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FOREWORD

The APEC Steering Group on Energy Standards was created to investigate the reduction of the need for energy performance testing in the APEC region. The investigation was to include mutual recognition of test results, the use of algorithms to translate between test methods, the alignment or harmonisation of test standards and, possibly, the eventual alignment or harmonisation of energy performance requirements.

A recent study on energy performance standards and regulations in APEC member economies shows that the circumstances for each product group are generally unique, and that different approaches are appropriate. Three product groups stood out as likely to benefit from in-depth technical consideration. The Colloquium on Minimum Energy Performance Standards, held in Seoul from 6th to 8th October 1999, concentrated on two of these products: domestic air-conditioners and ballasts for fluorescent lamps. (The third product group, domestic refrigeration appliances, will be the subject of a separate study.)

The colloquium assembled two groups of technical experts for three days. This gave time for all to gain a thorough understanding of the different circumstances that affect the energy performance requirements in the various APEC member economies, and to recommend ways of proceeding in order to meet the aims of the SGES. It was noteworthy that consensus was reached swiftly, and that the approaches recommended for the two product groups were distinctly different.

Especially pleasing was that at least two of the participating economies actively acted on the recommendations of the colloquium within two weeks. It therefore seems safe to recommend that those responsible for introducing and implementing energy efficiency performance requirements for air-conditioners and fluorescent lamp ballasts should consider carefully the outcomes of the colloquium as presented in this book and adopt the recommendations. In this regard, the colloquium definitely and significantly advanced the work of the SGES along its path.

The colloquium would not have been the success it was without the organisation and generous input made by the hosts. Particular thanks are due to Deputy Director Young-Kyun Ko of the Ministry of Commerce, Industry & Energy, and to Mr Sung-Moon Jung of the Korea Energy Management Corporation. Deputy Director Ko's predecessors at MoCIE, Mr Byung-Nae Yang and Dr Mi-Chung Anh, also made valuable contributions. The site visit to the Korea Testing Laboratory was very much appreciated, and helped maintain a link with reality. At the colloquium itself, Mr Lloyd Harrington and Dr George Wilkenfeld undertook their roles as facilitators in a highly commendable and competent manner, while Khun Sood Ratanadilok Na Phuket has produced an excellent record of the event.

Thanks are also due to the APEC Secretariat for their understanding and help with arranging the participation of the experts. In addition, I would like to thank my colleague at EECA, Miss Sheralee MacDonald, for dealing expertly and in a timely

manner with the details of the organisation of the colloquium. Lastly, of course, the colloquium would have been nothing without the active and enthusiastic participation of the assembled experts.

David Cogan, Project Overseer
Steering Group on Energy Standards, EWG, APEC

The colloquium provided a forum for representatives of APEC member economies to share and discuss issues related to minimum energy performance standards for ballasts and air conditioners. This compilation provides summaries of the discussions and exchanges of viewpoints and ideas that occurred, as well as summaries of the papers and presentations that were presented at the colloquium. It is also a collection of viewpoints of the editors and participants on related issues; as such, it does not imply the viewpoint of APEC. Comments or inquiries on the proceedings should be forwarded to:

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EXECUTIVE SUMMARY

The *Colloquium on Technical Issues of Minimum Energy Performance Standards*, held in Seoul, Korea on 6-8 October 1999, was organized under the initiative of the Steering Group on Energy Standards (SGES), a sub-group of the APEC Energy Working Group. The 3-day colloquium was one of several activities initiated by the SGES to stimulate progress in the alignment of international energy performance standards for electrical appliances and equipment. The colloquium focused on the issues of minimum energy performance standards (MEPS) for two energy-consuming products: the ballast for fluorescent lamps and the air conditioner.

The main objectives of the colloquium were to:

- Provide and exchange information on the technical requirements and issues of energy performance standards and testing of ballasts and air conditioners in APEC member economies;
- Increase awareness of the importance of standards alignment;
- Improve networking and information sharing between those involved in energy performance standards and testing of ballasts and air conditioners;
- Stimulate formation of expert groups for ballasts and air conditioners to carry on the work; and
- In the long run, increase the availability of energy efficient products by reducing non-tariff trade barriers between APEC member economies.

Approximately 30 representatives from eleven member economies attended the colloquium to share technical expertise and viewpoints. The majority of participants were selected technical experts on ballast or air conditioner (A/C) testing. The colloquium facilitated a forum for the delegates to discuss and exchange viewpoints on the technical issues and problems of energy performance testing for ballasts and air conditioners.

The delegates were separated into two groups: Ballast group and A/C group. Separating the sessions was a critical strategy that helped stimulate detailed discussions on the issues specific to each product type. The following are the important key points and recommendations from the colloquium.

Ballast Session

Current international standards for ballasts do not include a method to determine the efficacy of all ballast types, consequently:

1. There is a number of different test procedures for determining ballast energy consumption and efficacy, partly due to the different ballast types in some markets, such as switch start, rapid start, and electronic types.
2. There is no suitable international standard for the measurement and expression of fluorescent lamp ballast efficacy;
3. Those economies with MEPS requirements for ballasts generally set different MEPS levels, even for the same product classes. Energy labelling requirements also vary.

Despite differences in the approaches, there is a great deal of commonality between all of the test methods. After careful examination of the major test methods, the Ballast group believed that it will be feasible to draft a testing procedure that can provide the test data universally required by the standards in all APEC member economies. Key elements of such a testing standard are outlined below.

Variables that need to be measured:

- Total input power
- Relative light output
- Input power for lamp on reference ballast
- Input power for lamp on the test ballast (where possible)

Other information required:

- Rated lumen output for reference lamp
- Rated lamp power at rated output for reference lamp

Reference system:

- Specifications for reference ballasts and lamps.

Technical issues to be resolved:

- Competence of the various systems currently used (box system vs. room measurements vs. integrating sphere) for determination of relative light output
- Optimal frequency of the high-frequency supply to high-frequency reference ballasts
- Formulation of a function that can represent the variation of light output with respect to lamp input power

Conclusion of the Ballast Session

The participants from Australia, Japan and Korea agreed to investigate whether information on these points above already exists or whether further testing is required. The Ballast group agreed that the basic next steps are as follows:

1. Finalise agreement on major issues and undertake research on outstanding technical points.
2. The project overseer and rapporteur to report to APEC Steering Group on Energy Standards (SGES) meeting in November 1999 and get in principle approval for next steps and future directions.
3. Formally engage all APEC Economies that have ballast efficacy requirements in place or proposed to ensure that the proposed method is acceptable.
4. Develop a draft standard document in consultation with participants and APEC SGES members. Australian SGES representatives are to take a lead role.
5. Australia and New Zealand may take the draft document and proceed to publish it as a joint standard in late 1999/early 2000.
6. SGES to form a self funded project to move the draft standard into IEC as a new work item proposal.

Air Conditioner Session

There were 5 main issues that were discussed by the A/C group. Below are the issues and recommendations for actions concluded at the colloquium.

A/C Test Standard

It was agreed that ISO5151-1994 is generally satisfactory as a common basis for testing. However, the standard does not address some factors which have been found to impact on test results, such as atmospheric pressure variations due to the altitude of the laboratory, and some economies depart from the standard test conditions. Algorithms should be developed to:

- adjust results from non-standard tests to standard conditions; and
- compensate for the altitude effect.

These algorithms should be developed co-operatively, on the basis of further research and with the involvement of experts from APEC economies, to ensure that they will be widely accepted as alternatives to physical tests. They should be included in a future revision of ISO 5151.

Repeatability, Variability and Acceptability of Tests

Some economies only accept the results of tests done locally or from selected laboratories. Others apply a range of criteria to decide which laboratories are acceptable. The greater the confidence in test results carried out in different laboratories, and other economies, the less demand there will be that products are re-tested for each economy.

- It is desirable to strengthen and expand mutual recognition agreements covering the testing of air conditioners for regulatory compliance purposes. The existing moves in APEC toward mutual recognition should be supported.
- It is desirable that the test tolerance that economies accept for regulatory purposes should converge, and ultimately be harmonised.

Classification of Products

There is a need for a standard classification system for air-conditioners, covering cooling and/or cooling-heating equipment that is electrically powered and has a direct expansion device, and that would be tested and compared under ISO standards 5151, 13253 and 15042.

Inverter/VSD Products

Existing steady-state test does not rate energy efficiency in the most likely modes of operation. The problem increases when comparing inverter and variable speed drive (VSD) machines with single speed machines. This issue is currently under discussion in ISO Working Group 6, which was considered to be the appropriate forum for resolving it. The A/C group:

- supports ISO Working Group 6 and request that it develops procedures as quickly as possible; and
- encourages APEC members to actively participate in Working Group 6 to help bring its work to a rapid conclusion.

Modelling and Simulation

The A/C group discussed the issue of allowing manufacturers to demonstrate compliance to MEPS with a computer simulation, instead of physical testing. The delegates considered that computer simulation was reasonably reliable when manufacturers used their own proprietary ("private") programs to model the performance of their own products. However, using "public" programs to model the performance of products from different manufacturers is not sufficiently reliable for regulatory purposes at present. Further development of modelling and simulation programs or criteria for such programs, with the involvement of APEC experts, is recommended to increase confidence in these programs as an optional alternative to physical testing.

Conclusions of the A/C Session

The highest priority issue was considered to be the development of equivalence algorithms, followed by the development of a standard classification of products. Increasing the repeatability of tests and the acceptability of results between laboratories were the next highest priorities.

The A/C group concluded that full harmonisation of test procedures and test conditions are desirable objectives, but likely to be achieved at different rates. The harmonisation of MEPS levels did not receive support at this stage.

- The harmonisation of test procedures is a medium term objective.
- The harmonisation of test conditions is a medium term objective.
- The harmonisation of MEPS levels is an issue for longer term consideration.

Overall Conclusions

The colloquium achieved its primary goals of providing a forum for experts from different APEC economies to examine the possibility and tasks of aligning testing standards for ballasts and air conditioners. Voluntary tasks have been laid out for the two groups of experts to further their progress.

The colloquium fueled greater regional support for the alignment of testing standards, which in the long run, can help overcome impediments to trade that arise from different regulatory requirements in the various economies. It also improved the network of contacts and information exchange among the professionals involved in energy testing and standards for ballasts and air conditioners. Following these two products, energy testing procedures and minimum energy performance standards for refrigerators will be examined at the APEC Symposium on Domestic Refrigeration Appliances in March 2000 in Wellington, New Zealand.

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I. INTRODUCTION

The APEC *Colloquium on Technical Issues of Minimum Energy Performance Standards* was hosted by the Ministry of Commerce, Industry & Energy (MoCIE) and the Korea Energy Management Corporation (KEMCO) in Seoul, Korea on 6-8 October 1999. The Energy Efficiency and Conservation Authority (EECA) of New Zealand, with technical assistance from Energy Efficient Strategies (EES) and George Wilkenfeld and Associates (GWA), organized the colloquium on behalf of the APEC Steering Group on Energy Standards (SGES).

A. Objectives of the Colloquium

The colloquium was one of the activities initiated by the SGES to stimulate progress in the alignment of international energy performance standards for electrical appliances and equipment. The colloquium focused on technical issues of energy performance standards for two types of electrical equipment: ballasts and air conditioners.

The ballast and air conditioner (A/C) were selected as the first electrical products to be investigated by technical experts from various APEC economies. The selection was decided based upon recommendations from the *Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies*[1], a study conducted in early 1999 by EES with, GWA, PW Consulting, and the International Institute for Energy Conservation (IIEC) for the SGES.

These products were selected as the subjects for the colloquium for a range of reasons. They are manufactured in many APEC economies and are traded in large quantities between the economies. Their technology and patterns of use are reasonably consistent in all markets, so common procedures and standards are feasible. In the case of air conditioners there is already a high degree acceptance of international standards, while with ballasts there are many common elements even though the existing standards differ.

In summary, the main objectives of the colloquium were to:

- provide information on the technical requirements and issues of energy performance testing of ballasts and air conditioners in APEC economies;
- increase awareness of the importance of standards alignment;
- improve networking and information sharing between those involved in energy performance standards and testing;
- stimulate formation of expert groups for ballasts and air conditioners to carry on the work; and
- in the long run, increase the availability of energy efficient products by reducing non-tariff trade barriers between APEC economies.

[1] EES 1999, Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies, project EWG03/98T, prepared by Energy Efficient Strategies (Australia) et al for APEC Secretariat, Singapore, 27 November 1999. ISBN 0-646-38672-7

B. Summary of Events and Activities

Approximately 30 representatives from 11 member economies (Australia, China, Japan, Korea, New Zealand, Malaysia, Mexico, Philippines, Chinese Taipei, Thailand, and USA) participated in the three-day event. The majority of participants were selected technical experts on ballast or air conditioner testing. The colloquium facilitated a forum for the participants to discuss and exchange viewpoints on the technical issues and problems of energy performance testing for ballasts and air conditioners.

Day One

Opening

Mr Jong-Min Yoon, Director of MoCIE, welcomed the APEC delegates and delivered the opening address. He noted the importance of aligning standards between economies and mentioned that:

- Korea has already started to contribute to this initiative by establishing minimum energy performance standards (MEPS) for some products in parallel with international standards.
- The current efforts of the APEC Energy Working Group (EWG) will help move forward the international process.
- By setting common MEPS in the region, long-term objectives of promoting the common prosperity of APEC economies can be achieved.

Mr David Cogan, the SGES project overseer, introduced the SGES and APEC organization to the participants. He also briefly explained how the colloquium came about and what the main objectives were. The colloquium was designed to allow air conditioning and ballast experts to discuss issues in separate focus sessions.

Focus Sessions

The participants separated into two groups: Ballast group and A/C group. The groups convened in separate rooms to start discussions on their topics. The Ballast group included delegates from Australia, China, Japan, Korea, New Zealand, Malaysia, and Thailand. Mr Lloyd Harrington of EES was the moderator for the Ballast group while the A/C group was moderated by Dr George Wilkenfeld of GWA. The A/C group consisted of delegates from all eleven participating economies, except Malaysia.

Figure 1: Ballast Group discusses energy performance testing procedures

The participants in the A/C group spent most of the day sharing information and the status of air conditioner standards and labeling programs in their economies (see Section IV for summary of presentations). The Ballast group also went through a short series of presentations from China, Japan, Korea,

and Thailand. In addition to information exchange about standards activities in the above economies, the discussion papers prepared by Mr Harrington and Dr Wilkenfeld were used to stimulate discussion among the participants in each group.

Day Two

Laboratory Tour

Day two started with an on-site tour of the Korea Testing Laboratory (KTL). Mr Jeong, head of technical supervision division at KTL, introduced the organization, facilities, capabilities, and activities of KTL. The laboratory was established in 1966

Figure 2: Delegates at the Korea Testing Laboratory

and is the authorized testing laboratory for government testing for safety and quality. KTL is appointed by MoCIE to perform high efficiency equipment testing in accordance with the Energy Use Rationalization Law. The delegates were divided into two groups and were given a tour of the various laboratories in the facility.

Focus Sessions

In the afternoon, delegates returned to continue discussions within their focus groups. The Ballast group spent most of the afternoon defining procedures that would cover the ballast energy performance testing requirements of most economies, based on existing methods and references. The A/C group summarised and grouped the issues raised in the first day. Delegates discussed and reached a consensus on the work required to resolve the outstanding issues. These tasks were then voted and ranked in order of priority.

Figure 3: A/C Group discusses issues of air conditioner testing standards

Day Three

Conclusion

In the morning, the two separate focus groups finalized their discussions over the two previous days. The groups recombined in the afternoon for the concluding session. Each group presented their findings and recommendations for comments from all the delegates. Mr Harrington summarized the recommendations for the Ballast group while Dr Wilkenfeld presented the conclusions of the A/C group. All participants agreed that the summaries of their discussions were true and reasonable.

Figure 4: Ballast Group revises recommendations

Closing

Mr Young-Kyun Ko, Deputy Director of MoCIE, thanked the delegates for their participation in the colloquium. He closed the workshop with an appreciation of the initiative of the SGES and the resulting success of the colloquium. This colloquium served as a progressive step towards aligning energy performance testing standards within the Asia-Pacific region. The colloquium also gave encouragement to the participants; it showed the participants how a small working group of international experts may effectively influence international standards.

C. Structure of Colloquium Proceedings

The proceedings of this colloquium provide a reference for the participants and energy professionals who are interested in energy performance standards and testing of ballasts and air conditioners.

Sections II and III are the full summaries of discussions and recommendations of the Ballast and A/C groups, respectively. These summaries are the main parts of the proceedings; it is where the most essential details of the colloquium are captured. Notes on the individual economy presentations on ballasts and air conditioners follow the summaries in Section IV.

The appendices contain the participant list, list of relevant standards, list of downloadable documents (papers and presentations), and the ballast and air conditioner discussion papers (revised and updated with information presented at the colloquium).

II. BALLAST SESSION SUMMARY

The Ballast session was attended by delegates from Australia, China, Japan, Korea, New Zealand, Malaysia & Thailand. Below is a summary[2] of the issues, discussions, and recommendations on ballast energy performance testing standards.

A. Session Objectives

- Exchange of information;
- Examine the potential for translating between different test procedures (conversion algorithms) to reduce costs of retesting;
- Looking towards the use of compatible test procedures for the testing of ballasts.

B. Background

Ballast trade within APEC is large, with some 380 million units imported into and exported from APEC annually. A large proportion of trade (more than 80%) is currently or potentially affected by requirements for MEPS and/or energy labelling within APEC.

Most economies use local standards based on IEC60921 and IEC60929 to assess the performance of ballasts. The present international standards do not include a method to determine the efficacy of all ballast types. This has resulted in the development of a range of different methodologies within APEC for the measurement and expression of ballast efficacy.

A traded product must comply with mandatory requirements in all the markets where it is sold, and the authorities in each market will usually ask for evidence that it does so. This means that a ballast exporter may need to have each model tested several times to demonstrate that it complies with the MEPS requirements in each of the markets where it is sold and that the information on any energy label in each market is correct (where applicable).

The cost and time needed to comply with different energy efficiency programs can add significantly to the cost of traded ballasts, and can constitute a barrier to trade. A common test method for the measurement of ballast efficacy therefore appears likely to contribute to the free flow of products with APEC. However, the workshop participants recognised that the optimum energy program type and requirements within each economy will depend on a range of factors such as market structure, production costs, energy costs, level of economic development and so forth.

The APEC Energy Working Group recently commissioned a review of energy efficiency test standards and regulations in APEC member economies[3]. This

[2] The Ballast Summary was prepared and written by Lloyd Harrington of Energy Efficient Strategies, who was the facilitator and rapporteur for the Ballast session.

[3] EES 1999, Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies, project EWG03/98T, prepared by Energy Efficient Strategies (Australia) et al for APEC Secretariat, Singapore, 27 November 1999. ISBN 0-646-38672-7

surveyed a wide range of energy-using products, including fluorescent lamp ballasts, and detailed the differences in product classifications, MEPS requirements, energy test standards and labels between APEC economies. The study confirmed that the energy program conditions affecting ballast trade do impose costs higher than the "ideal minimum", for the following reasons:

7. There are a number of different test procedures for the determination of ballast energy consumption and efficacy. This is (at least in part) due to the different technology types that are available in some markets; different approaches are required for switch start, rapid start and electronic types.
8. There is no suitable international standard for the measurement and expression of fluorescent lamp ballast efficacy;
9. Those economies with MEPS requirements for ballasts generally set different MEPS levels, even for the same product classes. Labelling requirements also vary.

Current programs within APEC are summarised in Table 1 below.

Table 1: Fluorescent Lamp Ballast Program Types in APEC Economies

	Program Type				
Economy	A. Comparison Label	B. Endorsement Label	C. MEPS	D. Industry Target	E. Other
AUSTRALIA	VL (2002)		M (2002)		
CANADA			M (1995)		O,BC,Q,NS,NB (a)
CHINA		V (2000)	M (2000)		
JAPAN				VH(2005) (b)	
KOREA	M(1992, 1999)		M(1992, 1999)		
MALAYSIA	(d)		M (1999, 2000, 2001)		
NEW ZEALAND	V(UC)		M(UC)		
PHILIPPINES	M (target 1999)		M (target 2000)		
SINGAPORE					VL(1996) (c)
CHINESE TAIPEI			M(1993)		
THAILAND	VL(1996)		M(2003)		
USA			M(1991, 2003?)		
VIETNAM		VL (UC)	(UC)		

Notes: M = mandatory, VL = voluntary program with low impact, VH = voluntary program with high impact, UC = under consideration

- Years in brackets indicate year of implementation plus updates where applicable.
- These are MEPS levels that are set at Provincial level in addition to national Canadian levels: applies in Ontario, British Columbia, Quebec, Nova Scottia, New Brunswick. MEPS levels are all the same but the implementation dates vary from the national date.
- Top Runner program for Japan sets total efficacy requirements for luminaire-ballast-lamp systems – the sales weighted average efficacy for each company's range of products has to meet the target
- Singapore is the accelerated depreciation program which is available for businesses which install high efficiency products.
- For Malaysia, the watts loss for the ballast has to be marked on the product.

C. Information Exchange

Brief summaries of the major test methods used to determine MEPS or labelling requirements in each economy are included below. Most systems require the use of a reference lamp which is run with a reference ballast. The same reference lamp is then run by the ballast under test.

Australia

The European method is under consideration for adoption. MEPS levels are expressed in terms of total circuit power, adjusted for light output and corrected to the nominal lamp power.

Canada

The method is aligned with the North American approach. MEPS levels are expressed in terms of Ballast Efficiency Factor (relative light output per total circuit watts).

China

The method is aligned with the North American approach. MEPS levels are expressed in terms of Ballast Efficiency Factor (relative light output per total circuit watts).

Japan

The method has been developed within Japan. Top Runner requirements specify ballast/lamp total nominal lumens per watt (relative total lumens per watt, adjusted with a temperature factor to take into account the actual temperature of the lamp during normal operation).

Korea

The method has been developed in Korea. MEPS levels are expressed in terms of test ballast/lamp lumens per watt over reference ballast/lamp lumens per watt.

Malaysia

The method that has been developed in Malaysia is based on IEC60921 – it is not suitable for rapid start or electronic ballasts. MEPS levels are expressed in terms of ballast watts loss. The test method is currently under review.

New Zealand

The European method is under consideration for adoption. MEPS levels are expressed in terms of total circuit power, adjusted for light output and corrected to the nominal lamp power.

Philippines

The method has been developed in Philippines based on IEC60921 – it is not suitable for rapid start or electronic ballasts. MEPS levels are expressed in terms of ballast watts loss.

Singapore

No testing required or MEPS levels specified.

Chinese Taipei

The method appears to have been developed in Chinese Taipei but the methodology is not documented in relevant local standards. MEPS levels are expressed in terms of ballast watts loss – it is not known whether this is corrected for lamp output or how this is determined for rapid start and electronic systems.

Thailand

The method has been developed in Thailand. MEPS levels are expressed in terms ballast watts loss but this is verified through a measurement of total lumens per watt.

USA

The method is aligned with the North American approach. MEPS levels are expressed in terms of Ballast Efficiency Factor (relative light output per total circuit watts).

Vietnam

The test method and MEPS levels are under consideration.

D. Observations

Despite differences in the approaches, there is a great deal of commonality between all of the test methods. All use a reference lamp and compare the operation of this lamp with a test ballast and a reference ballast. Most methods use metrics that combine relative light output (or a substitute for light such as lamp input power) and total circuit power input. Some also require correction of the lamp power to nominal values (Australia/NZ) while Japan requires lamp surface temperature in the luminaire to be determined so that an additional correction factor can be applied.

After careful examination of the major test methods, the Ballast group believed that it will be feasible to draft a testing procedure that can provide the test data universally required by the standards in all APEC economies. Key elements of such a testing standard are outlined below.

Variables that need to be measured:

- Total input power – for both reference and test ballast systems
- Relative light output – for both reference and test ballast systems (may need an integrating sphere for Thailand)
- Input power for lamp on reference ballast, plus test ballast for low-frequency systems (Australia/NZ only)

Other information required:

- Rated lumen output for reference lamp (from catalogue specifications)
- Rated lamp power at rated output for reference lamp (from catalogue specifications & IEC)

Reference system:

- The source of specifications for reference ballasts and lamps needs to be specified. Best source is likely to be IEC standards 60081, 60901, 60921 & 60929 as these already define suitable reference lamps and ballasts for all lamp and ballasts types.
- There is a need to use ILCOS coding system (IEC TS 61231).

Technical issues to be resolved:

- Box system versus room measurements versus integrating sphere for determination of relative light output – some direct comparative measurements are required to ensure that relative light output remains unaffected by type of box (note that IEC60921 has broad specifications for relative lamp output - non photometric measurements).
- Frequency of operation for high frequency reference ballasts – currently IEC uses 25 kHz while Japan specifies 45 kHz – need to determine how lamp output is

affected by change in frequency above 25 kHz.

- When using the non-preferred method of lamp input power (instead of relative light output), there is a need to develop a function of lamp power versus light output and to verify that this is not affected by changes in ballast type, changes from 50 to 60 Hz or the lamp type and size (eg mono-phosphor versus tri-phosphor lamps). If a satisfactory stable relationship can be established, this function needs to be incorporated into the standard.

The participants from Australia, Japan and Korea agreed to investigate whether information on these points already exists or whether further testing is required.

E. Conclusions – The Way Forward

The meeting agreed that the basic next steps are as follows:

1. Finalise agreement on major issues and undertake research on outstanding technical points.
2. The project overseer and rapporteur to report to APEC Steering Group on Energy Standards (SGES) meeting in November 1999 and get in principle approval for next steps and future directions.
3. Formally engage all APEC Economies that have or propose ballast efficacy requirements to ensure that the proposed method is acceptable (project overseer to make contact through SGES representatives).
4. Develop a draft standard document (based on topic headings developed during the colloquium) in consultation with participants and APEC SGES members. Australian SGES representatives to take lead role and compile comments via email.
5. Australia and New Zealand may take draft document and proceed to publish as a joint standard in late 1999/early 2000.
6. SGES to form a self funded project to move the draft standard into IEC as a new work item proposal (this carries most weight if a published national standard is used as the basis for the new work item). This will require some ongoing commitment to attend meetings from project participants. There is a need to flag the proposed standard with key European players to minimise possible resistance.

III. AIR CONDITIONER SESSION SUMMARY

The Air Conditioner (A/C) session was attended by experts from nine of the sixteen APEC economies with air conditioner energy efficiency programs: Australia, China, Japan, Korea, Mexico, the Philippines, Chinese Taipei, Thailand and the USA. Collectively, these economies represent over 90% of the world air conditioner market.

A discussion paper (see Appendix IV) was circulated prior to the colloquium. The colloquium proceeded as follows:

1. Each delegate made a presentation in which they clarified the situation in their economy, responded to issues raised in the discussion paper and identified other matters of importance.
2. The facilitator summarised and grouped the issues raised.
3. Delegates discussed and reached a consensus on the issues and the further work required to resolve them.
4. Delegates ranked the tasks identified in order of priority.
5. The facilitator summarised the proceedings and reported to the plenary session.

Below is a summary[4] of the issues, discussions, and recommendations on air conditioner energy performance testing standards.

A. Session Objectives

The objectives of the A/C session were:

- To consider the material concerning air conditioners in the *Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies*[5] and add to or correct it where necessary;
- To consider the benefits of, and barriers to, harmonising aspects of the energy test procedures and other protocols for air conditioners
- If the benefits are considered worthwhile, to advise on a "convergence strategy".

B. Background

Air-conditioner trade among APEC economies was worth about US$ 3,000 – 3,300 million in 1996. Much of this trade is affected in some way by minimum energy performance standards (MEPS) and energy labelling programs. Imports into APEC economies that have mandatory MEPS and/or labelling programs for air conditioners (see Table 2) accounted for 76% of the value of intra-APEC air conditioner trade. If economies with voluntary programs are included (some of which are likely to become mandatory), then more than 95% of intra-APEC air conditioner trade is destined for economies with MEPS and/or labelling programs.

[4] The A/C Summary was prepared and written by Dr George Wilkenfeld of George Wilkenfeld and Associates, who was the facilitator and rapporteur for the A/C session.

[5] EES 1999, Review of Energy Efficiency Test Standards and Regulations in APEC Member Economies, project EWG03/98T, prepared by Energy Efficient Strategies (Australia) et al for APEC Secretariat, Singapore, 27 November 1999. ISBN 0-646-38672-7

Table 2: APEC Economies with Air Conditioner Energy Efficiency Programs

	Program Type				
Economy	A. Comparison Label	B. Endorsement Label	C. MEPS	D. Industry Target	E. Other
AUSTRALIA	M(1987)	V	UC(2001)[1]		
CANADA	M		M(1995-98)		Province MEPS
CHINA		V(2000)	M (1989)		
HONG KONG, CHINA	V(1996,97) M(UC)		M(UC)		
JAPAN					TEPS (2004-7)
KOREA	M		M(1996, 1999)		
MALAYSIA			M(UC)		
MEXICO	M(1995,98)	V(1997)	M(1995,98)		
NEW ZEALAND	V(1987) M(UC)				
PHILIPPINES	M(1994)		M(1994)		
RUSSIA			M(1986)		
SINGAPORE		V(1998)			V(1996)
CHINESE TAIPEI	UC	V	M(1991)		
THAILAND	V(1995) M (UC)		M(UC)		
USA	M	V	M(1990-95)		
VIETNAM	V(UC)		V(UC)		

Notes: M = Mandatory, V = voluntary, UC = Under Consideration. TEPS = Target energy performance standards.
(1) For three-phase units up to 65 kW cooling capacity.

A traded product must comply with mandatory requirements in all the markets where it is sold, and the authorities in each market will usually ask for evidence that it does so. This means that an air conditioner exporter may need to have each model tested several times to demonstrate that it complies with the MEPS requirements in all the markets where it is sold and that the information on the energy labels in each market is correct. The exporter (or its local representative) will also have to ensure that each product carries the correct energy label for that market.

The cost and time needed to comply with different energy efficiency programs can add significantly to the cost of traded air conditioners, and can constitute a barrier to trade. It is still likely that the benefits from lower energy use will outweigh the energy program costs, but the cost-effectiveness of energy efficiency programs for APEC economies as a group would be higher if the compliance costs were minimised.

C. Major Issues

The major issues raised and discussed were as follows:

- departures from the standard test conditions in ISO5151-1994
- the repeatability and variability of tests, and the acceptability in each economy of tests performed in other economies
- product classifications and definitions

- whether testing can fairly reflect the performance of all technologies
- computer simulation vs physical testing
- the prospects for harmonisation of test procedures.

Discussions and recommended actions on these issues are summarised below.

A/C Test Standard

It was agreed that ISO5151-1994 (which is in process of revision) is generally satisfactory as a common basis for testing. However, the standard does not address some factors which have been found to impact on test results, ie atmospheric pressure variations due to the altitude of the laboratory. It should be possible to develop algorithms to adjust test results for this effect.

Some economies depart from the standard test conditions with regard to "outdoor" side wet bulb temperature, "indoor" side wet bulb temperature and condenser water temperature. These non-standard test conditions can give significantly different test results compared with the standard conditions. It should be possible to develop algorithms to adjust the result of tests conducted under these non-standard conditions to standard conditions, and vice versa, provided the departure from the standard conditions is within certain limits.

Regulators would be more likely to accept the use of such algorithms if they were included in or appended to the ISO standard. These might be termed "public" algorithms, which could be incorporated in computer programs.[6]

The ISO standard does not explicitly recognise non-physical tests such as outputs from the computer simulation of product performance. Some manufacturers already use computer simulations to derive capacity and energy efficiency ratio (EER) values to demonstrate compliance with MEPS and other regulatory requirements, especially when there is a large number of possible combinations of components. They usually perform physical testing on the most common combination, and derive other results by modelling. They are able to do this confidently because they have developed their own computer simulation programs suited to their products, and have access to all the proprietary data. These might be termed "private" algorithms.

Recommended Action on Test Standard

It was recommended that "public" algorithms should be developed to:

- adjust results from non-standard tests to standard conditions (if the difference is within specified limits); and
- compensate for the altitude effect.

These "public" algorithms should be developed co-operatively, on the basis of further research and with the involvement of experts from APEC economies, to ensure that they will be widely accepted as alternatives to physical tests. They should be included in a future revision of ISO 5151.

[6] The type of simulation discussed here is "limited" in that a physical test has also been carried out, and the objective is to simulate performance under a sightly different set of test conditions. This is a different concept from "unlimited" simulation, in which no physical test may need to be carried out at all, and performance under an infinite range of operating conditions could be modelled.

It is likely that the "private" algorithms and simulation programs used by some manufacturers are already capable of making these adjustments.
Each economy should then decide whether it will:

- accept test results calculated using the agreed "public" algorithms as a means of demonstrating compliance; and
- accept test results calculated using "private" algorithms and programs as a means of demonstrating compliance (in effect this already occurs).

Repeatability, Variability and Acceptability of Tests

Some economies only accept the results of tests done locally or from selected laboratories. Others apply a range of criteria to decide which laboratories are acceptable. Sometimes the criteria are different according to whether the test is for initial demonstration of compliance (in which case it can often be done by the manufacturer) or to verify compliance (in which case more strict criteria may apply). The greater the confidence in test results carried out in different laboratories, and other economies, the less demand there will be that products are re-tested for each economy.

Variations in test results could be due to a range of factors:

(a) the general competence and "quality" of laboratories;
(b) the interpretation of the test procedure: in some cases equally competent laboratories could get different results because the test procedure is not specified clearly enough;
(c) acceptable variability within the test procedure: in some cases the test procedure specifies an acceptable variation range (eg temperature to be controlled within + 0.5°C of the standard condition) but some laboratories work to a narrower range;
(d) the range of variability which the regulators tolerate: some economies accept test results if they are within + 5% of the nameplate value, whereas other economies accept results if the variation is + 10%.

Factor (a) could be addressed, and is being addressed, though accreditation and mutual recognition arrangements. Such arrangements already exist between some laboratories and industry organisations, generally for non-regulatory tests. There is also progress on a Mutual Recognition Agreement between governments and laboratory accrediting authorities, although it is not clear which test standards will be included.

Factor (b) could be addressed through further improving the description of the test procedure in ISO 5151. One example discussed was the issue of sensor location for wet bulb measurement in calorimeter-type test labs, but it was not clear how to resolve this.

Factor (c) could be addressed through harmonising the acceptable variability range used in testing to ISO5151. Many laboratories already use a narrower range than the maximum permitted in 5151, and the range is tending to decrease over time as laboratories improve their instrumentation. It was also noted that in the current revision of ISO 5151, the test tolerances will revert to the narrower range specified in ISO859.

Factor (d) could be addressed if all test laboratories work to the narrowest tolerance acceptable in the markets in which the product is likely to be sold, or if economies agree on a common tolerance range.

Recommended Action for Repeatability, Variability and Acceptability

- It is desirable to strengthen and expand mutual recognition agreements covering the testing of air conditioners for regulatory compliance purposes. The existing moves in APEC toward mutual recognition should be supported and strengthened.
- It is desirable that the test tolerance applied by economies for regulatory purposes should converge, and ultimately be harmonised.

Classification of Products

It was agreed that there is a need for a standard classification system for air-conditioners, analogous to the International Lamp Coding System (ILCOS), published as IEC TS61231.

Economies could cross-refer their own classifications to the standard classification as soon as it is developed, without affecting their MEPS or labelling programs. In the longer term a common classification system would assist harmonisation of testing and MEPS requirements.

The following factors were considered significant for classification purposes:

- cabinet configuration (eg unitary, split, with or without louvres etc: the standard could include diagrams to illustrate these)
- function (eg cooling only, cooling + heating, resistance heating etc)
- condenser cooling mode (air/water/earth cooled)
- special features (eg inverter/VSD).

The classification system could also include the cooling capacity in kW (and heating capacity in kW if applicable), eg "A-B-C-D-3.5-4.9."

Recommended Action for Classification Issues

It was recommended that a separate classification standard be developed, covering cooling and/or cooling-heating equipment that is electrically powered and has a direct expansion device, and that would be tested and compared under ISO standards 5151, 13253 and 15042.

Inverter/VSD Products

It was agreed that the existing steady-state test does not rate energy efficiency in the most likely modes of operation. The problem increases when comparing inverter and variable speed drive (VSD) machines with single speed machines.

There was some discussion on the simplified method for calculating annual energy consumption for inverter/VSD models adopted by the Japan Refrigeration and Air Conditioning Association. This is based on only 5 rating points:

- operation at T1
- operation at half the cooling capacity established at T1
- operation at H1

- operation at half the heating capacity established at H1
- operation at H2 (low temperature)

One possible approach would be for all economies to agree to base their MEPS or labelling requirements for inverter/VSD machines on these five points (or a subset of them: some economies may not require the low temperature test).

This issue is currently under discussion in ISO Working Group 6, which was considered to be the appropriate forum for resolving it.

Recommended Action for Inverter/VSD Products

The colloquium:

- supports ISO Working Group 6 and request that it develops procedures as quickly as possible, and
- encourages APEC members to actively participate in Working Group 6 to help bring its work to a rapid conclusion

Modelling and Simulation

There was some discussion of the proposed Australian approach to setting MEPS for larger (7.6-65 kW cooling) packaged air conditioners, where manufacturers would have the option of demonstrating initial compliance with either a physical test or a computer simulation. The simulation program would have to meet specified criteria, and some physical parameters would need to be measured, but this would not require a calorimeter test room. If subsequent physical test results varied from the simulated performance by more than a specified range, further physical testing would be required.

The delegates considered that computer simulation was reasonably reliable when manufacturers used their own proprietary ("private") programs to model the performance of their own products. Suppliers should have the option of using them to demonstrate initial compliance, if they are willing to take the risk that later physical testing might not verify the results.

However, using "public" programs to model the performance of products from different manufacturers is not sufficiently reliable for regulatory purposes at present. Reliability could be increased if there were further development of simulation programs, and the confidence of regulators in this approach would be higher if the development was carried out jointly by APEC economies.

Recommended Action for Modelling and Simulation

The colloquium recommends the further development, with the involvement of APEC experts, of modelling and simulation programs (or criteria for such programs) so that these programs can be used with greater confidence as an optional alternative to physical testing.

D. Priorities for Actions

Delegates were asked to rate the relative importance they would assign to the tasks identified during the colloquium, if they had to decide priorities for allocating their

own limited time and resources. Each delegate had three votes, and was asked to give his highest priority a weight of 3, the next priority a weight of 2 and the third priority a weight of 1. Table 3 summarises the outcome.

Table 3: Priorities for Action

Task	Weight	Votes
1. Harmonisation (specifically of MEPS)	0	0
2. Develop equivalence algorithms	15	8
3. Develop laboratory accreditation	10	3
4. Refine test procedure	7	3
5. Harmonise variability	10	4
6. Develop Standard Classification	11	5
7. Develop inverter/VSD approach (ISO Working Group 6)	0	0
8. Develop modelling and simulation	2	2

Although harmonisation as such was not identified as a priority, the tasks identified as priorities (2, 3, 5 and 6) would increase the confidence with which each economy interprets and accepts the results of tests done elsewhere, and so they would make greater harmonisation possible in a practical sense.

The highest priority task was considered to be the development of equivalence algorithms, and the next highest the development of a standard classification.

Tasks 3, 4 and 5 taken together all contribute to the objectives of increasing the repeatability of tests undertaken at different time and the acceptability of results from different laboratories. Their high combined weighting reflects the high priority placed by delegates on these objectives.

Conversely, the lack of votes for developing the inverter/VSD approach does not reflect a low priority for this task, but the view that it is already being handled in the most appropriate way, in an ISO Working Group.

E. Conclusions on Harmonisation

The colloquium concluded that full harmonisation of test procedures and test conditions are desirable objectives, but likely to be achieved at different rates. The harmonisation of MEPS levels did not receive support at this stage.

- The harmonisation of test procedures (ie how the tests are carried out, and the acceptable range of variability) is a medium term objective.
- The harmonisation of test conditions (ie the rating points) is a medium term objective (although harmonisation algorithms could be implemented within a shorter time frame).
- The harmonisation of MEPS levels (ie the minimum limit or sale-weighted EERs allowed in each economy) is an issue for longer term consideration.

IV. ECONOMY PRESENTATIONS

A. Ballast Session

In the ballast workshop, a total of 5 presentations were made. The key points raised in each presentation are shown below. A full copy of each presentation can be found in the electronic Annex.

Australia

Mr Barry Foreman, Technical Manager
ATCO

- Australia is currently developing a new test procedure based on European standard EN50294 - this is currently under review.
- The ballast efficacy measure is total circuit input power, corrected back to nominal light output. A small correction is also made to adjust the reference lamp input power back to nominal power on the reference ballast.
- Some technical issues were raised about the validity and accuracy of using lamp input power as a substitute for light output for low frequency ferromagnetic systems with an external starter.
- Australia is proposing to use the same voluntary labelling scheme used by CELMA in Europe (ratings from A1 (best) down to D).
- MEPS proposal for Australia is to eliminate ballasts with a rating of B2 or worse from 2002.

China

Mr Zhao Yeujin, Assistant Director
China State Bureau of Quality and Technical Supervision

- China is proposing the introduction mandatory MEPS for fluorescent ballasts and other lighting products in the period 2000-2002. An voluntary endorsement labelling program is also proposed during the same period.
- The test method for ballasts is defined in GB/T 15144-94 (EQV IEC60929).
- The test method to determine ballast efficacy is harmonised with that used in North America.
- The method of specifying MEPS in China is also the same as North America - Ballast Efficiency Factor (BEF) which is relative light output per total watt input.
- Market data that was used to determine the optimum MEPS level for China was presented. It was noted that the MEPS levels proposed for China are more stringent than those currently in force in Canada or the USA.
- The efficacy levels for the proposed endorsement labelling program were also presented.
- It is proposed that the program will also include fluorescent lamps, compact fluorescent lamps and ballasts for sodium vapour lamps.

Documents relating to above presentation

Energy Efficiency Standard for Fluorescent Lamp Ballasts in China

Japan

Mr Kenji Sugiyama, Chief Specialist
Fluorescent Lamp Engineering Group, Toshiba

- The Japanese Top Runner program for luminaires specifies total efficacy for ballast and lamp combinations. A total of 12 fixture types (lamp/ballast combinations) are specified under the program. The total sales weighted efficacy by type shipped for each manufacturer must reach the Top Runner target by 2005.
- The test method for efficacy has been developed in Japan. It requires the measurement of total light output (determined from relative light output compared with the reference system times the nominal lamp lumen output) and total circuit power input.
- There is also a temperature correction factor which takes into account the actual temperature of the lamp in the luminaire during normal operation (this adjustment may increase or decrease the efficacy, depending on the actual lamp type and temperature).
- Indication of efficacy must be in manufacturer catalogues by April 2000.
- Estimated ballast and lamp combinations required to meet Top Runner targets were provided.

Documents relating to above presentation

Status of Energy Saving Program Efficiency Target, Procedure for Efficiency Measurement, and Regulation in Japan

Republic of Korea

Mr Soo-Bin Han, Principal Researcher
Electric Energy Division, Korea Institute for Energy Research

- MEPS and labelling for a range of products including ballasts were introduced in Korea in 1992 - MEPS levels were revised in 1993, 1994, 1995, 1996 & 1999. T8 linear and 40W circular lamps were included in 1999 (commences in 2000). It was noted that revision of the levels are generally considered every three years.
- Efficiency measure (R) is relative Lumens per Watt for the test ballast/reference lamp compared to the Lumens per Watt for the reference ballast/reference lamp.
- Mandatory MEPS and 5 labelling grades are specified in terms of the index R.
- Detailed of labelling grades and MEPS levels by year for Korea were provided.
- Test procedures for ballasts used by Korea were listed.
- Key issues with respect to measurement of ballast efficacy were outlined. Some testing methodologies were examined and possible approaches proposed.
- A number of possible barriers to alignment of test procedures were noted (differing MEPS specifications, market structures).

Documents relating to above presentation

Energy Performance Standards and Regulations for the Fluorescent Lamp Ballast in Korea

Thailand

Mr Phanu Kritiporn, Managing Director
ERM Siam Co Ltd

- Details of current market situation and local manufacturer capabilities were presented. It was noted that standard ferromagnetic ballasts currently

predominate in Thailand (>90% market share) and there are some 25 local manufacturers.

- Various issues were considered during the development of MEPS in Thailand including the test procedure and its suitability for electronic ballasts.
- A range of performance indicators and cost/benefit estimates for ballast MEPS in the commercial and residential sectors were provided.

Documents relating to above presentation

Ballast Market in Thailand

B. Air Conditioner Session

Below are summaries of the presentations on air conditioner standards activities and status from nine member economies. A full copy of each presentation can be found in the electronic Annex.

Australia

Mr Greg Wild, Engineering Manager
Major Appliance Group

- He is engineering manager for a company that designs and builds window and wall air conditioners, and which also imports mini-split systems from Korea.
- Current Australian labelling regulations require annual energy consumption to be calculated on the basis of 500 hours of run time at full load, but it is proposed to replace this with a calculated to kWh usage per hour. This will allow customers to estimate their own individual running costs.
- Consumer priorities when purchasing an air-conditioner are (a) purchase price (b) appearance (c) energy costs.
- The endorsement label for air-conditioners in Australia is called the Galaxy award. It is awarded only to one product within each category. It is difficult to control use of the award in advertising, by suppliers who may have had a Galaxy award product in the past but no longer do so.
- Mr Wild supported use of conversion algorithms to compare test results. This would enable the manufacturer to test a product once and then either use the results directly or use the conversion algorithms to substantiate MEPS compliance or other regulatory requirements in other countries..
- If conversion algorithms are developed, manufacturers should have the option of using the algorithms or doing physical tests.
- In the case of inconsistency, physical tests should take precedence.
- If there is harmonisation of MEPS between economies, it should be applied to cooling only, because there are large differences temperatures in heating load and degree days for heating purposes.
- There is a checktest program in Australia, in which air-conditioners purchased on the market are tested for compliance.
- If a product is checktested and found not to comply, the issues of slight differences in standards could be raised. This is not a comfortable position for regulator. Thus, alignment of test standards would be a big help for the regulator.
- Variations in regulations add time and cost, especially when they are compounded by differences in language.
- In a recent revision of the Australian air-conditioner test standard, the energy labelling requirements which were previously in different regulations at the State level were included as part of the standard. This simplified matters and centralised the ability to make changes.
- Mr Wild also supported investigations of the computer simulation approach. If simulations were used for variable load conditions, it would be of benefit for variable speed compressor units. However, it would complicate the energy label, and this would be more difficult for regulators.

Documents relating to above presentation

Colloquium on Technical Issues of MEPS: Response to Discussion Paper

People's Republic of China

Mr Jianhong Cheng, Energy Standard Technical Committee
China Standardisation and Information Classifying and Coding Institute

- There are minimum energy performance standards applying to single package and split-system non-ducted room air-conditioners with a rated cooling capacity of less than 14 kW.
- There are different maximum EER levels according to whether the unit is single-package or split, and whether its cooling capacity is less than 2.5 kW, between 2.5 and 4.5, and greater than 4.5 kW.
- Only constant speed machines are covered. Other criteria apply to variable speed, two compressor and multi-split types.
- The current EER limits were set in 1985 and are being reviewed at present, with regard to both (a) limit values and (b) targets.
- The test method in GB 1202.3-1989 is the same as in ISO 5151-1994. The rated voltage is 220V single phase and 380V three phase, 50 Hz frequency.
- The calorimeter test method same as in ISO 5151-1994, but there are minor differences in the air-enthalpy method, such as instrument location.
- EER and COP are expressed in W/W. There is no estimate of energy use by resistance heating (if present) or of annual running cost.
- There is no comparison label. A voluntary endorsement label has recently been introduced for refrigerators, available to the most efficient 30% of products. It will be extended later to lamps, air-conditioners and motors.
- There are problems with the steady-state test conditions in ISO 5151-1994:
  - T1 is not typical, since units will usually operate at less than full capacity
  - It encourages manufacturers to optimise performance at the rating condition, perhaps to the detriment of performance and efficiency at non-rated conditions
  - The benefits of variable speed drives and other new technologies do not appear at steady state, and their performance at T1 may worse than for other units.
- Suggestions on harmonisation:
  - international definitions for air-conditioners should be developed and gradually adopted by economies
  - Conversion algorithms to compare test results from different procedures should be developed
  - Computer simulation to model the operation of units under both standard and non-standard conditions should be developed
  - Aligning test conditions to T1 in ISO 5151-94 would be a feasible option, but it would first be necessary to resolve the problems with this condition.
  - It would take a long time to agree on a harmonised label format, with a common language (or common second language) and grading scale. Economies are at different levels, and manufacturers will want to ensure that their products appear as energy efficient as possible.
  - It will be difficult to harmonise MEPS levels.
- Discussions and responses to questions:
  - About 20% of air-conditioners sold in China are imported

- There is relatively little enforcement at present, but this is less of a concern since nearly all products meet the MEPS levels.

Documents relating to above presentation

Energy Efficiency Standards and Labelling Program for Air-Conditioners in China

Japan

Mr Kazuya Matsuo, Chief Researcher
Mechanical Engineering Research Laboratory, Hitachi Ltd

- Products are classified as "room air-conditioners" (<10 kW cooling capacity, <3kW cooling power consumption: could be unitary or split) or "package" air-conditioners (<28 kW cooling capacity, >3 kW cooling power consumption).
- The market is about 6.6 m units per year; about 99% is split systems. Window/wall systems are no longer manufactured in Japan.
- >90% of market is heat pump. Inverter/VSD unit market share has increased from about 50% in 1988 to now >80%.
- JIS test standards are aligned with ISO 5151-1995 (non-ducted A/Cs and heat pumps) and ISO 13253-1995 (ducted A/Cs and heat pumps). There is a test for multi-split types which specifies the number of units connected and the length of refrigerant piping.
- MEPS are "target" rather than limit: it is possible for a supplier to sell some less efficient units provided that the weighted average of sales meets the target level.
- There are target COPs for 5 product types, and for some types target COPs vary by rated cooling capacity: there are 32 categories in all (eg the classification of "multi-split types" has 6 size categories: (a) heat pump, and (b) cooling only in capacity ranges of up to 4.0 kW cooling, 4.1-7.0 kW cooling and 7.1-28 kW cooling).
- The COPs achieved by a manufacturer are calculated as follows:
  - For each model, the COP is the average of cooling COP (at T1) and heating COP (at H1)
  - A "harmonic average" COP is calculated for each category Harmonic average depends on the characteristics of each model in that category rather than on sales, so there is a penalty associated with having a low-COP model in the range.
  - the COP for each classification is calculated by weighting the harmonic average of products in each size category by the sales
  - the COP for the manufacturer is calculated by weighting the COP of each classification by the sales
- In April 1999, target COPs for each of the 32 categories were set under the Law Concerning the Rational Use of Energy. These targets correspond to the most efficient models on the market in 1998
- Manufacturers are required to achieve these targets as follows:
  - For split and window/wall types of up to 4 kW cooling capacity (ie the largest selling categories), in the refrigeration year 2004 (October 2003–September 2004)
  - For other categories, in the refrigeration year 2007
- The penalties for failure to achieve the targets are (a) publication and (b) fines. Publication would be the greater commercial disadvantage, since dealers would be likely to discount the products of the manufacturer.
- Participation in a compliance testing regime is voluntary, not mandatory.

Testing is done by the Japan Refrigeration and Air Conditioning Industry Association (JRAIA), which selects 3 units from a lot of 30 to 50. If a significant deviation is found from the capacity and COP values in the catalogue, this is publicised and the chef executive of the manufacturer is advised.

- The JRAIA has developed a simplified method for calculating annual energy consumption, especially for inverter/VSD models:
  - Five rating points are used: operation at T1, operation at half the cooling capacity established at T1, operation at H1, operation at half the heating capacity established at H1, and operation at H2 (low temperature)
  - Information about operation at these 5 points is combined with weather data for Tokyo and assumptions about operating hours to derive an estimate of annual consumption.
- Because manufacturers have such a large model range with so many possible combinations of components, they tend to carry out physical tests only on the best-selling combinations, and use computer simulation to calculate performance for other combinations. They are able to do this confidently because they have developed in-house simulation programs for their own products.
- However, universal simulation (ie using the same program for all manufacturers' products) is not possible at present.

Documents relating to above presentation

Energy Efficiency Standards and Test Conditions for Air Conditioners in Japan

Republic of Korea

Mr Jun-Young Choi, Senior Researcher
Technical Supervision Division, Korea Testing Laboratory

- Regulations on energy labelling were first issued in August 1992, by the Ministry of Commerce, Industry, and Energy. They have been revised 5 times: 1993, 1994, 1995, 1996, 1999.
- 7 items now covered: refrigerators, A/Cs, ballasts, washing machines, CFLs, cars, T10 and T8 lamps, incandescent lamps.
- There are both MEPS and TEPS (Target Energy Performance Standards) for A/Cs of cooling capacity up to 15,000 kcal/h (17.4 kW). For units of up to 9,000 kcal, MEPS took effect on 1 January 1997 and the target for TEPS achievement is the end of 1998. For units of more than 9,000 kcal, MEPS took effect on 1 September 1998 and the target for TEPS achievement is the end of 1999.
- For single speed units, MEPS and TEPS levels are expressed as EERs (kcal/Wh). For inverter/VSD units, the MEPS and TEPS levels are expressed as seasonal EERs (kcal/Wh). Will be restated as W/W to conform to international practice
- The goal of TEPS is to reduce average unit energy consumption by ~10-30%.
- Products are classified by (a) function (cooling only, cooling + heating etc), (b) construction (integral or split), (c) Condenser cooling (air or water) and (d) cooling capacity.
- Test does not conform to ISO test condition exactly. Indoor wet bulb setting is 19.5°C, compared with 19.0°C in ISO T1. This can give as much as 10% higher cooling capacity.
- Monthly energy consumption for A/Cs is calculated as: W (rated cooling capacity at T1) x 0.6 (operation rate) x 12 hrs/day x 30 days
- There are 5 levels or grades on the energy label: 5 (least efficient) to 1 (most efficient). The share of A/C sales that are Grades 1 or 2 increased from about

92% in 1993 to 97% in 1998, even though qualifying EERs for these grades increased and there was more enforcement effort. In addition, about 77% of A/C models on the market at the beginning of 1997 met the TEPS level (compared with 40% for refrigerators and only 1% for incandescent lamps).

- The market was about 1.6 million units in 1997 – roughly equal numbers of split and unitary models. However, about 98% of exports were window-type models. Inverter/VSD models account for less than 5% of the Korean market.
- Discussions and responses to questions:
  - Measurement of the wet bulb temperature is very difficult and is an art in itself.
  - One reason why inverter units have a high (>80%) share of the market is that is that the climate requires heating capacity to be 50% higher than cooling capacity, and single speed compressors can't achieve this.

Documents relating to above presentation

Energy Efficiency Standards and Labelling Program for Air-Conditioner in Korea

Mexico

Engr J. Pedro Guzman Valenciano, Certification Sub-Director
National Commission for Energy Conservation

- Experience with standards for room A/Cs in Mexico goes back to 1994, with publication of NOM-073-SCFI-1994.
- Efforts to have been made to harmonise A/C efficiency test methods and MEPS with the USA and Canada.
- NOM-021-ENER-1999 applies higher MEPS levels to air-cooled window units, with/without reverse cycle heating and with/without louvred sides, of up to 36,000 BTU/hr (10.6 kW) cooling capacity. It uses the same classes and sets the same class MEPS levels (to apply from January 2001) as those to take effect in the USA in October 2000, but it covers only 12 classes compared with 17 in the USA.
- Work on a test standard for "mini-splits" (ie split systems in US terminology) to be carried out in 2000.
- About 50% of models already meet the "Stage II" (January 2001) levels.
- The standard covers testing in both calibrated room type calorimeters and balanced ambient type calorimeters.
- EER is calculated as ϕ_{ti}/P where ϕ_{ti} is the net total effect of cooling on the "indoor" side and P is the average of 7 power measurements taken over a 1 hour steady state operating period.
- The test result is accepted if the net total effect of cooling on the "indoor" side is within 4% of the net total effect of cooling on the "outdoor" side.
- Tests in Nogales Sonora (1,100 m altitude) and Monterrey (700 m) test facilities can give results varying as much as 3% due to air pressure differences.
- Mexico is changing the A/C energy label, from a European style (grades A to E) to a horizontal bar with model EER and MEPS level EER marked (but not indicating most and least efficient on the market, as occurs on the USA label). Apparently consumers did not understand the current label.
- NOM-021-ENER/SCFI/ECOL-1999 combined the standard for product efficiency, safety, and CFCs. The use of R22 is permitted until 2020 in Mexico (to 2010 in the USA).
- Test results from labs in outside countries are accepted, and some verification tests are carried out in Mexico. The private accreditation agencies EMA (Mexican

Accreditation Agency) certifies labs and ANCE certifies products.

- Discussions and responses to questions:
  - APEC Subcommittee on Standards and Performance is working on the issue of international lab accreditation
  - Despite long lead times for phasing out R22, in reality production is capped and its manufacturers are increasing the price to get people to shift over to other non-CFC refrigerants (HFCs 407C and 410A)

Documents relating to above presentation

Mexican Experience: Energy Efficiency for Room Air-Conditioners

Philippines

Engr Isigani C Soriano, Senior Science Research Specialist
Fuels and Appliance Testing Laboratory

- The labelling program is implemented by Department of Energy (DOE), Bureau of Product Standards (BPS), and Association of Home Appliance Manufacturers.
- Implementing Guidelines for labelling were finalised in 1989. Initially, only covered window type A/Cs with cooling capacity less than 6,000 kCal/hr. Mandatory implementation began in 1993.
- Product sampling is by BPS. Testing is done by DOE (the Fuels and Appliance Testing Laboratory). EER must be >90% of value claimed.
- Manufacturers print their own labels, but each label validated and administered by DOE. Each label has a control number.
- Minimum Efficiency Performance Standards for A/Cs were implemented in 1993. They are reviewed and revised every 5 years.
- The test used (in PNS 214) uses an external wet bulb temperature of 27°C compared with 25°C in condition T1 in ISO 5151-1994, to reflect higher humidity in the Philippines. EER can be ~3% lower using PNS standard compared to ISO standard – but this estimate is based on one test and will likely vary by capacity)
- Cooling capacity is expressed in KJ/hr (whereas ISO uses W).
- Split type systems covered from 1999. EER must be >90% of value claimed, and power input <110%. Most split models are imported. May be only one local manufacturer.
- There are 10 local manufacturers and assemblers, and 167 models currently certified. About 80% of certified models are local, and 20% imported. Local models carry the "Q mark" and imported models the "ICC mark".
- Sales have increased over the past decade, from about 42,000 units sold in 1988 to 250,000 units sold in 1998 (of which about 200,000 were domestic manufacture). These sales data cover window-types only –split type sales are low.
- There is about 94% compliance with the mandatory requirement to display the energy label. Some dealers not aware of the program, and they remove the label
- Level of compliance with current MEPS levels not certain, but it is though that about 5% already pass the 2002 level.
- A degree of convergence in energy test standards would probably be beneficial in the Philippines, so both importers and manufacturers would be on equal terms.
- Discussions and responses to questions:
  - It is likely that an algorithm to compare results from T1 and the Philippines slightly higher wet bulb temperature can be devised.

Documents relating to above presentation

Philippine MEPS and Labelling for Room Air Conditioners

Chinese Taipei

Dr Yie-Zu Hu, Deputy Director and Senior Researcher
Thermofluids Technology Division, Industrial Technology Research Institute

- World A/C market: USA largest (about 10 million units/year), then Japan, then China and rest of SE Asia. Middle East and Europe not very significant. APEC economies therefore represent the great majority of the world A/C market.
- Chinese Taipei market dominated by Room A/Cs (about 1.57 million sold in 1998). Package type only about 50,000 units/year. Within room A/Cs, window:mini-split ratio is about 2:1. Inverter/VSD units currently <1% of market.
- There is a need for common definition of product types among APEC economies.
- Also need to standardise methodology for measuring efficiency: eg, some use COP, some use EER, different units, etc.
- In Chinese Taipei, A/C sizes are categorised by power consumption rather than cooling capacity, but a possible change is under discussion.
- MEPS were introduced in 1993. There are lower MEPS levels for inverter classes, in recognition that it is harder for an inverter/VSD to achieve cooling at full capacity , constant load
- Noise level limits not mandatory, but enforced by the Environment Protection Agency, and most suppliers meet them.
- MEPS have been in force since 1981. EER levels for package units similar to 1993 USA levels (2.22 kcal/Wh for air-cooled, 2.88 for water-cooled).
- A/C product registration in Chinese Taipei looks at about 15-20 different characteristics, including safety, energy, etc. Registration and certification handled by BSMI (Bureau of Standards, Methodology, and Inspection). Sample testing by TERTC (Taiwan Electric Research and Testing Centre).
- Product testing regime includes regular tests (before product goes to market) and random tests (both in the factory and on distributed products). If a supplier has an accredited test laboratory and quality assurance, different procedures apply. In effect, random testing concentrates on those products where supplier does not have accreditation or quality assurance, or where there has been a record of variance. Manufacturers pay for all testing expect random market sampling.
- Test of costing varies dramatically with scale of production, eg production lines in Chinese Taipei may produce only 250 units, whereas some in China might produce 1 million units. It is much easier for large factory to afford to set up its own test lab.
- There is a "Green Mark" label to indicate high energy efficiency. To qualify, A/Cs have to be ~15-20% more efficient better than the MEPS. Fairly common in the market: eg., a manufacturer may have 10 different models in the one category and 3 of them may be Green Mark. The commercial value us that the government will pay a 5-10% price premium for Green Mark products.
- These is also an "S Mark" for products meeting higher environmental standards.
- MEPS for A/Cs will be raised on 1 January 2001, by about 5% for Room A/Cs and about 10% for packaged units.
- Suggestions to APEC:
  - Accreditation or certification program for testing labs within APEC

- Testing methods (procedures) should be standardised (not testing conditions)
- Testing reports prepared in one economy should be accepted when products are exported.

- There are problems with computer simulation for rating purposes. The simulation of packaged unit performance can be unreliable, because it is very difficult to accurately model how the compressor, evaporator, heat exchangers and piping act and work together. For example, just changing air flow on louvres can reduce capacity (and thus efficiency) by 10-20%
- Discussions and responses to questions:
  - It was that US manufacturers use variations of Oak Ridge Heat Pump model to model their system efficiency, and for large U.S. manufacturer, tests have shown that these simulations are fairly accurate
  - But the caution is that these manufacturers are using models that are tailored specifically for their product line.

Documents relating to above presentation

Energy Efficiency Measurements of Small Air-Conditioning Systems in Chinese Taipei

Thailand

Assoc Prof Dr Withaya Yongchareon, Head of Measurement Laboratory
Mechanical Engineering Department, Chulalongkorn University

- Market Shares in Thailand: Split units represent 95% of the market. 29% of these are between 7,000 and 9,000 BTU/hr, 32% between 9,000 and 13,000 BTU/hr and 19% between 13,000 and 18,000 BTU/hr.
- Most units are cooling only, so inverter/VSD units account for only 1% of market.
- There is a voluntary labelling program. Most of the highest ranking (Level 5) and some of the next ranking (Level 4) models are labelled, but not the others. About 30% of models are labelled in all. The levels are:
  - Level 5: EER > 10.6
  - Level 4: EER > 9.6
  - Level 3: EER > 8.6
- A recent study has been done on the cost-effectiveness of adopting MEPS, based on (a) engineering analysis and (b) manufacturer estimates of incremental cost to improve efficiency to the higher label efficiency levels. The manufacturer estimates of costs were significantly higher, and the engineering estimates were used.
- The analysis estimated the following increases in costs for split units:
  - Level 2 => Level 3: 9.6% increase
  - Level 3 => Level 4: 4.8% % increase
  - Level 4 => Level 5: 9.1% increase
- The analysis estimated the following increases in costs for window units:
  - Level 2 => Level 3: 10.0% increase
  - Level 3 => Level 4: 13.6% % increase
  - Level 4 => Level 5: 8.3% increase
- The proposed MEPS level is 4 for Split Type and 3 for Window Type, to take effect in 2004.
- Based on engineering calculations, the benefit/cost ratios for the proposed MEPS are at least 3.

Documents relating to above presentation

Minimum Efficiency Performance Standard for Air Conditioners in Thailand

United States of America

Mr Greg Rosenquist

Lawrence Berkeley National Laboratory

- Explanation of U.S. classification of A/Cs for MEPS purposes: Room A/Cs, Window Type, Mini-Split (corresponding to split types common in Japan), Central A/Cs, Ducted Split, Ducted Single Package.
- Window type sales fluctuate a lot; they tend to be impulse purchase. Virtually no mini-split A/Cs sold in the U.S. largely because of very large price premium compared with window type.
- Almost 50% of households in the U.S. now have central A/C or heat pumps, and about 25% have a window type (could be some overlap, with some households having both types).
- Electrolux, Whirlpool, and Fedders have about 64% of window type A/C market. Central A/C and HP Market more evenly distributed among 8 large manufacturers
- Test procedure for window types is very similar to ISO T1 test condition. Identical to Canadian and Mexican procedure.
- Very simple equation used to calculate Annual Energy Use: (capacity/SEER) x 1,000 hrs
- This value is about 50% higher than the estimated consumption derived from household survey (RECS), suggesting in-use consumption is about 2/3 value calculated using this formula.
- US Energy Efficiency Standards authorised under National Appliance Energy Conservation Act (NAECA) passed in 1987
- For Central A/Cs: Split system – 10 SEER effective in 1992; Single package – 9.7 EER became effective in 1993
- After room and central A/C SEER MEPS passed, efficiency levelled off. Manufacturers are playing "wait and see" before next standard takes effect

Documents relating to above presentation

Residential Air Conditioner in the USA: Market, Test Procedures, and Efficiency Standards

APPENDIX I: PARTICIPANT LIST

No	NAME	ECONOMY	ORGANIZATION
1	Barry J. Foreman	Australia	ATCO Controls Ptd, Ltd.
2	Greg Wild	Australia	Major Appliances-Room Air Conditioners
3	George Wilkenfeld	Australia	George Wilkenfeld & Assiciates (GWA)
4	Lloyd Harrington	Australia	Energy Efficient Strategies (EES)
5	Cheng Jianhong	China	Energy Standards Technical Committee of China
6	Zhao Yuejin	China	Energy Standards Technical Committee of China
7	Kazuya Matsuo	Japan	Mechanical Research Laboratory, Hitachi, Ltd.
8	Ayako Sato	Japan	The Energy Conservation Center, Japan
9	Kenji Sugiyama	Japan	TOSHIBA Lighting & Technology Co.
10	Jong-Duck Kim	Korea	Korea Energy Efficiency Institute (KEEI)
11	Jin-Han Ahn	Korea	Korea Energy Management Corporation (KEMCO)
12	Chun-Suk Byun	Korea	Korea Energy Management Corporation (KEMCO)
13	Kwan-Hong Shin	Korea	Korea Energy Management Corporation (KEMCO)
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15	Soo-Bin Han	Korea	Korea Instirtute of Energy Research (KIER)
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17	Jun-Young Choi	Korea	Korea Testing Laboratory (KTL)
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30	Phanu Kritiporn	Thailand	Manger ERM-Siam Co., Ltd.
31	Gregory Rosenquist	USA	Lawrence Berkeley National Laboratory

APPENDIX II: ACRONYMS AND RELEVANT STANDARDS

Standards Acronyms

AHAM	Association of Home Appliance Manufacturers (USA)
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute (USA)
AS	Australian Standards
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc.
CAN/CSA	Canadian Standards Association
CIE	Commission Internationale de L'Eclairage
CNS	Chinese National Standards of Chinese Taipei
EN	European Norms
GB	China State Bureau of Quality and Technical Supervision
GOST	Russian Committee for Standardisation
IEC	International Electrotechnical Commission
IES	Illuminating Engineering Society of North America (also IESNA)
ISO	International Standards Organisation
JIS	Japanese Industrial Standards
KS	Korean Standards
MS	Malaysian Standards
NOM	Official Mexican Norms
NZS	New Zealand Standards
PNS	Philippine National Standards
TIS	Thai Industrial Standards
EQV	Technically equivalent

Ballasts Standards

AS 2643-1991 Fluorescent lamp ballasts of reactive type - Performance requirements EQV to IEC60921.

AS 3963-1991 a.c. supplied electronic ballasts for tubular fluorescent lamps - Performance requirements EQV IEC60929.

AS/NZS 50294 (draft) Performance of electrical lighting equipment – ballasts for fluorescent lamps: measurement method for total input power of ballast lamp circuits (EQV EN50294 with minor amendments)

CAN/CSA-C654-M91 Fluorescent lamp ballasts efficacy measurements

CIE 13.3 Method of measuring and specifying colour rendering properties of light sources.

CIE 84 Measurement of luminous flux

CNS 927-96 Ballasts for Fluorescent Lamp

CNS 3888-85 Method of test for Ballasts for Fluorescent lamp ballasts

GB XXXX.X Limited values of energy efficiency and evaluating values of energy

consumption of ballasts for tubular fluorescent lamps (Draft only)
External Reference: Ballast performance - GB/T15144 (EQV IEC60929)

IEC 60081:1997 Double-capped fluorescent lamps - Performance specifications

IEC 60901:1996 Single-capped fluorescent lamps - Performance requirements

IEC 60921:1988 Ballasts for tubular fluorescent lamps- Performance requirements

IEC 60929:1990 A.C.-supplied electronic ballasts for tubular fluorescent lamps - Performance requirements

IEC 61231:1993 International lamp coding system (ILCOS)

JIS C8108 Magnetic ballasts for fluorescent lamps

JIS C8117 AC supplied electronic ballasts for fluorescent lamps

KS C8100-1997 - Electronic ballasts for fluorescent lamps (EQV IEC 60928 & IEC 60929)

KS C8102-1995 - Magnetic ballasts for fluorescent lamps (EQV JIS C8108)

MS 141 Fluorescent lamp ballasts

PNS 12-2:1996 Ballasts for tubular fluorescent lamp – performance (EQV? IEC 60921)

TIS 23-2521 Fluorescent lamp ballasts (ferromagnetic)

TIS 1506-2541 AC supplied electronic ballasts

Air Conditioner Standards

ANSI/AHAM RAC-1-1982 Room Air Conditioners

ANSI/ASHRAE 103 Methods of testing for heating seasonal efficiency of central furnaces and boilers

ANS Z234.1-1972 Room Air Conditioners (sections 4, 5, 6.1 and 6.5)

ARI 210/240 Unitary air-conditioning equipment and air-source unitary heat pump equipment

ARI 310/380 Packaged terminal air-conditioners

AS/NZS 3823.1.1:1998 Performance of household electrical appliances - Room airconditioners - Non-ducted airconditioners and heat pumps - Testing and rating for performance

AS/NZS 3823.2:1998 Performance of household electrical appliances - Room airconditioners - Energy labelling requirements

ASHRAE 16-69 Method of testing for rating of air conditioners

CAN/CSA-C273.3-M91 Performance standard for split-system central air conditioners and heat pumps

CAN/CSA-C368.1-M90 Performance standard for room air conditioners

CAN/CSA-C446-94 Performance of ground source heat pumps

CAN/CSA-C655-M91 Performance standard for internal water-loop heat pumps

CAN/CSA-C656-M92 Performance standard for single-package central air

conditioners and heat pumps

CAN/CSA-C744-93 Standard for packaged terminal air conditioners and heat pumps

(jointly published as ARI 310/380-93)

CAN/CSA-C746-98 Performance standard for rating large air conditioners and heat pumps

CAN/CSA-C748-94 Performance of direct expansion (DX) ground source heat pumps (regulated only by selected Canadian Provinces)

CNS 2725-95 Unitary air conditioners

CNS 3615-95 Room air conditioners

GB 12021.3-89 Limited values of energy consumption and method of testing for room air conditioners, Published 1989-12-25, In force 1990-12-01
External Reference: Air conditioners - GB 7725 (EQV? ISO 5151)

GOST 26963-86: Self-contained room air conditioners. General specifications.

ISO 5151 Non-ducted air conditioners and heat pumps - Testing and rating for performance

ISO 13253 Ducted air-conditioners and air-to-air heat pumps - Testing and rating for performance

JIS B8615 Central air conditioners

JIS B8616 Unitary air conditioners

JIS C9612 Room air conditioners

KS B6369-1985 – Testing Methods for Unitary Air Conditioners (EQV JIS B8616)

KS C9306-1997 – Room air conditioners (EQV JIS C9612)

NOM-011-ENER-1996 Central air conditioners

NOM-073-SCFI-1994 Room air conditioners

PNS 240:1989: Method for testing and rating room air conditioners

PNS 396 Part 1:1991: Standard for energy efficiency ratio and labelling requirements of air conditioners

TIS 1155-2536 Room air conditioners

APPENDIX III: DOWNLOADABLE DOCUMENTS

The following documents (in PDF format) will be available for download on the APEC Energy Working Group website.
For more information, contact Lloyd Harrington at lloydh@ozemail.com.au

No	ECONOMY	AUTHOR	TITLE	FILE NAME
1	APEC	Various	Proceedings of the APEC Colloquium on Technical Issues of MEPS	Proceedings.pdf
2	APEC	George Wilkenfeld	Air Conditioner Discussion Paper	AC-disc paper.pdf
3	APEC	Lloyd Harrington	Ballast Discussion Paper	Ballast-disc paper.pdf
4	Australia	Greg Wild	Colloquium on Technical Issues of MEPS: Response to Discussion Paper	AC-Australia.pdf
5	China	Cheng Jianhong	Energy Efficiency Standards and Labelling Program for Air-Conditioners in China	AC-China.pdf
6	China	Zhao Yuejin	Energy Efficiency Standard for Fluorescent Lamp Ballasts in China	Ballast-China.pdf
7	Japan	Kazuya Matsuo	Energy Efficiency Standards and Test Conditions for Air Conditioners in Japan	AC-Japan.pdf
8	Japan	Kenji Sugiyama	Status of Energy Saving Program Efficiency Target, Procedure for Efficiency Measurement, and Regulation in Japan	Ballast-Japan.pdf
9	Korea	Soo-Bin Han	Energy Performance Standards and Regulations for the Fluorescent Lamp Ballast in Korea	Ballast-Korea.pdf
10	Korea	Jun-Young Choi	Energy Efficiency Standards and Labelling Program for Air Conditioners in Korea	AC-Korea paper.pdf AC-Korea presentation.pdf
11	Mexico	Pedro Guzman	Mexican Experience: Energy Efficiency for Room Air-Conditioners	AC-Mexico paper.pdf AC-Mexico presentation.pdf
12	Philippines	Isagani Soriano	Philippine MEPS and Labelling for Room Air Conditioners	AC-Philippines.pdf
13	Chinese Taipei	Yie-Zu Hu	Energy Efficiency Measurements of Small Air-Conditioning Systems in Chinese Taipei	AC-ChineseTaipei.pdf
14	Thailand	Withaya Yongjaroan	Minimum Efficiency Performance Standard for Air Conditioners in Thailand	AC-Thailand.pdf
15	Thailand	Phanu Kritiporn	Ballast Market in Thailand	Ballast-Thailand.pdf
16	USA	Gregory Rosenquist	Residential Air Conditioner in the USA: Market, Test Procedures, and Efficiency Standards	AC-USA.pdf

APPENDIX IV: BALLAST DISCUSSION PAPER

APPENDIX V: AIR CONDITIONER DISCUSSION PAPER