
  - knowledge from different sources better in use
- The tender can base on the functionality or usability of the space despite the technology enabling it
- The invitation for tenders has to be far more detailed than earlier and on the other hand it should leave space for creative solutions, and thus it is difficult to compose
- On the other hand, the building owner is forced to get acquiantance with own needs and the requirements set on the building project
- The specific invitation of tenders is a valuable tool for comparison of tenders, and what is interesting, the comparison can be more reliable base on the price of the tender
- On the detailed level difficulties in fitting together overlapping tenders

# Contract Documentation

- New contracting mechanisms needed allowing for both partners the possibilities for good earnings during the whole life span of the building while the fixed contracts do not necessarily work long enough
- On the other hand, the fees and sanctions have to be predestinated after certain coals and easily verified measures before the operations are possible
- If operation is failing, the contractor is obligated to compensate the harm or inconvenience to the client, and on the other hand, the contractor should be able to benefit from the more effective operations than those agreed on, the mutual benefit (win–win) makes good grounds for the agreement, better than that of confrontation
- Due to the unpredictable situations the clear risk assessment is needed
- The starting point is that the original agreement holds, and the negotiations on the changes are secondary
- Contract can be on constant development for ever better energy efficiency in changing conditions
- Traditional court system does not necessary fit in agreeing of the disagreements with life-cycle projects, because it rather looking back than forwards
- The use of neutral middle-man either for advising or for decisions is one useable solution





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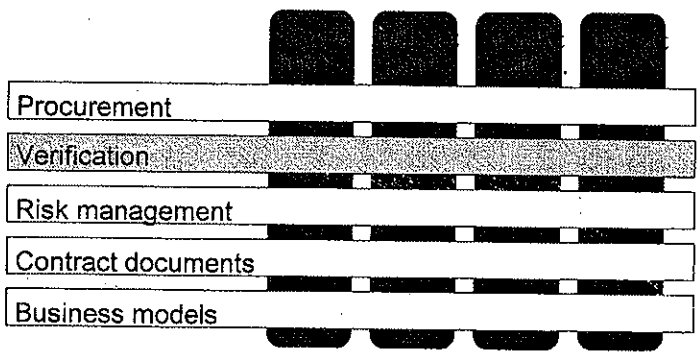
*Future Life Cycle Building Services*






# Verification

- Verification can base on calculations, short monitoring period or one-time measurements or constant measuring, verification can cover the whole building or parts of it
- Constant measuring is reliable but the instrumentation and reporting is costly, need for more cost effective methods, interest in the use of building automation for verification
- ESCOs in need of standard verification methods
- IPMWP (International Performance Measurement and Verification protocol): choice of verification method is dependent on the size and nature of the case it is used for, certain difficulties has to be taken into account in verification such as exceptional weather conditions or occupation rates
- Verification of the energy consumption by the building systems and the occupant is needed, because in the case of high consumption rates it is unclear if the occupant has some activities or equipment using energy or if building system is not operating correctly

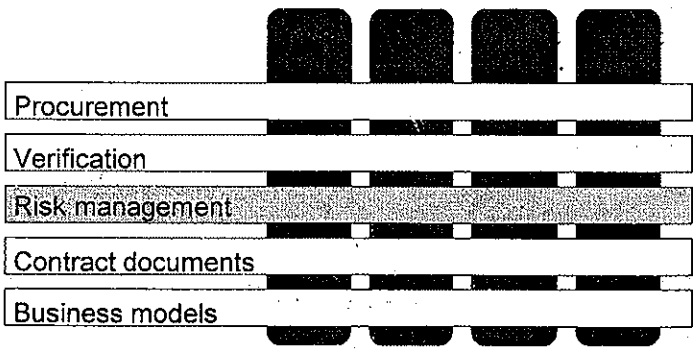




*Dr Mervi Himanen*

CUBENet

*Future Life Cycle Building Services*








*Dr Mervi Himanen*

## Risk management

- The risk assessment covers
  - economical, political, natural risks
  - technical and contracting risks
  - risks concerning contracting or personnel
- The systematic risk assessment can benefit from the risk assessment tabulations pointing who is responsible for what, pricing of the risks and weighting of them
- Clear need for methods for risk assessment which was in many cases performed insufficiently
- The tender documentation is not suitable starting point for risks assessment and the contract phase increases a factor to the list of risks with whom the final contract will be done, etc.

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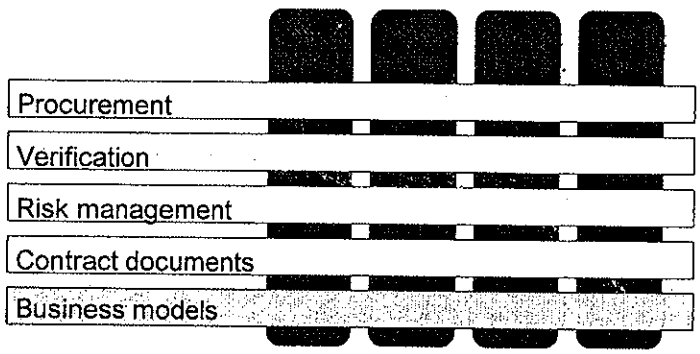
*Future Life Cycle Building Services*







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## Business Model

- Life-cycle building services are not yet in Finland in the position of profitable business, but various clusters develop their co-operations to be able to serve as soon as the demand is there
- How the client experience the conditions will form grounds for the business activity, which is not as concrete base into which engineers are used to and increases the responsibilities of the service provider
- The role of the neutral entities such as public sector or design engineering, are under development
- Each operator had to choose the tactics: between the roles of pioneer, follower or survivor



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## Future Life Cycle Building Services

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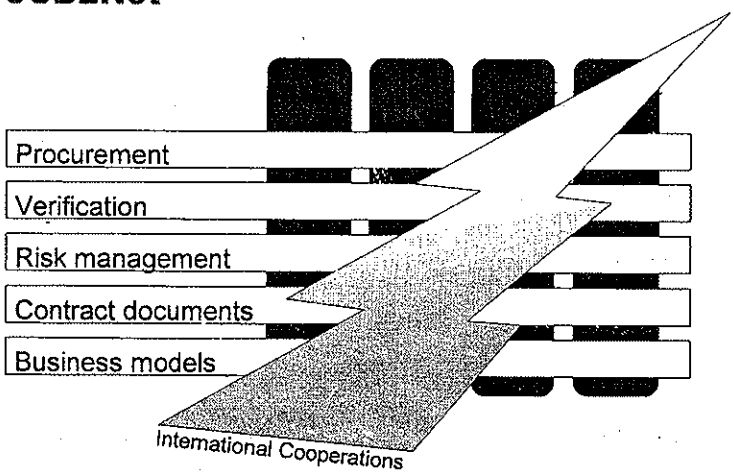




Dr Mervi Himanen

# Events

EC-ASEAN 64&68

- 29 March ~ 5 April, 2005 Commencement meeting, Athens Greece.
- 22 Sep ~ 23 Sep, 2005 Half year progress meeting, Brussels Belgium.
- 13th of Jan, 2006, National Seminar, Singapore
- 6 ~ 7 March, 2006 One year progress meeting, Kuala Lumpur, Malasia.

IEA, Annex 46

- March 2005, Meeting with Alexander Zhivov at VTT Espoo, Finland
- October 5th, 2005, International Seminar Improvement of Energy Efficiency of Buildings, Helsinki, Finland
- October 6-7th, 2005, Third Planning Workshop, Helsinki, Finland
- Jan 16th, 2006, Working meeting and workshop in Chicago

CUBENet goes International

- 26th of Aug 2005, CUBENet workshops at the Annual conference of SARA and CUBE technology programs, Helsinki, Finland
- (19th - 20th of Oct 2005, ib2005 conference in London)
- 14th Oct 2005, Meeting Lucrezia Patruno, U.S. General Services Administration, Espoo Finland
- 20th Oct 2005, Meeting at DEWG, London
- 21st Oct 2005, Meeting with Skanska UK, London
- A researcher working at NUS/Singapore 25th Oct 2005 ... 31st March 2006
- 9th Nov 2005, Meeting Dr. Patrick Hartigan Moher Technologies, about EU funded Core Business project (www.core-business.org)

Eurocontract

- 10-11.2.2005 Project Kick off Meeting in Brussels
- 6-7.10.2005 Project Interim Meeting in Vienna

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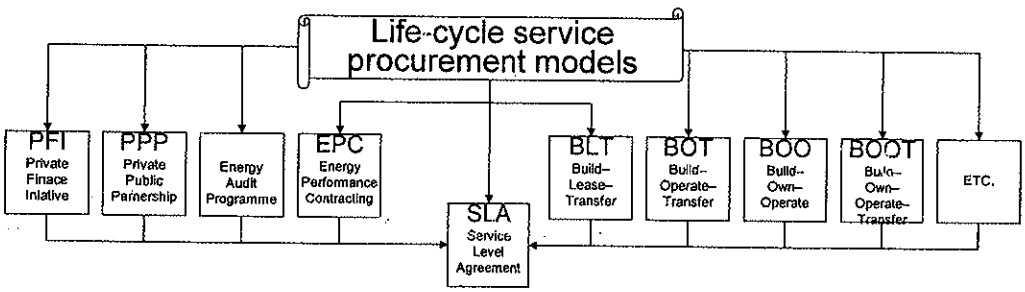
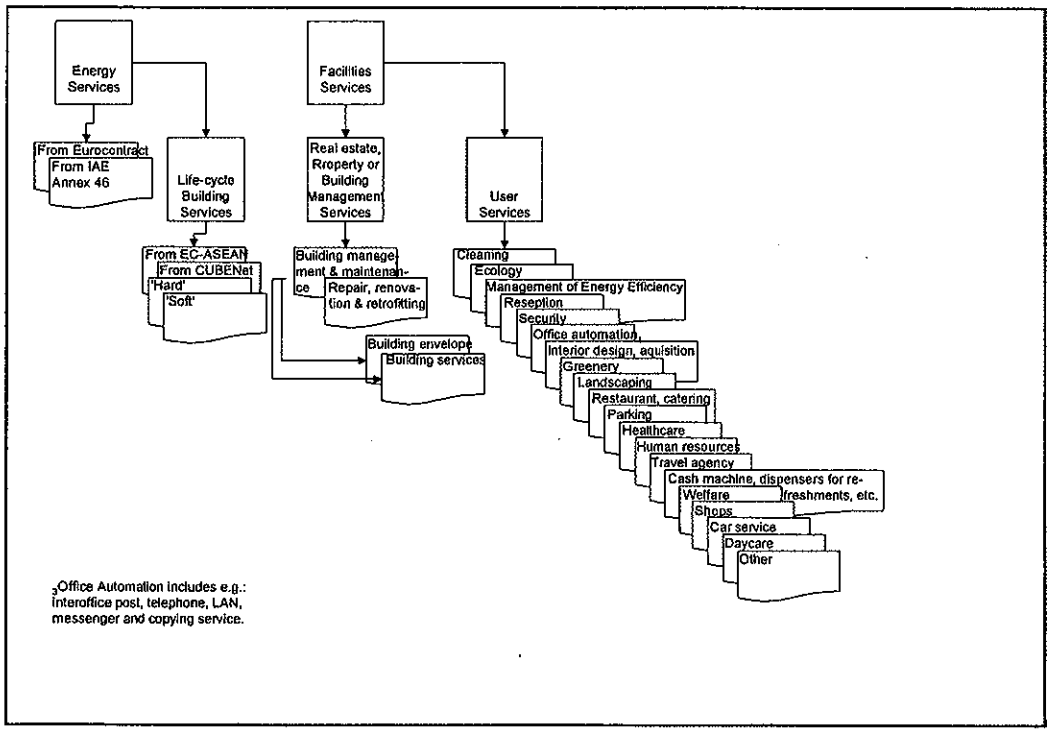
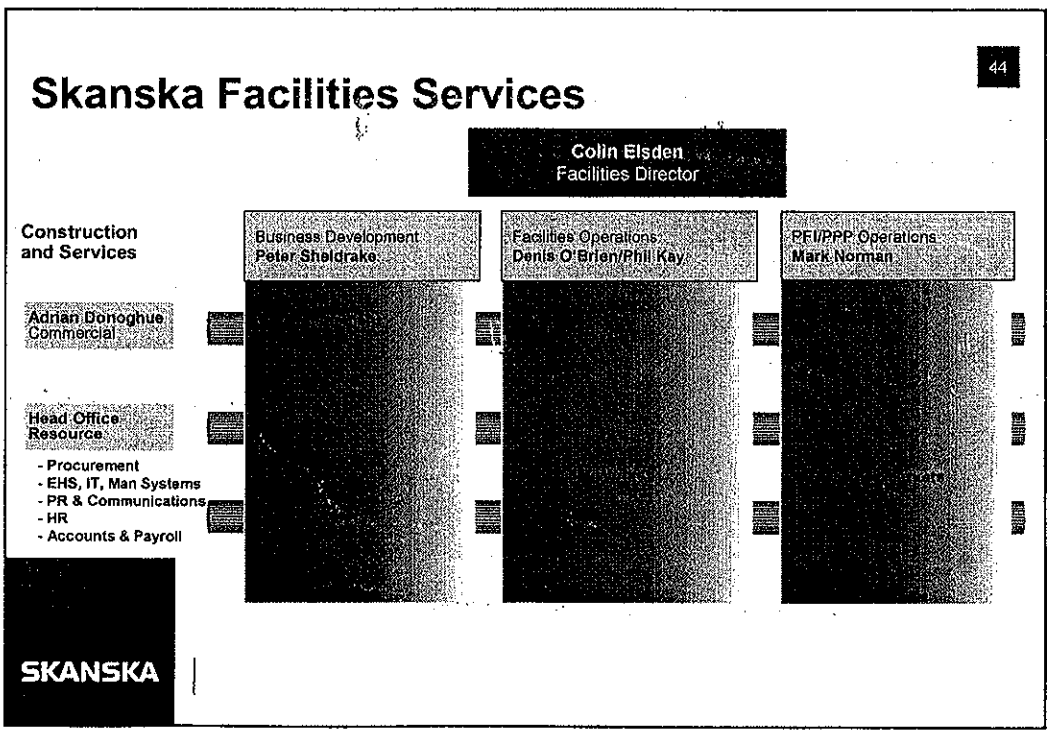
# First steps towards the future

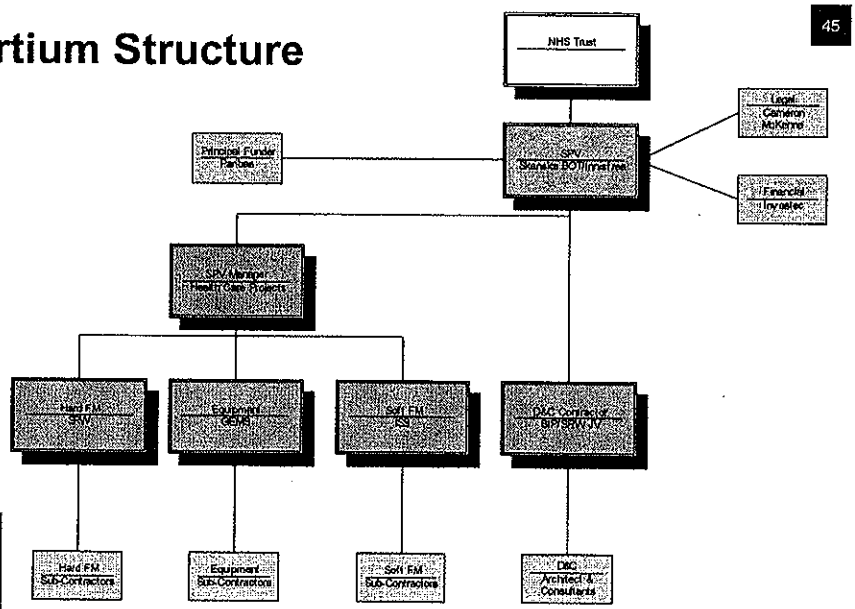



Energy Services
Facilities Services
From Eurocontract
From IAE Annex 46
Life-cycle Building Services
Real estate, Property or Building Management Services
User Services
From EC-ASEAN
From CUBENet
'Hard'
'Soft'
Building management & maintenance
Repair, renovation & retrofitting
Building envelope
Building services
Cleaning
Ecology
Management of Energy Efficiency
Reception
Security
Office automation,
Interior design, aquisition
Greenery
Landscaping
Restaurant, catering
Parking
Healthcare
Human resources
Travel agency
Cash machine, dispensers for refreshments, etc.
Welfare
Shops
Car service
Daycare
Other
3Office Automation includes e.g.: Interoffice post, telephone, LAN, messenger and copying service.


44
Skanska Facilities Services
Colin Elsden
Facilities Director
Construction and Services
Business Development
Peter Sheldrake
Facilities Operations
Denis O'Brien/Phil Kay
PFI/PPP Operations
Mark Norman
Adrian Donoghue
Commercial
Head Office Resource
- Procurement
- EHS, IT, Man Systems
- PR & Communications
- HR
- Accounts & Payroll
SKANSKA

# Consortium Structure

45

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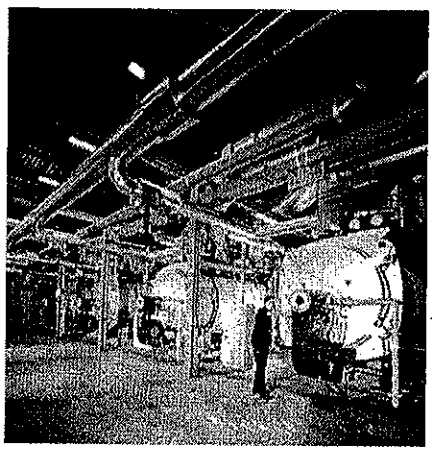
# Energy

46

- Trust Output Requirement
- Consumption Risk with ProjectCo
- Tariff Risk with Trust
- Design Requirements
- Material and Product Selection
- Energy Protocol



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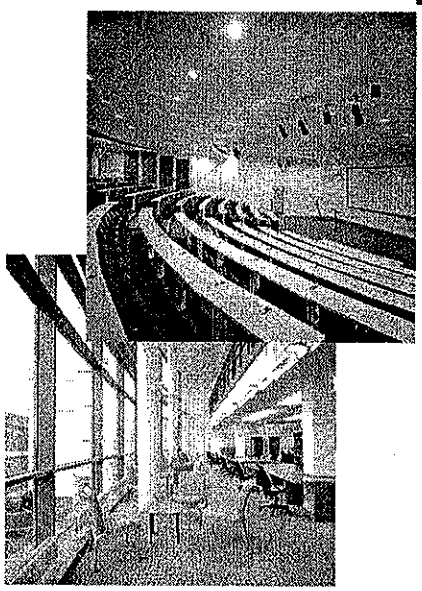
# Lifecycle

- FM Design Input
- Construction Cost Plans
- Benchmark Information
  - Consultants, BSRIA, HVCA, Life Expectancy
- Lifecycle Plan
- Plan Review and Management



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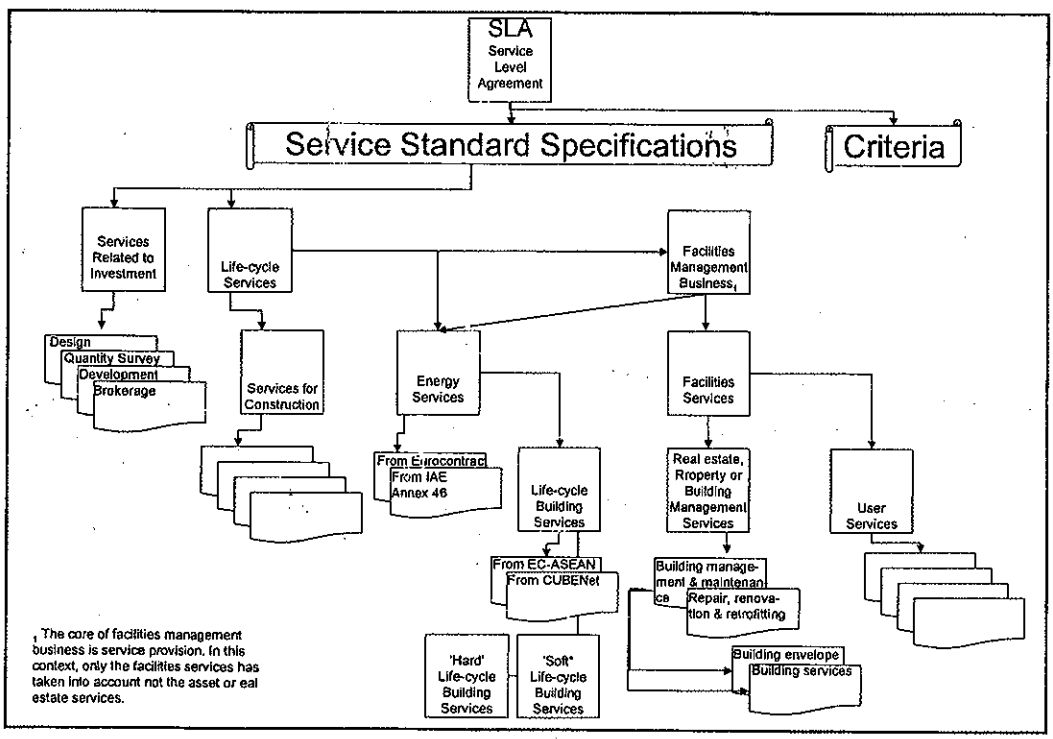
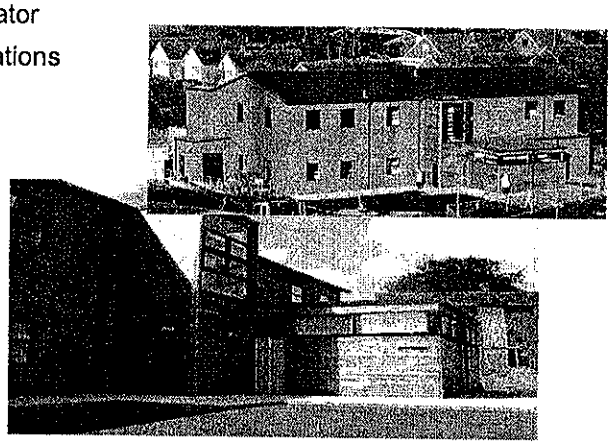


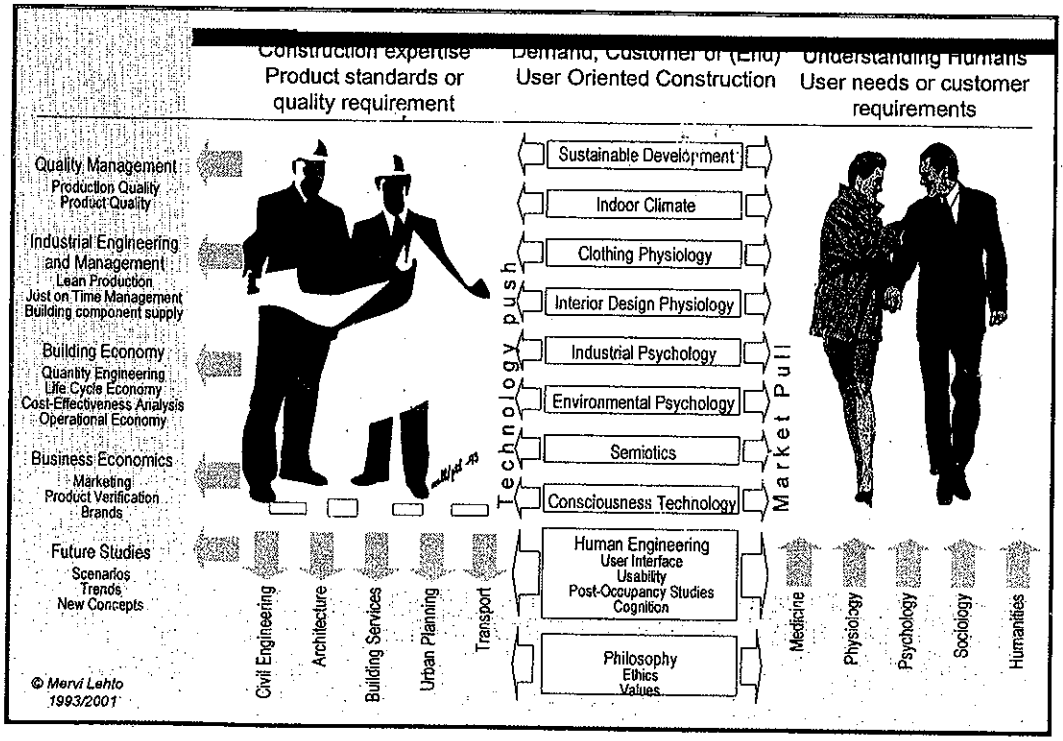
# Client Requirements

49

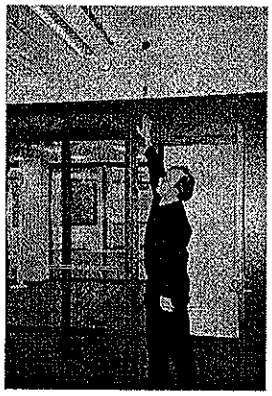
- Outline Business Case
- Public Sector Comparator
- Client Output Specifications
- Compliance
  - HBN's
  - HTM's
  - Trust Policies

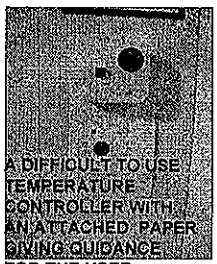


SKANSKA

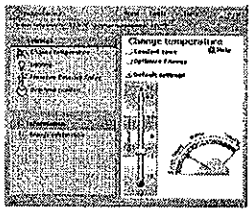


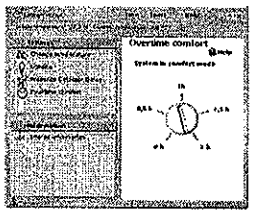
**The radical objective of the EBOB project was to create new technological and socio-economic solutions in order to make energy efficient behaviour natural, easy and intuitively understandable for the end-users.**
**This combining approach is called 'forgiving technology'.**





A DIFFICULT TO USE TEMPERATURE CONTROLLER WITH AN ATTACHED PAPER GIVING GUIDANCE FOR THE USER.





ebob

VTT

## CLASSIFICATION OF PROBLEMS IN USABILITY





- Technical: A feature of the prototype or a programming- or functional error **discovered during the usability assessment**, which affects the usability of the product. Is likely to have to be corrected before the implementation of the product.
- User Expectation: User's wish for something generally to be added, but isn't really a usability problem.

*Source: M. Himanen, J. Brissman, S. Lundberg, R.Vastamäki.* Forgiving Technology In Automated Office Buildings. Helsinki: CIB. 2005.

- Catastrophic: Can lead to a situation where the user has to suspend the use of the product. The problem is catastrophic when it prevents the user from completing his task, causes distortion of information or when it is related to a crucial function. Has to be eliminated.
- Severe: Significantly disrupts the efficient use of the product or slows it down remarkably. Prevents the learning of its functions. Should be corrected.
- Major: Moderately disturbs the efficient use of the product or prevents the efficient use of a limited part of the product. Recommended to be corrected.
- Minor: Disturbs the efficient or fluent use of the product to some extent, generally however within a quite restricted situation. Worth correcting if it is not too difficult.
- Cosmetic: Doesn't directly affect the use of the product, but it might affect the user's experience about the reliability and convenience of the product.

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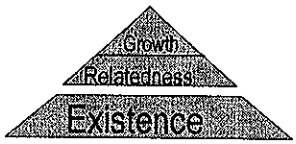
## MOTIVATION AND CONTROL

- Motivation is based on the human tendency to use intelligence for the benefit of oneself and for satisfaction of needs
- The Maslow's Hierarhy of Needs and the Alderfer's Hierarchy of Motivational Needs

- How end-users can control the personal workspace is based on
  - o Possibilities
    - – forgiving technology
  - o Limitations
    - – external
    - – internal

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## LIMITATIONS

EXTERNAL LIMITATIONS

- The action is under the control (or responsibility) of other actors
- Limitations of social or work-related roles
- There is no (realistic, good) alternative
- Lack of information available
- Lack of tools available
- Time limitations
- Economical limitations

INTERNAL LIMITATIONS

- Psychological aspects (personality, addiction, habit, lack of motivation)
- Cognitive aspects (lack of knowledge, biased mental models, lack of skill, has not thought about the issue before).

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## ENERGY INFORMATION by EBOB ENERGY MANAGEMENT TOOLBOX

NEED OF MANAGER
- Keeping up motivation constantly
- Informing of the latest achievements and developments

TYPE OF INFORMATION
- General tips and knowledge
- Specific characteristics for this building
- Real-time feedback in the user interface

EXAMPLES
- Comparisons
  - o With other's energy usage
  - o To see one's status compared to the average usage is useful
  - o To see one's status compared to one's earlier usage
- To display the usage in a graphical or in another easy-to-understand format,
- To display the energy usage in comparable terms which are easy to understand i.e. number of trees that can be saved by the energy savings

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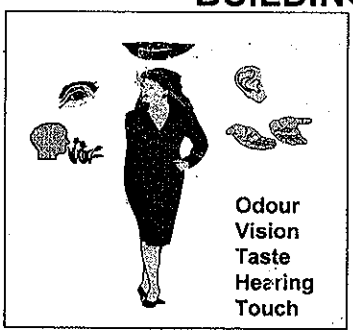
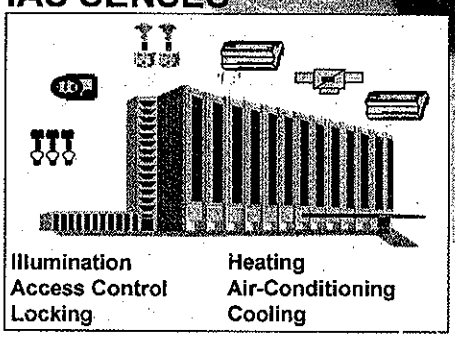
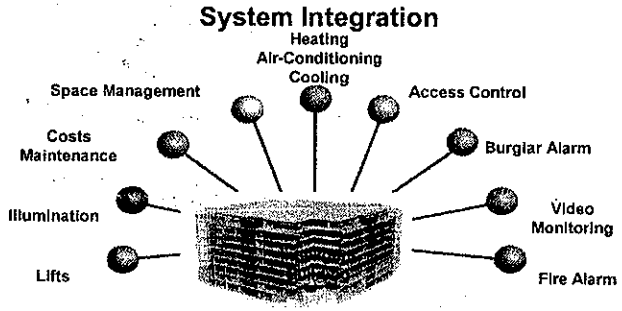
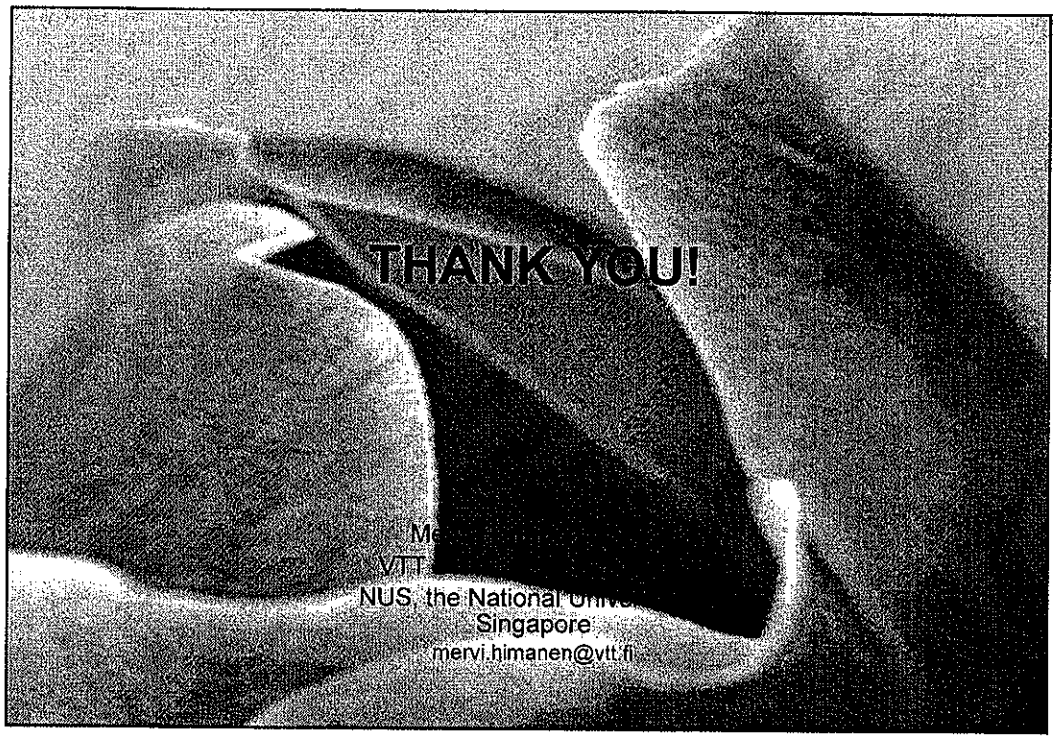
## BUILDING HAS SENSES




### System Integration

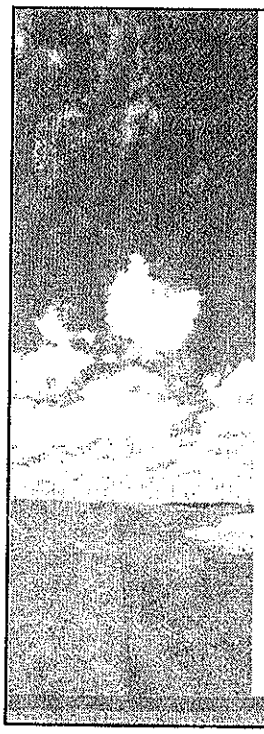



THANK YOU!
VTT
NUS, the National
Singapore
mervi.himanen@vtt.fi

# Development of Public Sector Energy Performance Contracting

Presented by
Mr. Tan Kok Kwang
Resource Conservation Department
National Environment Agency

***at the Seminar on***
***Energy Performance Contracting & Benchmarking***
*13 Jan 06*

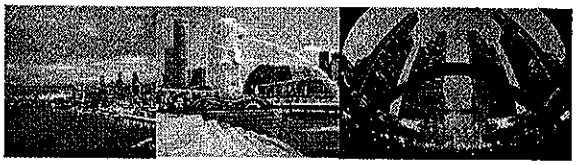


## Outline

- Introduction
- Tenders for the provision of energy savings performance contracting services
- Progress and challenges ahead

# Introduction

- Small city-state
  - **Total land area of 699 sq km**
- High population density
  - **Population of > 4.2 mil**
- Highly industrialised economy
- Dependent on imported fossil fuels
- Lacking in natural resources



Pictures Courtesy of Singapore Tourism Board

# Imperatives

**Environmental**

*Use of fossil fuels for energy generation results in*

- **Greenhouse gas emissions**
- **Air pollution**

**Economic**

*Wasteful or inefficient energy use*

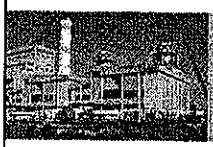
- **Reduces cost-competitiveness**
- **Undermines resilience of economy**

**Develop strategies to supply and use energy in an efficient, responsible and environmentally sustainable way**

## National Energy Efficiency Committee

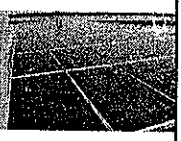
- Formed in Apr 2001
- Chaired by Senior Parliamentary Secretary of the Ministry of the Environment and Water Resources
  - **Associate Professor Koo Tsai Kee**
- Representation from 45 organisations
  - **Government ministries and statutory boards**
  - **NGOs**
  - **Industries**
- Structure
  - **4 Sub-Committees and 1 R&D Workgroup**

## NEEC's Key Thrusts



Promote energy conservation through the *efficient* use of energy in the industrial, building, transportation and consumer sectors

Promote use of *cleaner* energy sources and *renewable* energy

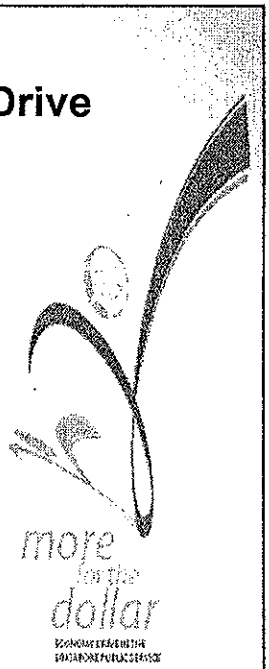




Promote *test-bedding* of pioneering energy technologies and the development and commercialisation of clean energy technologies

## Public Service Economy Drive

- Why the Economy Drive (ED)
  - **Tight Fiscal Position**
  - **Maintaining Public Trust**
  - **Value for Money**
- Service-wide ED Initiatives:
  - **ED through NEV**
  - **ED through Best Sourcing**
  - **ED through Process Innovation**
  - **ED in Govt Procurement**
  - **ED in IT Expenditure**
  - **ED in Discretionary Expenditure**
  - **ED in Energy Use**




## ED in Energy Use

- Objectives
  - **Assist public sector agencies in implementing energy saving projects, which could also serve as showcases for the building sector**
  - **Develop standard documents for procurement of energy performance contracting services**
  - **Develop local energy service industry**
- 8 public sector agencies participating in the pilot energy performance contracting projects

## ED in Energy Use

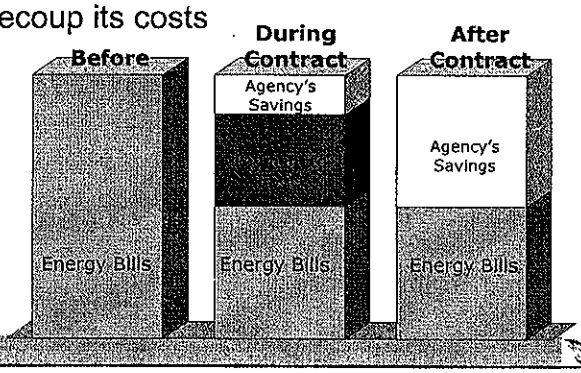
- Supported by Technical Committee comprising representatives from:
  - **NEA**
  - **EDB**
  - **EMA**
  - **NUS**
  - **BCA**
  - **DSTA**
  - **(private sector representative)**
- Common pre-qualification exercise carried out for Energy Service Companies (ESCOs)
  - **Only pre-qualified ESCOs could submit offers for the pilot energy performance contracting projects**

## Tenders for the provision of energy savings performance contracting services

- Separate tenders by each agency for the appointment of an ESCO to:
  - **carry out an Investment Grade Energy Audit, and**
  - **implement recommended energy saving measures under a performance contract**
- Contract models
  - **Shared Energy Savings Performance Contracts (Shared ESPC)**
  - **Guaranteed Energy Savings Performance Contracts (Guaranteed ESPC)**

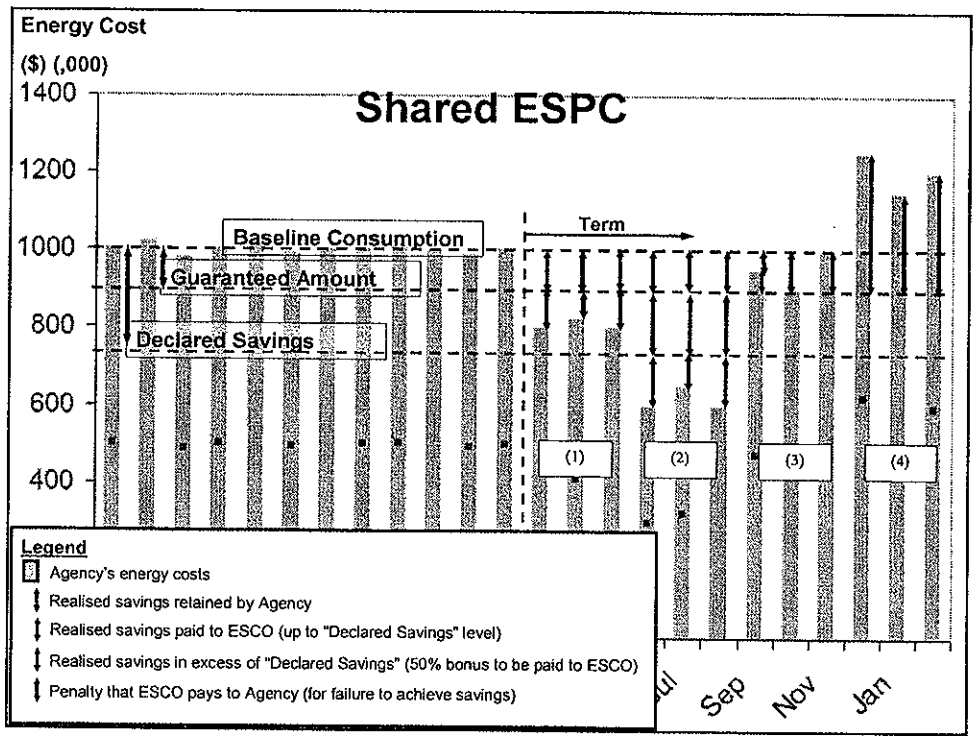
## Shared ESPC

- ESCO finances the investment costs for implementation of energy savings measures and recoups his costs from the realised energy savings
- Longer contracts envisaged to allow ESCO to recoup its costs (up to 8 years)




## Shared ESPC

- ESCOs to offer in its tender:
  - **Audit Fee**
  - **Annual Declared Savings**
  - **Annual Guaranteed Amount**
  - **Term**




## Guaranteed ESPC

- Agency finances the investment costs for implementation of energy savings measures
- ESCO provides a financial guarantee that energy savings will be achieved
- ESCOs to offer in its tender:
  - **Consultancy Fee**
  - **Annual Guaranteed Savings**
  - **Guaranteed Return On Investment**

## Guaranteed ESPC

- ESCO to make up for shortfall in savings necessary to achieve Guaranteed ROI
- Performance incentives for ESCO if actual project ROI exceeds Guaranteed ROI by more than 50%

## Progress

| Agency | Contract Model | Tender period |
|---|---|---|
| MEWR | Shared Savings | Jun - Jul 05 |
| MOM | Guaranteed Savings | Sep - Dec 05 |
| MOF | Shared Savings | Nov - Dec 05 |
| SGH | Shared Savings | Nov - Dec 05 |
| (4 other public sector agencies to call tenders in coming months) | | |

## Challenges

- Measurement and verification of savings
  - **Establishing baseline**
  - **Determination of savings**
  - **Adjustments to baseline**
- Introducing performance contracting to other public sector agencies, as well as the private sector

## Thank you

National Environment Agency

# Development of Measurement & Verification Guideline for Singapore

Energy Sustainability Unit

Seminar on EAEF Project 64 & 68:
Energy Performance Contracting & benchmarking
13 January 2006
School of Design & Environment, NUS

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***Energy Sustainability Unit***
***National University of Singapore***

## Agenda

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- The introduction of M&V guideline
- Basic concept and methodology of M&V
- Why Singapore needs its own M&V guideline
- EU Project 64
- The development of commercial building baseline model in Singapore
- Current and future work

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# Introduction of M&V

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- **What is M&V?**

  Measurement and Verification is a process or protocol to confirm the actual energy savings realized from a Demand Side Management project once the project is implemented and operating

- **Why M&V?**

  Savings are guaranteed, but actual savings fluctuate every year.



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# Current M&V guidelines worldwide

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- ASHRAE Guideline -14P
- IPMVP
- FEMP M&V guideline
- Various M&V guidelines in different countries



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## Introduction of M&V

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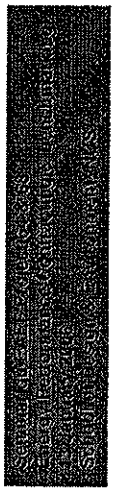
- Basic concept

  ***Energy savings=Baseyear Energy Use - Post-Retrofit Energy Use ± Adjustments***

- Methodologies --- 4 Options ✧
- Implementation

  Guidance on energy saving project procedures, documentations, etc.



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## Why Singapore need its own M&V guideline?

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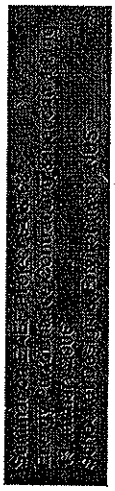
- The tropical weather condition
- Singapore lacks standard energy saving performance contract (EPC) framework
  - ➢ Standard EPC form
  - ➢ Financial options for EPC
  - ➢ Procedure and relative documentations



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# The EU Project 64 and its objectives

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- **EU Project 64 –**

Development of a business model for building energy performance services in the ASEAN region

- **Objectives:**
  - An ASEAN building energy performance model for commercial buildings
  - Energy services procurement template in terms of procedure and documentation
  - Project financing options and relevant documents and project progress monitoring and management documentation

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# Developing 4 options for Singapore M&V

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- **Option A**
  Example: Lighting system
  Count --- the number of lights
  Measure --- the light power
  Stipulate --- Operation hours
- **Option B**
  Example: VSD on HVAC Fan
  Measure --- Power of the VSD Fan
  Operation hours

E Savings = $Hour_{before}$*$kW_{Before}$ – $Hour_{after}$*$kW_{After}$

- Cost Savings = (Unit Cost) (Energy Savings)

We keep the baseline method for Option A&B same with IPMVP

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# Developing 4 options for Singapore M&V

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- Option C (whole building approach)
- ASHRAE standard 14P provides 7 methods to develop baseline model
- ESU Methods:
  - Statistical regression
  - Neural Network
  - Support Vector Machine

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# Developing 4 options for Singapore M&V --- Option C

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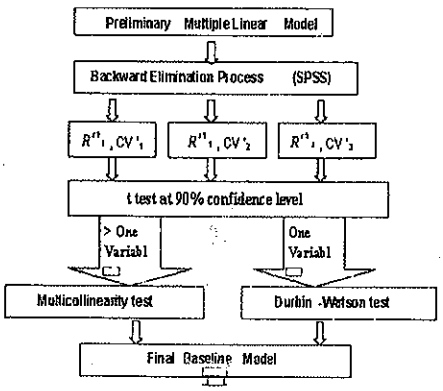
- Whole building holistic baseline method
  -- ***A combination of simple regression and multiple regression method***




***Independent variables:***

- ✓*Outdoor dry bulb temperature*
- ✓*Relative humidity*
- ✓*Global solar radiation*

$$\hat{E}=\beta_0+\beta_1 T_O+\beta_2 RH+\beta_3 GSR$$

Why not analogy.

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# Developing 4 options for Singapore M&V --- Option C

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| Building | Regression Equation |
|---|---|
| A | $\hat{E} = -32.46 + 2.23T_o - 0.02GSR$ |
| B | $\hat{E} = -30.64 + 1.85T_o$ |
| C | $\hat{E} = -31.15 + 2.32T_o$ |
| D | $\hat{E} = -35.83 + 2.18T_o$ |
| E | $\hat{E} = -50.11 + 2.76T_o$ |
| F | $\hat{E} = -20.01 + 1.74T_o$ |
| G | $\hat{E} = -47.69 + 1.78T_o + 0.28RH$ |
| H | $\hat{E} = -19.6 + 2.01T_o - 0.02GSR$ |
| I | $\hat{E} = -20.21 + 2.37T_o - 0.25RH$ |
| J | $\hat{E} = -28.76 + 2.01T_o$ |

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# Neural Network & Support Vector Machine --- Option C

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- Advantage

  More accurate in prediction compared with statistical regression method
- Disadvantage
  - ➢ The large pool of data are needed for model training (at least 4 years)
  - ➢ Time consuming
  - ➢ Limited to access to software

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# Developing 4 options for Singapore M&V --- Option D

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- **Option D**

  **ESU Methods**
  - DesignBuilder (Engine: EnergyPlus)
    http://www.designbuilder.co.uk/
  - E-Quest (Engine: DOE2)
    http://www.doe2.com/equest/
  - Visual DOE
    http://www.archenergy.com/products/visualdoe/
- **Advantage:**
  Detailed system performance analysis and diagnostic
- **Disadvantage:**
  - Very detailed building and system information are needed
  - Limited to access to software and manpower
  - Time consuming

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# Comparison among ESU methods

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- Mean Absolute Error (MAE)

$$MAE(\%) = \frac{\overline{E}_{predicted} - \overline{E}_{measured}}{\overline{E}_{measured}} \times 100$$

| Option | Method | MAE (%) |
|---|---|---|
| Option C | Single Linear Regression | 0.8 – 15.33 |
| | Multiple Linear Regression | 0.14 – 3.49 |
| | Neural Network | 0.64 – 7.33 |
| | Support Vector Machine | 0.14 – 0.73 |
| Option D | DesignBuilder | 0.004 |
| | E-Quest | -7.33 |
| | Visual DOE | 11.00 |

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# Summary of ESU methods

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| Methods | Description | Output |
|---|---|---|
| Statistical Methods | •Single variant linear regression<br>•Multiple variant linear regression | •Easy to establish<br>•Most commonly used |
| Computer Simulation | •DesignBuilder<br>•Visual DOE<br>•E-Quest | •High accuracy<br>•Not easy to use<br>•Need detailed physical and system data |
| Artificial Intelligence | •Neural Network<br>•Support Vector Machines | •High accuracy<br>•Need large pool of data |

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# Implementation of M&V

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- To implement M&V to real project, energy performance contract is needed.
- The EPCs in several countries were reviewed
  - ✓ ***US***
  - ✓ ***Australia***
  - ✓ ***UK***
  - ✓ ***Belgium***
  - ✓ ***Malaysia***
  - ✓ ***Singapore***
- Singapore standard energy performance contract is coming soon

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# Review of Energy Performance Contract

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| Country | Resource | Financing | M&V Clause |
|---|---|---|---|
| US | Mississippi state | Guaranteed | ✓ |
| UK | Energy saving project for EU | Design & Build | ✓ |
| Australia | AEPCA | | ✓ |
| Belgium | | Guaranteed | ✓ |
| Singapore | NEA, EMA,NUS,EDB,BCA, DTSA | Guaranteed/Shared | ✓ Detail M&V requirement (ASHRAE&IPMVP) |
| | Local ESCO | Guaranteed | ✓ Basic |
| Malaysia | MIEEIP | Government funding | ✓ (Optional) |
| | MESA PTM MODEL | Shared | ✓ |

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# What we will do next?

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- The framework of Singapore M&V guideline
- The Singapore standard EPC form
- The financial options for EPC in Singapore

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# Reference & Further Reading

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- Baseline Model


[1] B. Dong, S.E. Lee, M.H. Sapar, *"A holistic utility bill analysis method for baselining whole commercial building energy consumption in Singapore"*, Energy and Buildings, vol.37(2), pp. 167-174, 2005

[2] B. Dong, C.Chen, S.E.Lee, *"Applying support vector machines to predict building energy consumption in the tropics"*, Energy and Buildings, vol.37(5), pp. 545-553, 2005

[3] B. Dong. Baseline Model Development for Commercial Buildings in the Tropics , Master candidate thesis, Department of Building, School of Design and Environment, National University of Singapore, 2005

[4] Bing Dong, Lee Siew Eang, Majid Haji-Sapar, *Evaluating utility bill analysis for predicting the whole building energy use in Tropical Region*, Improving Energy Efficiency in Commercial Building Conference, Frankfurt, Germany , April 19-22, 2004

[5] Bing Dong, *Baselining Office Building Energy Consumption*, Seminar on Energy Management Best Practices & Technologies ,SAFEco and NUS , 7 April 2005, Hotel Le Meridien, Singapore


- Energy Performance Contract
- Malaysia, http://www.ptm.org.my/mieeip/document.html
- UK,http://energyefficiency.jrc.cec.eu.int/ESCO/esco_Model%20Third%20Party%20Financing%20Contracts.htm
- Australia, http://www.aepca.asn.au


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# Thanks!

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# 4 options in M&V

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| M&V Option | How savings are calculated |
|---|---|
| **Option A:** Based on *measured* equipment performance, measured or *stipulated* operational factors, and annual verification of *'potential to perform.'* | Engineering calculations. |
| **Option B:** Based on *periodic or continuous measurements* taken throughout the term of the contract at the device or system level. | Engineering calculations using measured data. |
| **Option C:** Based on *whole-building* or facility level utility meter or sub-metered data adjusted for weather and/or other factors. | Analysis of utility meter data. |
| **Option D:** Based on *computer simulation* of building or process; simulation is calibrated with measured data. | Comparing different models. |

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# Energy Performance Contracting

## An ESCO's Perspective



Richard A. Uy
(Director)
G-Energy Philippines Inc.

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# Current Problems:

1. Environmental/Public:
   - Uncomfortable Environment



2. Facility:
   - Old and degraded
3. Operational:
   - High cost of electrical operations
4. Financial:
   - High cost of investment



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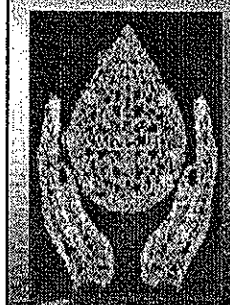
# The Consequences:



- Occupancy discomfort
  - generally poor working environment
- Generally decreased productivity & morale
- Public criticism
- Increased environmental waste
- High maintenance cost
- Frequent equipment breakdowns
- Risky cost of breakdown
- High cost of operations



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# Our Solution:

## *"Energy Performance Contract"*

**The only guaranteed TOTAL solution!**

Technical Solution – YES!
Financial Solution – YES!



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# How to go about it?

## Energy Performance Contract

We will negotiate a contract based on performance over a number of years, wherein we will **guarantee** the following:

1. No initial cash outlay from your side!,
2. Comfort conditions are met according to internationally accepted ASHRAE standards (24 deg C +/- 1 deg C),
3. Facility upgrade,
4. Energy and operating cost savings.



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# Guaranteed Savings?

SCHEME 1:
We offer you % share on the actual energy savings, with a minimum savings.

SCHEME 2:
We offer you a fixed monthly share in Peso while we are compensated with the actual energy savings derived from the project.



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# SCHEME 1:

Example:

Contract period = 8 years

| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Actual Savings (PHP) | 11,681,280 | 13,178,880 | 15,425,280 | 12,729,600 | 13,178,880 | 14,227,200 | 14,976,000 | 17,971,200 |
| G-Energy Share | 100% | 95% | 90% | 85% | 80% | 75% | 70% | 65% |
| | 11,681,280 | 12,519,936 | 13,882,752 | 10,820,160 | 10,543,104 | 10,670,400 | 10,483,200 | 11,681,280 |
| Client Share | 0% | 5% | 10% | 15% | 20% | 25% | 30% | 35% |
| | - | 658,944 | 1,542,528 | 1,909,440 | 2,635,776 | 3,556,800 | 4,492,800 | 6,289,920 |

Guaranteed total share of **PHP 21 Million (USD 396K)** over 8 years time



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# SCHEME 1:

If the Actual Shared Savings > Guaranteed Shared Savings, the excess will be carried forward and applied against any shortfall in the future guarantee years.

If the Actual Shared Savings < Guaranteed Shared Savings, G-Energy Philippines will pay Client the amount of such shortfall, after giving credit for any excess savings carried forward from previous guarantee years.



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# SCHEME 1:

| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Actual Savings (PHP) | 11,681,280 | 13,178,880 | 15,425,280 | 12,729,600 | 13,178,880 | 14,227,200 | 14,976,000 | 17,971,200 |
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| Year | Guaranteed Shared Savings | Actual Savings | Actual Shared Savings | Difference |
|---|---|---|---|---|
| 1 | Php0 | Php10,500,000 | Php0 | Php0 |
| 2 | Php658,944 | Php14,500,000 | Php725,000 | Php66,056 |
| 3 | Php1,542,528 | Php18,500,000 | Php1,850,000 | Php307,472 |
| 4 | Php1,909,440 | Php12,000,000 | Php1,800,000 | -Php109,440 |
| 5 | Php2,635,776 | Php11,500,000 | Php2,300,000 | -Php335,776 |
| 6 | Php3,556,800 | Php12,000,000 | Php3,000,000 | -Php556,800 |
| 7 | Php4,492,800 | Php18,000,000 | Php5,400,000 | Php907,200 |
| 8 | Php6,289,920 | Php15,000,000 | Php5,250,000 | -Php1,039,920 |
| Total Difference | | | | -Php761,208 |



G-Energy will pay
Client **PHP761,208.00 (USD 14K)!**

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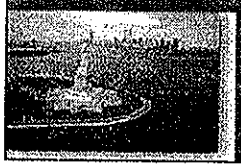
# SCHEME 2:

Example:
Contract period = 8 years

| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Actual Savings (PHP) | 11,681,280 | 13,178,880 | 15,425,280 | 12,729,600 | 13,178,880 | 14,227,200 | 14,976,000 | 17,971,200 |
| G-Energy Share | 8,681,280 | 10,178,880 | 12,425,280 | 9,729,600 | 10,178,880 | 11,227,200 | 11,976,000 | 14,971,200 |
| Client Share | 3,000,000 | 3,000,000 | 3,000,000 | 3,000,000 | 3,000,000 | 3,000,000 | 3,000,000 | 3,000,000 |

Guaranteed Annual Share of PHP 3.0 Million (USD 56K)
or, a total of **PHP 24 Million (USD452K)** in 8 years time!



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# The Benefits:

- **NO INITIAL CASH OUTLAY** required from Client!
  - Financial resources are scarce considering economic downturn
- Flexible Financial Solution!
- Comfort Solution!
  - Improved working environment
- Facility Upgrade Solution!



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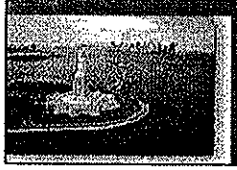
# The Benefits:

- Increased productivity & morale
  - Less employee absences (hopefully)
- Good public image
- Potential energy efficiency candidate/awardee
- Environment friendly equipment/buildings
- Reliable equipment
- Reduced maintenance cost



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# The Benefits:

- Upgraded facilities
  - improved asset valuation upon project turnover
- Reduced energy costs
- Stable cash inflows from shared savings
- Cash inflows as financial resource for other related projects
- Minimized if not totally eliminated equipment breakdowns



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# The Benefits:

- Reduced workload on project implementation
- Comprehensive coverage
  - supplied equipment have warranty over the contract period
- No financial investment risk exposure
- Minimal if not totally eradicated technical risks
- Opportunity on project multiplicity
- Transfer of technology



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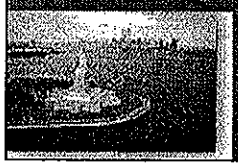
# The Benefits:

- Become one of the pioneering implementors of energy performance contracting in the country
- Intelligent building showcase
- Replaced existing equipment can be used as back up for the same or another building
- Long term and sustainable solution
- Guaranteed continuous improvement



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# Energy Performance Contracting



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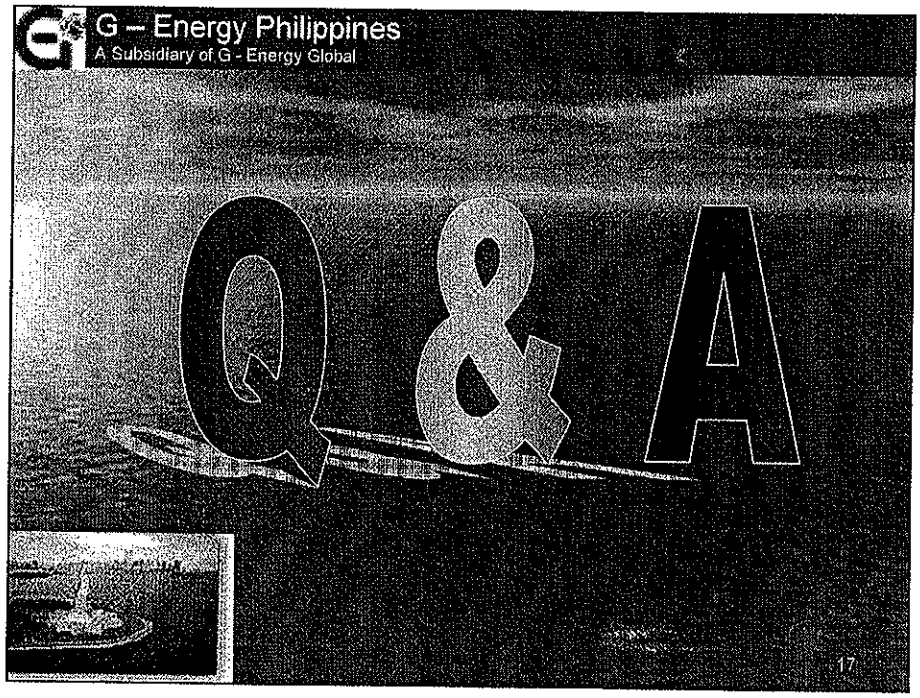
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Q & A
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# Energy Smart Tool

Energy
Sustainability
Unit

Seminar on EAEF Project 6/03-68
Energy Performance Contracting & benchmarking
13 January 2006
School of Design & Environment, NUS

**Sun Hansong**

Energy Sustainability Unit
Department of Building
School of Design and Environment
National University of Singapore

## Energy Smart news

Energy
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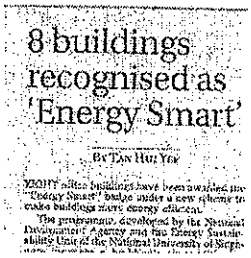
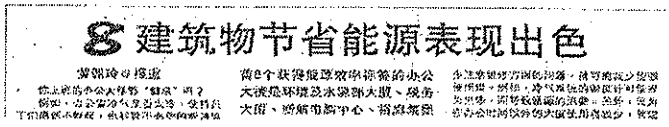

8 buildings recognised as 'Energy Smart'

By Tan Hui Yee

(Straits Times, 17 Dec 05)

(Channel News Asia, 16 Dec 05)


8 建筑物节省能源表现出色

(Lianhe Zaobao, 17 Dec 05)

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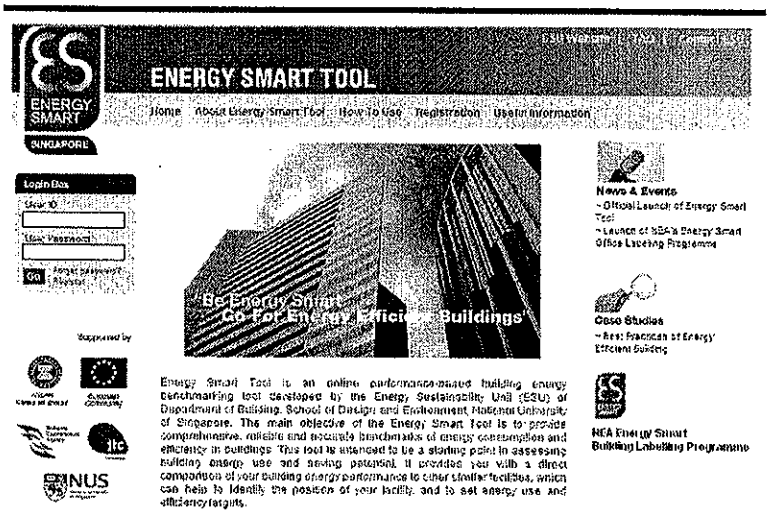
# The Energy Smart Tool

http://www.esu.com.sg/smarttool.php




Energy Smart Tool is an online performance-based building energy benchmarking tool developed by the Energy Sustainability Unit (ESU) of Department of Building, School of Design and Environment, National University of Singapore. The main objective of the Energy Smart Tool is to provide comprehensive, reliable and accurate benchmarks of energy consumption and efficiency in buildings. This tool is intended to be a starting point in assessing building energy use and saving potential. It provides you with a direct comparison of your building energy performance to other similar facilities, which can help to identify the position of your facility, and to set energy use and efficiency targets.

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# Outline

- Background
- Objectives
- Expected impacts on target groups
- How to use
- Benchmark mechanism
- Technical description
- What is next
- Acknowledgement

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## Background

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- EU-ASEAN Energy Facility Project 68
- NEA's building energy smart labelling programme

Dev of a Comprehensive Database for Bldg Energy Performance Benchmarking in the ASEAN Region

www.esu.com.sg/research2.html

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## Objectives

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- To develop a comprehensive, independent and reliable internet based energy benchmarking system accessible by all users.
- From the benchmarking system, to develop a building energy performance classification system, paving the way for building energy labelling.

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## Expected impacts on target groups

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Target Groups:

- Building owner
- Energy Services Companies (ESCOs)
- Financial Institutions (e.g. Banker)
- Public agencies
- Professionals (e.g. property managers, energy engineers and building designers)

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## Expected impacts on target groups

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- Set energy saving targets which are achievable
- Create a transparent and vibrant energy services sector for ESCOs, who can use benchmark as reference in persuading to invest in energy retrofit
- Provide a decision support system for the financing institutions. It also serves to build capacity and save resources.
- Facilitate public agencies in developing incentive schemes and labeling system that would further promote the industry.
- Give guidance and targets for the design and construction of new buildings.

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# How to use

http://www.esu.com.sg/howtouse.php

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Normal User

↓

Registration

↓

Log in

↓

My Facilities
1. Building Contact
2. Building Profile
3. Energy Consumption Data
4. Summary & Results
5. Download Report

↓

Survey

**Remarks**

- For Normal User, registration is free of charge.
- After registration, User can immediately log in to use the Tool.
- My Facilities is the main page after User log in. Click Add New Facility to start data entry. This includes Building Contact, Building Profile and Energy Consumption Data. Click Submit to see the Summary and Results. User can download a report of Summary and Results in a PDF file.
- Under one user account, User can perform benchmarking of multiple buildings (maximum 20). List of the buildings is shown on My Facilities. User can also edit, duplicate or delete buildings from the list.
- User can change password and others information in the User Profile.
- Terminology is provided as guidance for inputting the right data and understanding the results.
- On the printed report, it is stated that the benchmarking result is subject to the data quality input by the User. ESU does not warrant or represent that any outcome produced as a result of the use of the Tool is accurate, or will be the same as, or is indicative of the outcome of any official rating by ESU.
- All the information entered will be saved for the User to review in future logins.
- By filling out the survey (optional), User can give comments and suggestions on the design and functions of the Energy Smart Tool. Your comments/ feedbacks are most welcomed.

*This project has been supported by ASEAN Centre for Energy through the EC-ASEAN Energy Facility*

# Benchmark mechanism

Energy Sustainability Unit

**Design sample frame**

Ensure the sample is representative of the entire building stock targeted and covers a wide spectrum of each building parameter.

manageable by contractor, designer, etc.
- Result of TTV

**Parameter investigation**

Understand manageable and unmanageable factors

geographical climate type of bldg type of HVAC sys.

**Design data collection form & define terminology**

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## Benchmark mechanism

Energy Sustainability Unit

**Data collection & processing**

**Applying primary filters and exclude unqualified data set**

**Data validity test**

Apply statistical integrity and normality tests to ensure accuracy and validity of data set

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## Benchmark mechanism

Energy Sustainability Unit

**Parameter analysis & normalization**

- Weather normalization
- Primary determinant factors
- Correction factors
- Secondary determinant factors

**Determination of energy efficiency indicator**

**Establish benchmark**

Benchmark look-up table and cumulative percentile curve

**Develop web-based benchmarking and application concepts**

*This project has been supported by ASEAN Centre for Energy through the EC-ASEAN Energy Facility*

## Technical description

Energy Sustainability Unit

93 commercial office bldg → in S'pore.
59 flatted [illegible]

- Data sources and building types
- Data primary filters
- Required key input information
- Energy efficiency indicator
- Benchmarking Summary and Results (example)
- Limitations



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## What is next

Energy Sustainability Unit

Version 2.0

- Upgraded database
- Extended building types
- Enhanced normalization strategy
- Benchmark for the ASEAN region
- Promotion of Energy Smart Label/ Tool
- Energy Smart Tool's Corporate Account
- Real time monitoring and benchmarking



*This project has been supported by ASEAN Centre for Energy through the EC-ASEAN Energy Facility*

## Acknowledgement

Energy Sustainability Unit

ESU would like to express deepest gratitude to the National University of Singapore (NUS), EC-ASEAN Energy Facility (EAEF) Project 68, National Environment Agency (NEA), Jurong Town Corporation (JTC) and building owners for their support towards the development of Energy Smart Tool.

# Thank you

Energy Sustainability Unit

*For further information of the Energy Smart Tool, visit- www.esu.com.sg*

Sun Hansong (Project Leader of EAEF Project 68)
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# Preparing for Energy Smart Office Awards- Experience from the 8 Energy Smart Offices

Energy Sustainability Unit

Seminar on EAEF Project 64 & 68
Energy Performance Contracting & Benchmarking
13 January 2006
National University of Singapore

**Priyadarsini**

Energy Sustainability Unit
Department of Building
School of Design and Environment
National University of Singapore

National Environment Agency

## Outline

- Introduction
- The Process
- Performance Standards
- Benchmarking
- Systems' performance
- Indoor Environmental quality
- Future work

Seminar on Energy Performance Contracting and Benchmarking 13 January 2006

## Introduction

ENERGY SMART OFFICE is a Building Energy Efficiency Labelling System.

This is the first product of the NUS-NEA joint project entitled "Development of Building Energy Efficiency Labelling System".



## The Process Towards Energy Smart Office

1. Preliminary Benchmarking
2. Appoint an accredited ESCO
3. Review by ESU
4. Set Target & Track Progress

Seminar on Energy Performance Contracting and Benchmarking 13 January 2006

## Performance standards

1. EUI in top 25 percentile
2. Systems' performance
3. Indoor Environmental quality
4. Occupants' survey



## Benchmarking- Energy Performance

- Top 25% < 177 kWh/m²/yr
- Should include the total (landlord + tenant) energy consumption
- Even though all the buildings reviewed were office buildings, the type of office usage had a significant effect on the EUI
- Banks, especially international ones consume a lot of energy for
  - data centers/server rooms in terms of high usage intensity
  - trading services in terms of long operating hours

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## Calculation of EUI

Normalised EUI= (TBEC-DCEC-CPEC)/(GFA-CPA-DCA).

Where,

- TBEC = Total building annual energy consumption
- DCEC = Data centre energy consumption = 3016 * DCA
- CPEC = Car park energy consumption
- *GFA = Gross floor area including car park
- CPA = car park area (above ground + under ground)
- DCA = data centre area

  * GFA shall be enlarged in the case of long operating hour tenants/ areas where the Enlarged area = actual area of long operation x actual operating hours/**normal operating hours

  ** Normal operating hours = 55 hrs/week



## Calculation of EUI

- Lower EUI does not always imply that the building is very energy efficient.
- The lower EUI can be as a result of the low intensity office activities.

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## Systems' Performance

- Air Conditioning
- Lighting
- Mechanical ventilation

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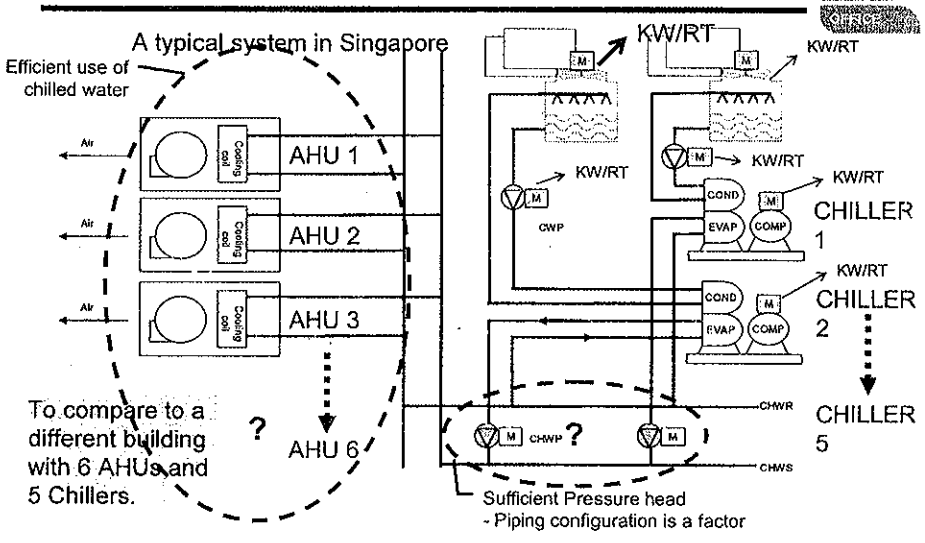
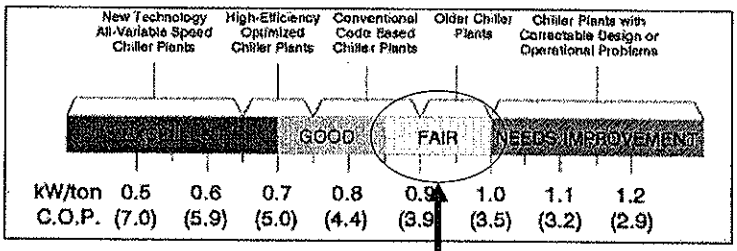
## Air conditioning Systems' Performance



## Air conditioning Systems' Performance




Plant room efficiency < 1.0 kW/RT

- Does not consider primary and secondary chilled water pumps for the calculations of air conditioning system performance

Source: ASHRAE Journal, September 2001

ENERGY SMART OFFICE

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## Air conditioning System's Performance

- The audit of the chiller plant should be planned and conducted with utmost care.
- The power consumption of each of the sub systems like chillers, pumps and cooling towers should be separately measured.
- The measurement time should represent the most typical days with full load conditions and continuous logging should be done for a minimum of 1 week.

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## Lighting System's Performance

- Use W/m$^2$ as an indicator for efficient use of energy in lighting need.
- Various methods of optimizing lighting's energy use such as timer controls, use of dimmers, integration with day lighting, Building Automation System (BAS) etc.







## Lighting System's Performance

- Record the total number of fittings;
- Identify the type of fixture including wattage and ballast lost;
- Estimate energy consumption from the rated power;
- Estimate the lighted areas from drawing plans;
- Calculate the lighting power density;
- Verify the calculated value by measuring the DB.






## Indoor Environmental Quality

- **Thermal comfort**
- **Illumination**
- **IAQ**
- **Ventilation**



## Indoor Environmental Quality

- Out of the 4 parameters, thermal comfort and illumination level were easily met by most of the buildings.
- However, Ventilation (fresh air) and Indoor Air Quality which is dependent on the ventilation were out of the specified range in many cases.
- High $CO_2$ level and high bacterial count were the most commonly observed problems.

## Ventilation measurement methodology

- Measure the air velocity at 9 different cross sections (m/s);
- Find the average air velocity (m/s);
- Measure the cross sectional area ($m^2$);
- Calculate the air volume (L/s) ;
- Measure the floor area served by that particular AHU ($m^2$);
- Calculate the ventilation rate in $L/s/m^2$ ;
- Repeat the same for other AHUs and find the average ventilation rate.

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## The Achievements of an Energy Smart Office

1. It is energy efficient, and among the top 25% of cohort.
2. Its systems are fine.
3. Its indoor environment is healthy.
4. Its users are satisfied.
5. It is independently checked, measured and verified.

Seminar on Energy Performance Contracting and Benchmarking 25 January 2006

## Future Works

- Hotels
- Hospitals
- Shopping Centres
- Schools



## Acknowledgement

**The ESU would like to acknowledge the following:**

**The Ministry for the Environment and Water Resources,**

**The National Environment Agency,**

**Industry members who support generously in the sharing of data and building information,**

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Seminar on Energy Performance
Connecting and Benchmarking
15 January 2008

# Benchmarking Industrial Building Energy Performance

Energy Sustainability Unit

Seminar on EAEF Project C4.8.68
Energy Performance Contracting & Benchmarking
13 January 2006
School of Design & Environment, NUS

**Chia Yen Ling**

Energy Sustainability Unit
Department of Building
School of Design and Environment
National University of Singapore

## Benchmarking Industrial Building Energy Performance

Energy Sustainability Unit

### Presentation Outline

- Objectives
- Introduction
- Methodology
- Key Energy Performance Indicators
- Energy Benchmark
- Benefits
- Potential Cost Savings
- Conclusion
- Ongoing work

*This project has been supported by Jurong Town Corporation*

## Objectives

Energy Sustainability Unit

- To identify and rank performance indicators affecting energy performance of industrial buildings.
- To develop a benchmarking curve or a set of curves for evaluating and benchmarking energy performance of industrial buildings.

*This project has been supported by Jurong Town Corporation*

## Introduction

Energy Sustainability Unit

### Types of Industrial Buildings

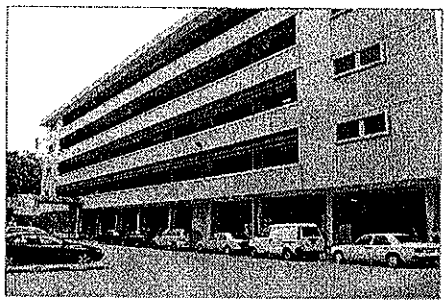
- Flatted Factories (77 blocks - 1.4mil $m^2$)
- Stack-up Factories (90 units - 2.4mil $m^2$)
- Standard Factories (1579 units - 0.2mil $m^2$)
- Workshops (796 units - 0.17mil $m^2$)

*This project has been supported by Jurong Town Corporation*

## Introduction

Energy Sustainability Unit

### What is a 'flatted factory'?



- High-rise industrial buildings ready-built multi-tenanted factories developed by industrial landlord
- Tenanted to various small to medium size enterprises for light industries

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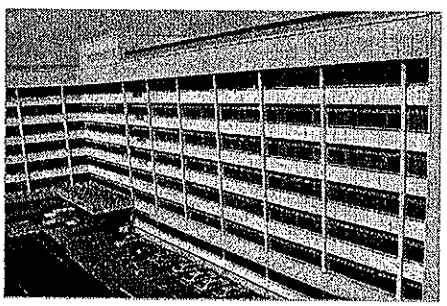
## Introduction

Energy Sustainability Unit

### What is a 'flatted factory'?



- Typically 5 to 7 storeys high
- Common spaces, shared amenities and services are maintained and operated by landlord

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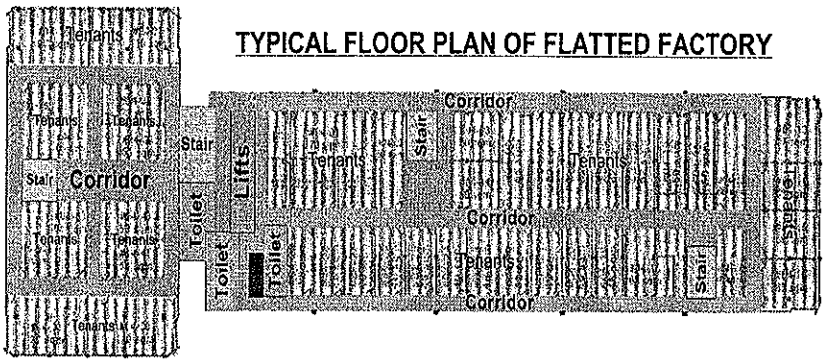
# Introduction

Energy Sustainability Unit

## Typical floor plan




*This project has been supported by Jurong Town Corporation*

# Methodology

Energy Sustainability Unit

**PLANNING PHASE**
- Define scope & frame study

- Total Population
- Sample Size

**DATA COLLECTION PHASE**
- Determine data required
- Develop survey instrument
- Administer trial survey
- Refine survey instrument
- Verify energy & building data
- Compile survey data

- Energy consumption data
- Determine time period for which bills are collected
- Formulation of data acquisition template
- Verify energy and building data

**ANALYSIS PHASE**
- Analyse survey results
- Measurement (Datalog)
- Conduct case studies

- Test for data reliability
- Identify energy performance indicators
- Establish energy benchmarks for flatted factories

**REPORTING PHASE**
- Identify beneficial practices
- Report study results
- Dissemination of findings

- Web-based benchmarking system
- Final technical report

# Methodology

## Step 1: Scope and definition

- Select industrial property type

  *Flatted factory*, Standard factory, Stack-up factories, Workshops

- Determine population size of existing stock

  77 flatted factories

- Determine sampling method

  Random sampling was employed. 59 responses out of a total of 77, resulting in a 77% response rate.

- Determine information requirements

  Building physical characteristics, operating schedules, management info

- Definition of terms

  e.g. Gross Floor Area, Common Area

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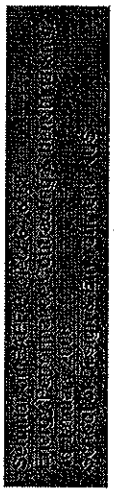
ENERGY SMART

Energy Sustainability Unit



# Methodology

## Step 2: Data Collection

- Energy consumption data

  *Extracted directly from original monthly electricity bills for each flatted factory, so a high level of accuracy was achieved.*

- Determine time period for which bills are collected

  *Electrical bills collected for a 12-month period for the year 2003*

- Formulation of data acquisition template

  *Building characteristics data were collected from industrial landlord & facility personnel*

- Verify energy and building data

  *Site visits were conducted to verify the information*

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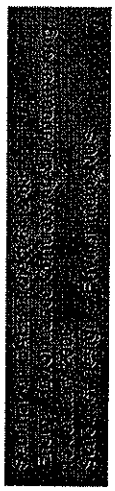
ENERGY SMART

Energy Sustainability Unit



# Methodology

Energy Sustainability Unit

## Step 3: Data Analyses

- Test for data reliability

  *Average design efficiency (gross lettable area to gross floor area) is 71% with a 95% confidence interval of +/- 2.1%.*

- Identify energy performance indicators

  1. *Simple linear regression*

  2. *Stepwise least-squares multivariate linear regression*

- Establish energy benchmarks for flatted factories industrial buildings

  *Approach 1: Using the average performance of a group as an energy benchmark*

  *Approach 2: Cumulative distributional energy benchmarking*

*This project has been supported by Jurong Town Corporation*

# Key Energy Performance Indicators

Energy Sustainability Unit

## Simple Linear Regression

| Potential Energy Performance Indicators | $R^2$ values |
|---|---|
| Gross floor area ($m^2$) | 0.684 |
| Rentable area ($m^2$) | 0.481 |
| Landlord common area ($m^2$) | 0.807 |
| Number of lifts (nos.) | 0.606 |
| Floor-to-floor height (m) | 0.463 |
| Volume of flatted factory ($m^2$) | 0.798 |
| Volume of landlord common area ($m^3$) | 0.855 |
| Age (years) | 0.339 |
| Occupancy rate (%) | 0.011 |

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# Key Energy Performance Indicators

Energy Sustainability Unit

## Stepwise least-squares multivariate linear regression

| Model | Equation | $R^2$ | Adjusted $R^2$ | P-Value | VIF |
|---|---|---|---|---|---|
| 1 | $\hat{E}$ = 3136.47 + 0.868 (***Volume of landlord common area***) | 0.854 | 0.852 | < 0.0005 | < 5 |
| 2 | $\hat{E}$ = 4306.386 + 0.708 (***Volume of landlord common area***) + 1930.804 (Number of Lifts) | 0.881 | 0.877 | < 0.0005 | < 5 |
| ⊗ | $\hat{E}$ = 4306.386 + 1.150 (***Volume of landlord common area***) + 2251.767 (Number of lifts) – 2.423 (Landlord common area) | 0.890 | 0.884 | < 0.0005 | > 5 |

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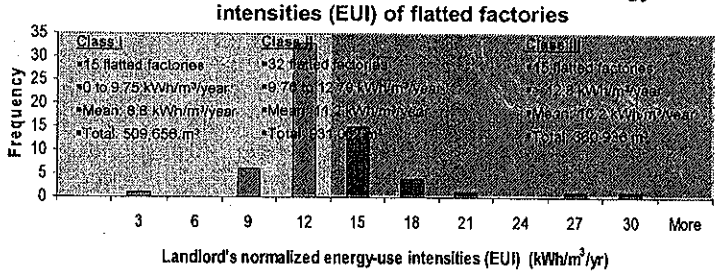
# Normalized Energy-Use Intensities (EUI) Benchmark

Energy Sustainability Unit

## Approach 1: Using the average performance of a group as an energy benchmark

**Frequency distribution of landlord's normalized energy-use intensities (EUI) of flatted factories**



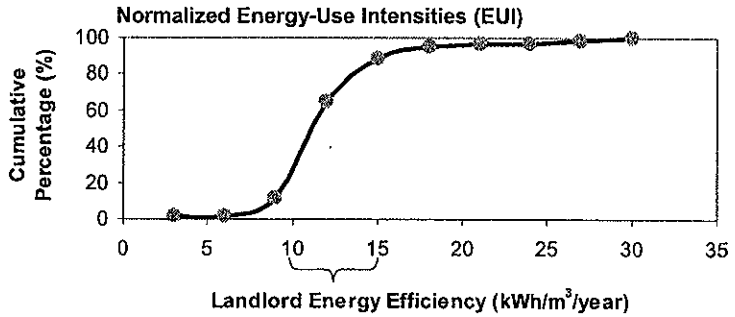

- Mean value is 11.71 kWh/m³/year
- Skewness value of 0.68
- Approximately 50% of the buildings studied have energy efficiencies below the mean value of 11.71 kWh/m³/year

*This project has been supported by Jurong Town Corporation*

# Normalized Energy-Use Intensities (EUI) Benchmark

Energy Sustainability Unit

## Approach 2: Cumulative distributional energy benchmarking




- 70% of the buildings studied have EUI of between 10 and 15 kWh/m$^3$/year
- Benchmarking metrics established by Royal Institution of Chartered Surveyors (RICS) in 1993 ranges from 29 to 38 kWh/m$^3$/year

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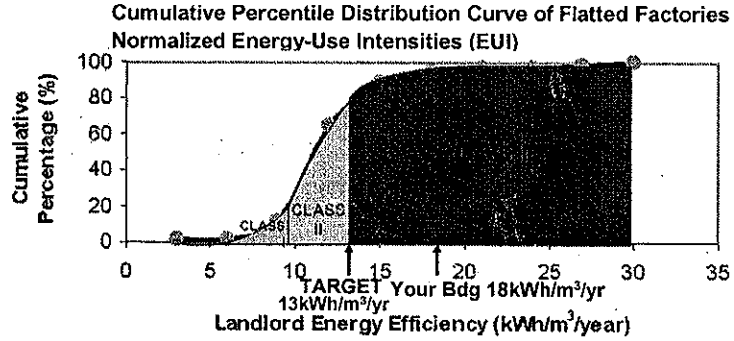
# Normalized Energy-Use Intensities (EUI) Benchmark

Energy Sustainability Unit

## Approach 2: Cumulative distributional energy benchmarking (Application)




- For *existing buildings*, building owners may determine his/her building performance ranking & set energy efficiency target for its management.
- For a *proposed new building*, a developer can set target for his design team.

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# Reliability of Benchmark Curve

Energy Sustainability Unit

1. **Variance**

$$Var = \frac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}{n-1}$$

2. **Coefficient of Variation**

$$CV = \left(\frac{S}{\overline{X}}\right)100\%$$

This applies to linear functions which involves one variable.

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# Reliability of Benchmark Curve

Energy Sustainability Unit

**The cumulative benchmark curve is**

- Non-linear function
- EUI is a composite measure of Energy Consumption (kWh) / Volume of landlord common area

Thus,

**TAYLOR SERIES LINEARIZATION METHOD is used.**

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# Reliability of Benchmark Curve

Energy Sustainability Unit

**TAYLOR SERIES LINEARIZATION METHOD** (Wolter, 1985)

If the function is a ratio of two random variables i.e. $\hat{R} = \frac{\hat{X}}{\hat{Y}}$ , then the simple expression for the ***Taylor linearized estimated variance*** is

$$Var(\hat{R}) = \hat{R}^2\left[\frac{Var(\hat{Y})}{\hat{Y}^2} + \frac{Var(\hat{X})}{\hat{X}^2} + 2\frac{Cov(\hat{Y},\hat{X})}{\hat{Y}\hat{X}}\right]$$

*where* $\hat{Y} = N\bar{y}$ & $\hat{X} = N\bar{x}$ (in the case of simple random sampling)

($N$ = *sample size,* $\bar{y}$ = *mean value of energy consumption,* $\bar{x}$ = *mean value of volume*)

And the corresponding ***estimated coefficient of variation (CV)*** is

$$cv(\hat{R}) = \sqrt{v(\hat{R})}/\hat{R}$$

*This project has been supported by Jurong Town Corporation*

# Reliability of Benchmark Curve

Energy Sustainability Unit

In applying TAYLOR SERIES LINEARIZATION METHOD,

The ***Taylor linearized estimated variance***

$$Var(\hat{R}) = 0.0051$$

And the corresponding ***estimated coefficient of variation (CV)*** is

$$cv(\hat{R}) = 0.006219\ (0.6219\%)$$

*Low variance and CV value indicates high reliability of the benchmarking curve developed!*

*This project has been supported by Jurong Town Corporation*

# Benefits

Energy Sustainability Unit

- With the accurate benchmarking developed, industrial landlords can set new energy targets for efficiency.
- Improved design and specifications for new or retrofitting projects.
- Identify buildings for retrofit.

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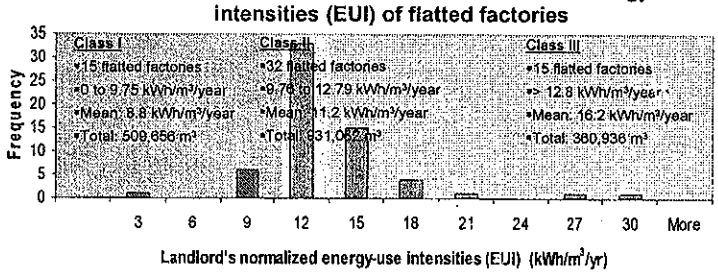
# Potential Cost Savings

Energy Sustainability Unit

**Scenario 1: All flatted factories meet the average performance**

**Frequency distribution of landlord's normalized energy-use intensities (EUI) of flatted factories**




- Average performance is 11.71 kWh/m³/year
- If all existing flatted factories is benchmarked against the average performance, these are the cost savings that can be accrued:

Possible Energy Saving (kWh/year) = 1.9 million kWh
Cost Savings (kWh/year) = $323,000

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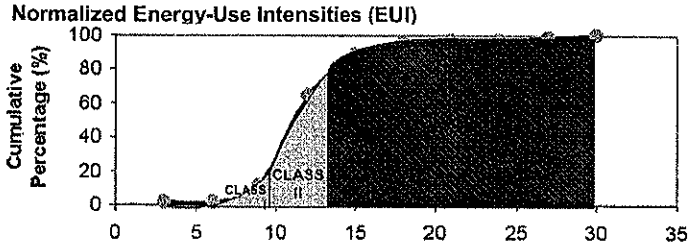
# Potential Cost Savings

Energy Sustainability Unit

**Scenario 2: All Class III flatted factories are benchmarked against Class II flatted factories**

Cumulative Percentile Distribution Curve of Flatted Factories
Normalized Energy-Use Intensities (EUI)




Landlord Energy Efficiency (kWh/$m^3$/year)

- If all Class III flatted factories is benchmarked against Class II performance, these are the cost savings that can be accrued:

Possible Energy Saving (kWh/year) = 1.4 million kWh
Cost Savings (kWh/year) = $243,000

*This project has been supported by Jurong Town Corporation*

# Ongoing Work

Energy Sustainability Unit

## Detailed Energy Audit Study

- Studies include site measurement, energy datalogging and building assessment.
- Aim:

  Diagnostics work

  To gain a profiling of energy performance with respect to systems' performance for the three classes.

  To develop systems' energy benchmark

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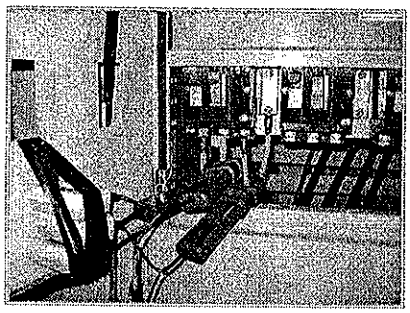
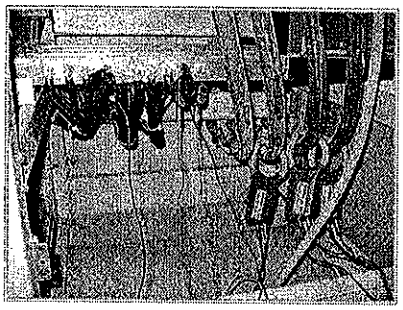
# Ongoing Work

Energy Sustainability Unit

**Class I Flatted Factory**





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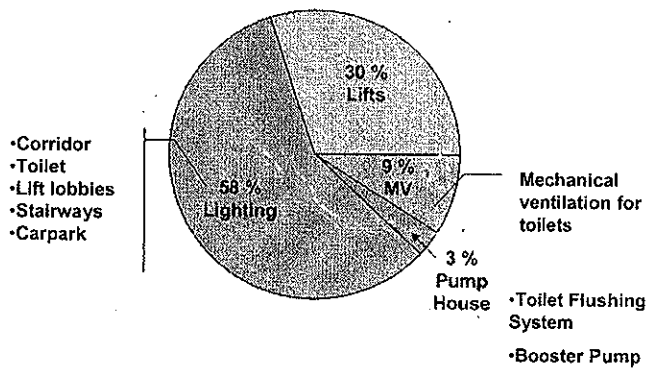
# Ongoing Work

Energy Sustainability Unit

## How is landlord's energy consumed in common spaces?




*This project has been supported by Jurong Town Corporation*

## Conclusion

- Volume of landlord common area is one of the key energy indicators of industrial buildings.
- Cumulative distributional energy benchmarking is a more effective benchmarking tool.
- Industrial landlords can use the energy benchmark curve to compare his own energy performance with that of others.

Energy Sustainability Unit

*This project has been supported by Jurong Town Corporation*

## THANK YOU

**The financial sponsorship and contributions of Jurong Town Corporation are hereby gratefully acknowledged.**

Energy Sustainability Unit

*This project has been supported by Jurong Town Corporation*