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APEC

DISTRIBUTION TRANSFORMER SURVEY: ESTIMATE OF ENERGY SAVINGS POTENTIAL FROM MANDATORY EFFICIENCY STANDARDS (MEPS)

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ACRONYMS

ACEEE	American Council for an Energy-Efficient Economy
AQSIQ	Supervision, Inspection and Quarantine of China
APEC	Asia-Pacific Economic Cooperation
BEE	Bureau of Energy Efficiency
CCNNIE	National Consultative Committee for Electrical Installations Standardization (Comité Consultivo Nacional de Normalización de Instalaciones Eléctricas)
CLASP	Collaborative Labeling & Appliance Standards Program
CNIS	China National Institute of Standardization
COF	Code of Federal Regulations
CONUEE	National Commission for the Efficient Use of Energy (Comisión Nacional para el Uso Eficiente de la Energía)
CQC	China Quality Certification Center
CRGO	Cold Rolled Grain Oriented
DCCEE	Department of Climate Change and Energy Efficiency
DOE	Department of Energy
DRET	Department of Resources, Energy and Tourism
DT	Distribution Transformer
ECC	Energy Conservation Center
EDF	Environment and Development Foundation
EECA	Energy Efficiency and Conservation Authority
EESL	Energy Efficiency Standards & Labels
EPA	Environment Protection Administration
FIDE	Trust for Saving Electrical Energy (Fideicomiso para el Ahorro de Energía Eléctrica)
ICA	International Copper Association
IEA	International Energy Agency

INDECOPI	National Institute of Competition Defense and Intellectual Property Protection (Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual)
KEMCO	Korea Energy Management Corporation
kVA	Kilovolt-Ampere
LBNL	Lawrence Berkeley National Laboratory
LI	Liquid-immersed
MEPS	Minimum Energy Performance Standards
MOIT	Ministry of Industry and Trade
NEMA	National Electrical Manufacturers Association
NDRC	National Development and Reform Commission
PACE	Property Assessed Clean Energy
PRC	People's Republic of China
ROI	Return on Incremental Investments
S&L	Standards and Labeling
SEC	Fuel and Electricity Superintendence (Superintendencia de Electricidad y Combustible)
SENER	Ministry of Energy (Secretaría de Energía)
STAMEQ	Directorate for Standards, Metrology and Quality
T&D	Transmission and Distribution
US	United States of America
ZBSTRI	Zhong Biao Standard Technology Research Institute Co. Ltd

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INTRODUCTION

The Asia-Pacific Economic Cooperation (APEC) secretary awarded Econoler this distribution transformer (DT) survey project in line with the APEC Regulatory Cooperation Process Mechanism on Trade-Related Standards and Technical Regulations.

The aims of the project are i) to analyze enablers for and barriers to introducing or raising mandatory minimum energy performance standards (MEPS) for DTs in individual APEC member economies; ii) to review the experience, successes and failures of current Energy Efficiency Standards & Labels (EESLs) programs for DTs and identify the best practices across the APEC member economies; and iii) to provide a strategic framework for developing national roadmaps for introducing or raising mandatory MEPS for DTs and the design and implementation of such programs.

The International Copper Association (ICA), a member of the Copper Alliance, is the project manager on behalf of APEC for the project overseen by the China National Institute of Standardization (CNIS). The ICA awarded to the Lawrence Berkeley National Laboratory (LBNL) a project linked to that of Econoler. Its goal was to evaluate the benefits of cost-effective improvements in energy efficiency of DTs in the APEC economies. Econoler and LBNL collaborated and developed possible synergies between the two projects.

The project was prompted by International Energy Agency (IEA) data, which stated that in APEC economies, the transmission and distribution (T&D) losses varied from 2.8% to 15.6% of final consumption. A third of these losses took place in DTs, which constituted a crucial component of the electricity supply system. Therefore, DTs represent a high potential for energy and cost savings in the APEC member economies.

The effective use of appropriate EESLs for DTs could lead to a global market with more efficient DT technologies, thereby having a positive impact on the global industry and generating continued CO_2 emission reductions.

Currently, in the APEC region, the development of standards and labeling (S&L) for DTs is not following a uniform pattern. Some member economies, like Australia; US and Viet Nam have developed MEPS and/or labels to reduce energy consumption of DTs. These MEPS were made mandatory by certain mandated governmental organizations. Several other member economies have not yet established any S&L.

To introduce such mechanisms, the APEC member economies would face barriers which could decrease their impacts and hinder successful application of the S&L. These barriers may include the following categories: lack of definition, technology, cost, financing, economic analysis and procurement barriers. They can be overcome with help from some enablers that will facilitate introducing or raising the mandatory MEPS for DTs.

Project Structure

Two reports have been separately accomplished under the APEC project EWG 15/2012A. The international work report (Volume 1) was carried out by Econoler, which presented experience

analysis, strategic national roadmaps of other APEC economies for DTs on introducing or raising mandatory MEPS.

The China work report (Volume 2) carried out by the Zhong Biao Standard Technology Research Institute Co. Ltd (ZBSTRI) presents a quantitative and qualitative evaluation of the situation in the People's Republic of China. It consists of four parts, the first part is enterprise questionnaire, the second part is policies and standards collection related to energy efficient DTs' promotion and application, the third part is current market status and energy efficiency data collection, and the fourth part is energy saving potential's estimation & market analysis from energy efficiency standards and policies. "

Moreover, the ICA is the project manager on behalf of APEC for the project overseen by the CNIS. The ICA awarded the LBNL a project associated to that of Econoler. The LBNL report evaluates EES&L programs for DTs in APEC economies from a quantitative point of view by assessing the national benefits of cost-effective improvements in energy efficiency of DTs. The benefits are calculated using a bottom-up approach called Bottom-Up Energy Analysis System (BUENAS) developed by the LBNL. Meanwhile, the Econoler present report looks at the subject from a qualitative point of view.

The Econoler and LBNL reports present a complete evaluation of the current status, the potential impact and the recommended roadmap for introducing or raising mandatory MEPS for DTs in each APEC member economy.

Therefore, the reports of Econoler (Volume 1), ZBSTRI (Volume 2) and LBNL should all be consulted to have a complete picture of APEC DTs evaluation.

Report Description

This report presents a qualitative analysis of the enablers and barriers to introducing or raising mandatory MEPS in the field of DTs by describing the successes and failures of each economy in the APEC region. In the overall analysis, the focus is upon DTs in electrical networks managed by utilities. The normative context and the stakeholders involved in the MEPS introduction are also introduced. The Collaborative Labeling & Appliance Standards Program (CLASP) and the APEC documentation have been used as the main references for the context section.

Each set of EESL for DTs is presented in the form of a worldwide review. This first section gives a useful overview by describing the best practices in this field. Then, the surveys' methodology and results are explained. The information collected through the surveys is used in the analysis of this study.

Before the general analysis of common barriers and enablers is presented, the specific situations of the APEC member economies are presented in the "member economy" sheets, which include a short description of the existing EESLs for DTs or those being developed and an analysis of successes and failures with introducing such regulations. Information about the successes and failures was provided by the survey results, direct communication with the organization in charge of EES&L (only for Australia) and a literature review. As for the member economies where no EES&L for DTs were introduced and no information was gathered in the surveys, a separate section describes their situations (see Section 3.13).

To develop an adequate understanding of the successes and failures of each individual economy, the common and specific barriers and enablers were analyzed based on the survey results and a literature review. Moreover, a strategic framework for developing national roadmaps for introducing MEPS for DTs has been developed and another has been developed for raising the level of the MEPS. Recommendations on overcoming the barriers are presented in the conclusion section of the report.

Introduction about Energy Efficiency Standards & Labels

EESL includes three main types of programs:

- Minimum Energy Performance Standard
- Endorsement label
- Comparative label

MEPS are procedures and regulations that prescribe the energy performance of manufactured products and sometimes prohibit the sale of products that are less energy-efficient than the minimum standards under government supervision. The MEPS define the testing protocols (test procedures) and determine indicators of energy performance.

Energy-efficiency labels are informative labels affixed to manufactured products describing the product's energy performance. Labels serve as a complement to MEPS by providing useful visual information about the energy efficiency of the equipment to allow the consumer to make informed purchase decisions.

Energy endorsement labels are awarded only to models meeting or exceeding a certain efficiency level and they indicate models of superior energy efficiency. They are a kind of voluntary labeling.

Comparative labels are labels attached to products to describe products' energy performance levels. They allow consumers to compare energy performance among models of similar products. Comparative labels can be mandatory or voluntary.

The effective use of the minimum performance standards and appropriate labeling schemes for DTs could have a positive impact on the overall industrial sector. These S&L should be developed by each country or province and adapted to the local market.

Types of Distribution Transformers Covered in the Analysis

The analysis focuses on DTs manufactured for utilities' network. The report does not cover the DTs used in the residential, commercial and industrial sectors.

Moreover, for the purpose of the survey, the definition of the IEC 60076-7 has been adopted. The upper voltage limit is 36 kV and the maximum capacity is 2,500 kVA three-phase or 833 kVA single-phase. The survey covered all types of energy-efficient DTs (liquid-immerged and dry).

1 REVIEW OF PRACTICES

This section presents an overview of current EESLs programs on DTs. Research on existing EESLs or those being developed has been performed using publically available information.

The three tables below present all the EESLs dealing with DTs in the world categorized by EESLs type. The information was found in a database developed by the CLASP. Because of the lack of a harmonized definition for DTs in the world, the EESLs have been selected based on the sector covered by the regulation. In this study, the targeted products are classified under industrial or commercial sectors; so the EESLs in the residential sector have not been taken into account. The tables are divided by country/economy to clearly identify which categories of EESLs have been developed in each country/economy.

Even though the objectives of this report are mainly related to MEPS, information about the other categories of EESLs can give a useful overview of the development of DTs regulation worldwide. Henceforth, the comparative and endorsement labels are also presented in the tables.

The detailed description of each APEC economy is provided in the specific “member economy” sheets in Section 3.

Table 1: Worldwide MEPS for DTs

Country/ Economy	Implementing Organization	Policy/Legislation	Dry (D) or Liquid-Immersed (LI)	Enforcement Date
Australia	Department of Climate Change and Energy Efficiency	3E Program: Equipment Energy Efficiency - AS2374.1.2-2003 Distribution Transformers[1] The standard specifies the technical requirements for single and three-phase power transformers, based on IEC 60076-1:1993.	D & LI	2004/2010
Brazil	Ministerio de Estado de Minas e Energia (Ministry of Mines and Energy)	Specific rules that define MEPS for liquid immersed DTs (new and refurbished, domestically manufactured or imported and for commercial sale and use in Brazil).	LI	2012
Canada	Natural Resources Canada Office of Energy Efficiency	Energy Efficiency Regulation[2]	D	2005/2010
China (PRC)	National Development and Reform Commission and General Administration of Quality Supervision, Inspection and Quarantine of China	China's SH15 standard.	D & LI	2010/2013
Egypt	Egyptian Organization for Standardization and Quality Control	2008/6977 Energy Efficiency of Distribution Transformers	-	2008
European Union	European Commission - DG Enterprise	The regulation has to be defined. The scope is expected to cover transformers used by industrial businesses and for distributing energy resources, such as exporting electricity from wind farms and cogeneration plants. The scope of the proposed ecodesign requirements includes small, medium and large power transformers with a minimum power rating of 1 kVA used in 50Hz electricity transmission and distribution.	-	Under development

[1] http://www.energyrating.gov.au/regulations/product-standards/overview/as2374/
[2] http://oee.nrcan.gc.ca/regulations/products/12742

Country/ Economy	Implementing Organization	Policy/Legislation	Dry (D) or Liquid-Immersed (LI)	Enforcement Date
India	Bureau of Energy Efficiency	This standard specifies the requirements for participating in the pilot scheme for oil-immersed, naturally air-cooled, three-phase, and double-wound non-sealed type outdoor distribution transformer. The referred Indian Standards are IS 1180 (part I). The MEPs level is that of Star 1.	LI	2012
Korea	Korea Energy Management Corporation	Energy Efficiency Label & Standard Program[3]	D & LI	2011
Mexico	National Commission for the Efficient Use of Energy	This standard establishes requirements for safety and energy-efficiency for distribution transformers.	LI	2014
New Zealand	Energy Efficiency and Conservation Authority	Energy Efficiency (Energy Using Products) Regulations 2002. [4] MEPS requirements are set out in AS 2374.1.2. The associated test procedure is IEC 60076-1	D & LI	2004/2010
Peru	Comisión de Normalización y de Fiscalización de Barreras Comerciales No Arancelarias (INDECOPI)	The draft of the technical standard defining the MEPS was issued on September 24, 2013. This MEPS will include liquid-inmersed and self-cooled monophase and three-phase DTs.	LI	Under development
United-States	US Department of Energy	National Efficiency Standard 10 CFR Part 431[5]	D & LI	2002/2007/ 2010/2013
Viet Nam	Ministry of Industry and Trade (MOIT)	For industrial, office and commercial equipment including DTs, the import and manufacture of equipment with an energy efficiency lower than the minimum energy efficiency will be prohibited from January 1, 2015. [6]	LI	2015

[3] http://www.kemco.or.kr/new_eng/pg02/pg02100200_2.asp
[4] http://www.eeca.govt.nz/node/1314
[5] 10 CFR Part 431
[6] http://asemconnectvietnam.gov.vn/lawdetail.aspx?lawid=2011

Table 2: Worldwide Comparative Label for DTs

Country/Economy	Implementing Organization	Policy/Legislation	Dry (D) or Liquid-Immersed (LI)	Enforcement Date
Chile	Superintendencia de Electricidad y Combustible (SEC)	NEMA TP-3 was released in 2000. It was updated in 2007 under the name NCh3039.	D & LI	2000/2007
China (PRC)	CQC (China Quality Certification Center)	China Energy Label - Power Transformer	D & LI	2010
China (PRC)	CQC (China Quality Certification Center)	CQC Mark Certification - Three-phase Distribution Transformers	D & LI	2013
India	Bureau of Energy Efficiency (BEE)	The referred Indian Standards are IS 1180 (part I) The standard and non –standard ratings are covered under the pilot energy labeling.	LI	2012
Japan	Energy Conservation Center, Japan	Top Runner Program[7]	D & LI	2002
Korea	Korea Energy Management Corporation	High-efficiency Appliances Certification Program[8]	D & LI	2011
Viet Nam	Ministry of Industry and Trade (MOIT)	Decision No. 51/2011/QD-TTg	-	2013
Viet Nam	Ministry of Industry and Trade (MOIT)	Viet Energy Star (confirmative energy label)	-	Under consideration

China (PRC)	India	Japan	Korea	Viet Nam	Viet Nam
					

[7] http://www.eccj.or.jp/top_runner/pdf/tr_transformers_summary.pdf
[8] http://www.kemco.or.kr/new_eng/pg02/pg02100101.asp

Table 3: Worldwide Endorsement Labels for DTs

Country/Economy	Implementing Organization	Policy/Legislation	Dry (D) or Liquid-Immersed (LI)	Enforcement Date
Brazil	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial - INMETRO	Portaria Inmetro nº 378 de 28/09/2010[9]	LI	2010
China (PRC)	CQC (China Quality Certification Center)	CQC Mark Certification - Three-phase Distribution Transformers	D & LI	2013
Korea	Korea Energy Management Corporation (KEMCO)	High-efficiency Appliances Certification Program[10]	D & LI	2011
Mexico	Fideicomiso para el Ahorro de Energía Eléctrica - FIDE (Trust for Saving Electrical Energy)	Sello FIDE No. 4148[11]	-	2008/2012
Chinese Taipei	Environment and Development Foundation (EDF)	In August 1992, the Environment Protection Administration (EPA) launched an eco-label program called "Greenmark".[12]	D	1992
Viet Nam	Ministry of Industry and Trade (MOIT)	Viet Energy Star (confirmative energy label)	-	Under consideration

Brazil	China (PRC)	Korea	Mexico	Chinese Taipei	Viet Nam
					

[9] http://www.inmetro.gov.br/legislacao/rtac/pdf/RTAC001604.pdf
[10] http://www.kemco.or.kr/new_eng/pg02/pg02100101.asp
[11] http://www.fide.org.mx/images/stories/sellofide/esp4148_01.pdf
[12] http://greenliving.epa.gov.tw/GreenLife/eng/fproduct.aspx

The above tables show that nine APEC member economies have already implemented MEPS for DTs. Moreover, Mexico and Viet Nam have already defined their regulations on which the MEPS will be based, but their enforcement will only start in the next few years. As for the European Union, the draft regulation was issued in May 2013.

The technology covered by each EESL is presented in Table 1: Worldwide MEPS for DTs the tables. DTs are distributed in two main categories: dry or liquid-immersed types. The majority of MEPS for DTs cover both technologies.

Several countries developed a complete set of regulations including several EESLs to reduce energy consumption of DTs. China and Viet Nam are in the process of developing three types of EESLs for DTs. Moreover, Korea; Mexico; Chinese Taipei and India decided to create a set of MEPS and a label, either a comparative or endorsement one. Although India is not an APEC economy, its experience in developing MEPS can be useful as a best-practice example. This example shows that a good solution to overcome the various barriers is to develop a complete set of EESLs and increase its stringency over time according to market response to the regulations.

The majority of the existing EESLs for DTs have been developed in the APEC member economies. This shows active efforts of this region in using standardization as a tool to reduce energy consumption.

2 STAKEHOLDER SURVEY

The surveys developed as part of this mandate targeted various stakeholders to gather information on the existing EESLs in the APEC member economies and on current barriers.

2.1 DATA COLLECTION TOOL

In order to analyze the enablers and barriers regarding introducing or raising mandatory minimum energy performance standards for DTs among manufacturers and end-users, Econoler experts developed two questionnaires based on Econoler's previous experience with conducting similar evaluations and secondary data analyses. The questionnaires were developed under the understanding that the most updated and relevant information on the enablers and current barriers to using the existing most efficient distribution transformers could be obtained from manufacturing firms as well as users of such equipment which are the electrical utilities. As mentioned previously, DTs for the residential, commercial and industrial sectors were not considered in the analysis.

The research themes broached in the questionnaires were based on the latest technology development, the existing EESLs, the usual barriers and similar projects on S&L. The themes were selected to qualitatively analyze the DT market and EESL implementation. The questionnaires covered the following themes:

- Interest in the development of energy-efficient DTs;
- DTs awareness;
- DTs technology;
- DTs cost, financing and economic analysis;
- DTs procurement.

In addition, both questionnaires included questions on each country's mandatory or voluntary energy efficiency standard and labels (EESLs) for DTs to determine which EESLs manufacturers or end-users are currently complying with. Finally, as requested by the Lawrence Berkeley National Laboratory (LBNL), the questionnaires also included some supplementary questions about the technical specifications of various DTs (liquid-immersed and dry-type) manufactured in the APEC member economies.

Since the term "distribution transformer" is defined differently by diverse economies and standards, a uniform definition was adopted for the purpose of the survey by using the IEC 60076-7 definitions and energy efficiency working group delimitation of 36 kV as the upper voltage limit.

2.2 WEB-BASED ONLINE SURVEY

Before carrying out the survey, a contact database was built to collect information on the current DT manufacturers and end-user utilities in the APEC member economies. The APEC, with the help of Econoler, compiled two lists of contacts (one for manufacturers and the other for utilities) to whom the questionnaire would be sent.

The main information included in the contact database was the organization name, contact name, email and phone numbers, as well as necessary characteristics to identify the type of respondent

and APEC member specifics. One major difficulty was to find the right person in the organization who knew about S&L and the associated barriers. Since the questionnaires included both qualitative and quantitative questions, they were sent to several contacts in some organizations to gather as much relevant information as possible.

Afterwards, an invitation form was sent to every contact to invite them to participate in the survey. The information in the invitation form included an introduction about the APEC project and the objectives regarding standards and labeling for DTs, as well as a website link for them to complete the web-based survey's two different questionnaires that had been developed for DT manufacturers and utilities.

The questionnaires used for the web-based survey can be found in the Appendix I and II.

Obviously, the biggest challenge was to obtain a significant number of respondents from the targeted population to make the final sample of respondents statistically adequate. Many efforts were made to achieve the highest response rate possible.

The survey was sent to the targeted population in two steps. First, the respondents were invited to complete a short version of the questionnaire (teaser), online or by email, to gather primary information. Then, they were invited to complete the full version of the questionnaire (including more technical questions from LBLN) by either following a hyperlink or being contacted by Copper Alliance directly. The mailings were done by APEC Secretariat and a cover letter was attached in the email together with the questionnaire to present the project for the stakeholder.

2.3 DATA ENTRY

For the purpose of the analysis, information gathered about the existing EESLs in the APEC member economies and on current barriers was compiled in a confidential database. Partially completed questionnaires by the two populations being studied (DTs manufacturers and end-users) were excluded from the database.

2.4 DATA ANALYSIS

Since individual member economies often had their own standards and labels or their unique market barriers and enablers, all the data collected was separately presented in an individual "member economy" report sheet for each APEC member economy and compiled on a confidential basis. The results were presented for each question in a statistical approach showing the number of respondents for each question asked. No percentages were given, since the number of respondents was too low. Some collected data were also presented in diagrams to facilitate the comprehension of results.

Based on the survey results, Econoler was able to identify enablers for and barriers to introducing or raising MEPS for DTs.

The segmentation of results allowed making comparisons among the economies and identifying the major obstacles to introducing efficient DT technologies into territories where the implementation of MEPS can be improved. The analysis also offers the opportunity to better understand how more efficient DTs could be better promoted across the APEC market.

2.5 DATA INTERPRETATION

Data interpretation was straightforward. Every APEC economy's report sheet was thoroughly evaluated to provide a clear picture of each member's current status with regard to standards and labeling or market barriers and enablers (see Section 3). The analysis of the survey results are compiled in APPENDIX III.

This approach allow providing a complete picture of the standards and labeling currently being implemented across the APEC member economies and revealing the general trends, comparisons and progress regarding MEPS for DTs.

In order to deliver a meaningful message, results must be interpreted carefully. Influence factors such as sample size, response percentages or potential biases must be taken into account throughout the process of results interpretation.

3 MEMBER ECONOMY-SPECIFIC ANALYSES

Member economy-specific analyses were made for member economies that had existing regulations on DTs or were developing them and intended to use the survey data. The member economy sheet includes a short presentation of the existing regulations related to EE for DTs, including the organizations responsible for developing and implementing these regulations. Moreover, the survey results for individual member economies are presented.

Since the survey responses did not cover the entire APEC region, Econoler contacted the organization in charge of MEPS implementation in Australia; Canada; PRC; New Zealand and US, as to collect information about best practices regarding MEPS for DTs. The questions focused on barrier removal to increase market penetration. Australia is the only economy that responded with valuable data and the information is presented in its member economy sheet.

For the APEC member economies without MEPS for DTs, there is one section that describes their general EESL development. For Peru, a specific member economy sheet presents the data gathered from a literature review and survey responses for Peru.

Due to the low survey response rate, member economy-specific strategic frameworks for developing national roadmaps for introducing or increasing the level of MEPS for DTs have not been defined. An overall roadmap for introducing MEPS for DTs and another one for increasing their level are defined in Section 5.

3.1 AUSTRALIA

3.1.1 Current S&L Programs for DTs

Since Australia and New Zealand both employ the same regulation system regarding MEPS for DTs, they will be discussed together. In fact, Australia and New Zealand are jointly developing mandatory minimum efficiency requirements for specific appliances. Co-funded by the Australian Department of Climate Change and Energy Efficiency (DCCEE) and the New Zealand government, the Equipment Energy Efficiency Program (3E) is intended to cover national appliance and equipment energy efficiency initiatives, especially those concerned with MEPS.

The objectives of introducing MEPS for DTs are the following:

- “Increase overall energy efficiency by reducing electricity losses in transformers, thereby moving toward a sustainable energy future; and
- Create a more productive and internationally competitive economy, by the maintenance of good international economic relationships.”[13]

[13] Energy Efficiency and Conservation Authority. “Minimum Energy Performance Standards for Distribution Transformers”, July 2013, p.3.

Issued In October 2004, the AS2374.1.2-2003 Standard specifies MEPS requirements especially for DTs and has been mandated as part of the MEPS program. In New Zealand, the same standard was incorporated into a regulation and is being monitored by the Energy Efficiency and Conservation Authority (EECA). This regulation bans transformers which do not meet minimum efficiency levels. The standards are defined for oil-filled DTs and for dry-type DTs. All new DTs sold in Australia and New Zealand are required to comply with these minimum efficiency (MEPS1) levels. The standard also specifies voluntary high efficiency levels.[14]

In addition, test methods for the verification of efficiency requirements are based on the IEC 60076 standard.

The creation of MEPS represents a significant action in both governments' response to climate change, aimed directly at reducing greenhouse gas emissions. As part of the 3E program, further energy efficiency performance standards are currently being developed to create a scheme for voluntary 'high efficiency' labeling.

3.1.2 Successes and Failures

Market Barriers

Part of the information on which the following analysis is based was collected from an email response from the Australian Department of Resources, Energy and Tourism (DRET). It stated that both Australia and New Zealand encountered several market barriers to introducing the MEPS for DTs. Following is a summary of the main barriers that were identified[15].

Data Availability

A current lack of repositories or commercial companies that collect data on distribution transformer numbers, typical rating, typical loading etc., was identified as one important barrier. This lack of data has been observed regarding three main transformer owner groups:

- "Public utilities;
- Isolated off-grid generators and distributors, such as mining companies;
- Grid-connected high-voltage customers who own their own transformers." [16]

This lack of data has made it extremely difficult, if not impossible, to take the following three necessary actions which would help enhance the stringency of performance standards or the scope of product coverage:

- "identifying and substantiating the existence of market failures preventing the purchase of more efficient transformers and thus justifying government intervention in the market;
- modeling the distribution of costs and benefits of a range of policy responses on key stakeholders;

[14] Energy Efficiency and Conservation Authority. "Minimum Energy Performance Standards for Distribution Transformers, July 2013, p.1-3.
[15] It should be noted that this section of the report is not statically relevant due to the low number of respondents. Results should be used and interpreted with caution.
[16] Department of Resources. Energy and Tourism, Appliance Energy Efficiency Branch, Australia.

› better research to understand the market and the barriers faced by different market segments to the uptake of higher efficiency distribution transformers." [17]

Further, the lack of real-time monitoring of electricity flows between the substation and consumers has prevented the distribution company from determining the real sources of losses.[18]

Regulatory Rules

The current regulatory framework for public electricity supply does not promote the use of highly efficient DTs. All the public electricity networks in Australia are heavily regulated due to their monopolistic characteristics. Under this regulatory system, the costs of losses incurred while distributing electricity, including load and no-load transformer losses, are allowed to be passed on to consumers.

For example, a private transformer owner can pass on costs of losses to tenants in large commercial buildings. There is thus little incentive for the transformer owner in buying highly efficient DTs units. "Transformers used in such buildings are most likely to be dry-type units which are not so readily available from Australian and New Zealand manufacturers. They are more likely to be imported units which are potentially cheaper but less efficient than locally manufactured units."[19]

Economic Analysis

Transformer efficiency is not an important factor to consider when deciding on the transformers to purchase in the industrial and mining sectors. Usually, when short-term operational and financial analyses are performed in the mining and manufacturing industries, the primary selection considerations focus on availability, reliability and initial capital cost. In contrast, loss assessment over lifetime costing is not a major selection factor for most industries.

No International or Widely Accepted Definitions of Energy-efficient DTs

According to the EECA, there is a lack of knowledge and awareness in the private sector regarding the benefits of using more efficient technology for DTs. This situation is especially evident in places where DTs provide "nonlinear loads that will increase transformer loss, causing overload, overheating and resulting in more rapid ageing of the transformer insulation, leading to a reduced transformer lifetime." [20]

Market Enablers

According to DRET, reviewing and revising the regulatory framework is a key priority in increasing the market penetration of high efficiency DTs. It shall be important, however, to ensure that the

[17] Department of Resources. Energy and Tourism, Appliance Energy Efficiency Branch, Australia.
[18] Department of Resources, Energy and Tourism, Appliance Energy Efficiency Branch, Australia.
[19] Energy Efficiency and Conservation Authority, "Proposed Revised Minimum Energy Performance Standards for Distribution Transformers", December 2010, p.28
[20] Energy Efficiency and Conservation Authority, "Proposed Revised Minimum Energy Performance Standards for Distribution Transformers", December 2010, p.28-29

changes to the market do not create negative unintended consequences, especially regarding greenhouse gas abatement and consumer electricity costs.[21]

3.2 CANADA

3.2.1 Current S&L Programs for DTs

With the CSA 802.1-00 standard, efficiency regulations have been amended to strengthen the MEPS, especially for dry-type transformers imported or shipped inter-provincially for sale or lease in Canada. However, this new regulation also applies to dry-type transformers in which the core and windings are in a gaseous or dry compound, following a voluntary agreement between NRCan and the Canadian Electricity Association (CEA). [22]The creation of a mandatory minimum efficiency standard for liquid-immersed DTs was discontinued after several years of development. CSA now administers the Canadian standard using the voluntary standards (NEMA TP 1 and TP 2) of the National Electrical Manufacturers Association (NEMA), especially for a range of regulated equipment, efficiency levels and transformer test procedures.

Transformers excluded from this proposed regulation are the following categories:

- “autotransformers;
- rectifier transformers;
- sealed transformers;
- non-ventilated transformers;
- testing transformers;
- furnace transformers;
- welding transformers;
- drive (isolation) transformers with two or more output windings or a rated low-voltage line current greater than 1500 A;
- transformers with a nominal frequency other than 60 Hz;
- grounding transformer;
- special impedance transformer;
- on-load regulating transformer; and
- resistance grounding transformer.” [23]

Energy Performance Test Procedure

Minimum efficiency values for dry-type transformers CAN/CSA-C802.2-00 are referenced as part of the test procedure for verifying the energy performance of transformers. Models that meet the regulated levels will bear a verification mark from a certification organization accredited by the Standards Council of Canada and recognized by Natural Resources Canada or a verification label issued by a province.

[21] Department of Resources, Energy and Tourism, Appliance Energy Efficiency Branch, Australia.
[22] Canadian Energy Efficiency Office, http://oee.nrcan.gc.ca/regulations/bulletins/16910, 2013.
[23] Natural Resources Canada, http://oee.nrcan.gc.ca/regulations/bulletins/660.

3.2.2 Successes and Failures

The analysis of barriers and enablers regarding the introduction of MEPS for DTs has not been made, due to inadequate responses to the online survey of manufacturers and utilities carried out by Econoler as a part of the APEC Survey project and therefore a lack of information.

3.3 CHILE

3.3.1 Current S&L Programs for DTs

Since its creation in 1985, the Superintendencia de Electricidad y Combustible (SEC) (Fuel and Electricity Superintendence) has been responsible for enforcing and monitoring S&Ls for electricity technologies in Chile. The Ministry of Energy is in charge of developing the regulation.

Based on a review of publicly available information, it appears that Chile only has a voluntary labeling program for DTs, namely NEMA TP-3, which was first implemented in 2000. This label was modified in 2007 and renamed as NCh3039 (INN, 2007c). It covers both dry- and liquid-type DTs.

In addition, the ministry is developing several mandatory comparative labeling schemes for lighting technologies. If completed, these schemes are expected to become effective at the end of 2013.

As for mandatory MEPS, they are currently being developed for refrigerators and incandescent and fluorescent lighting equipment.

Chile's current major concerns seem to be the standardization processes to address electricity network safety, rather than improving energy efficiency.[24]

The APEC, as the international organization committed to supporting the development of S&Ls, has been offering its support to Chile for the past and current implementation of mandatory comparative labels and MEPS.

3.3.2 Successes and Failures

The analysis of barriers and enablers regarding the introduction of MEPS for DTs has not been made, due to inadequate responses to the online survey of manufacturers and utilities carried out by Econoler as a part of the APEC Survey project and therefore a lack of information.

3.4 CHINA (PRC)

The information regarding China (PRC) is presented separately in the 'Distribution Transformer Survey: Estimate of Energy-saving Potential from Mandatory Efficiency Standards (MEPS) Volume 2 (China Work) by the ZBSTRI.

[24] http://www.revistaei.cl/revistas/imprimir_noticia_neo.php?id=847

3.5 JAPAN

3.5.1 Current S&L Programs for DTs

Following the Kyoto Protocol meeting in 1997, Japan has developed a labeling program by creating an EE Program. Administered by the Energy Conservation Center (ECC), the Top Runner program launched in 2002 covers a wide range of electrical equipment and appliances and sets out maximum target levels for permissible loss specifications. Dry-type and liquid-immersed DTs are both included in the program, which specifies the target levels of total losses for use in determining efficiency levels.

Comparative Label

Also launched in 2002 by the EEC along with the Top Runner Program, this comparative labeling scheme applies to dry-type and liquid-immersed transformers.

More precisely, the label applies to high-voltage receiving transformers and DTs (excluding gas insulating transformers), H-class dry-type transformers, single-phase transformers with capacity not more than 5kVA or three-phase transformers with capacity not more than 10kVA, transformers with capacity over 2,000kVA, Scott-connected transformers, transformers in mold structure for shared use between lighting and power, transformers with low-voltage output voltage below 100V or above 600V, forced-air-cooled or water-cooled type transformers, and multi-winding transformers.[25]

3.5.2 Successes and Failures

The analysis of barriers and enablers to the introduction of MEPS for DTs has not been made, due to inadequate responses to the online survey of manufacturers and utilities carried out by Econoler as a part of the APEC Survey project and therefore a lack of information.

3.6 REPUBLIC OF KOREA

3.6.1 Current S&L Programs for DTs

MEPS

In July 2012, the Korea Energy Management Corporation (KEMCO) adopted the Energy Efficiency Standards & Labeling (EESL) Program, which rates high energy consuming products from Grades 5 to 1. It is prohibited to produce and sell products that do not satisfy the MEPS. All domestic manufacturers and the importers must comply with the requirements of the program.[26] The EESLP applies to dry-type and liquid-immersed transformers.

The MEPS are based on measurement methods specified in KS C 4306, KS C 4311, KS C 4316, KS C 4317. These measurement methodologies refer to standards already published in the IEC 60076, which have been adopted without modification.

[25] Energy Conservation Standards working group, “Summary on Final Criteria”, 2002, p.2.
[26] Korea Energy Management Corporation, http://www.kemco.or.kr/new_eng/pg02/pg02100101.asp

Endorsement Label

Also launched in 2011 by KEMCO along with the EESLP, the High-efficiency Appliances Certification Program is a voluntary certification system promoting high-efficiency appliances and initiatives in the market. Certified products are entitled to bear the High-efficiency Appliance label and certificates are also issued. Currently, there are 44 target product categories, including dry-type and liquid-immersed transformers.[27]

3.6.2 Successes and Failures

The analysis of barriers and enablers to the introduction of MEPS for DTs has not been made, due to inadequate responses to the online survey of manufacturers and utilities carried out by Econoler as a part of the APEC Survey project and therefore a lack of information.

3.7 MEXICO

3.7.1 Current S&L Programs for DTs

On February 20, 2013, the National Commission for the Efficient Use of Energy (CONUEE), together with the National Consultative Committee for Electrical Installations Standardization (CCNNIE) and the Ministry of Energy (SENER), adopted a set of proposed standards, which are requirements for DT safety and energy-efficiency.[28] The proposed standards cover liquid-immersed DTs. The MEPS will be introduced in 2014.

On December 9, 2008, the Trust for Saving Electrical Energy (FIDE) launched an endorsement label program for distribution transformers, called Label No. 4148[29]. A revision to improve the image of the seal was introduced on February 20, 2012.

These two S&L tools use the same testing regulations.

3.7.2 Successes and Failures

The analysis of barriers and enablers to the introduction of MEPS for DTs has not been made, due to inadequate responses to the online survey of manufacturers and utilities carried out by Econoler as a part of the APEC Survey project and therefore a lack of information.

3.8 NEW ZEALAND

The content of this section is the same as the Australia section (Section 3.1).

[27] Korea Energy Management Corporation, http://www.kemco.or.kr/new_eng/pg02/pg02100101.asp
[28] PROYECTO de Norma Oficial Mexicana NOM-002-SEDE/ENER-2012, Requisitos de seguridad y eficiencia energética para transformadores de distribución.
[29] http://www.fide.org.mx/images/stories/sellofide/esp4148_01.pdf

3.9 PERU

3.9.1 Current S&L Programs for DTs

Based on a review of publicly available information, it appears that Peru is currently developing standards and labeling programs for DTs. A draft DT MEPS was issued on September 24, 2013 by INDECOPI. It was developed by the technical committee of standardization of medium and low-tension DTs. The drafting process started in November 2012. [30]

The MEPS is based on international and Peruvian references: IEC 60076-1 and NTP 370.002.

3.9.2 Successes and Failures

Market Barriers

When questioned on barriers to the introduction of MEPS for DTs in Peru, one manufacturer declared that the absence of harmonized test standards, the low demand for energy-efficient technology, the lack of financing and the long period of time required for achieving ROI were the main obstacles preventing the development of a more stringent and standardized market.

In addition, the same manufacturer mentioned a lack of awareness among local engineers, electrical contractors and end-users regarding the energy benefits of high-efficiency DTs and too high prices of energy efficient DTs as the two main barriers faced by their customers regarding the introduction of MEPS in the economy.

Market Enablers

When questioned on suggestions or enablers that could facilitate the introduction of MEPS for DTs in the Peruvian market, the same manufacturer stated that more marketing efforts should be made to promote and publicize the benefits of high-efficiency DTs, better financing options/low-rate credit and preparation of more stringent standard specifications for procurement and guidelines for purchasers.

3.10 CHINESE TAIPEI

3.10.1 Current S&L Programs for DTs

Endorsement Label

In August 1992, the Environment Protection Administration (EPA) launched an eco-label program called "Greenmark". Although the EPA is still managing the program via the Greenmark Program Review Committee, the implementation of all aspects of the program has been contracted to the Environment and Development Foundation (EDF). The program covers a large number of product categories, including paper, water-using devices and several energy-using appliances. All energy-using appliances must meet energy efficiency criteria to receive the label.[31]

[30] PROYECTO DE NORMA TÉCNICA PERUANA PNTP 370.400 2013
[31] Collaborative Labeling and Appliance Standards program (CLASP), http://www.clasponline.org/en/Tools/Tools/SL_Search/SL_SearchResults/SL%20Detail%20Page?m=93a0cfa9-c137-45bd-83a0-29104ca22162, 2013.

3.10.2 Successes and Failures

Market Barriers

A DT manufacturer from Chinese Taipei identified three main market barriers encountered in the Chinese Tapei market regarding the introduction of more stringent EESLs[32]:

- Barriers to the imports (tariff and non-tariff) of low-loss cold-rolled grain-oriented (CRGO) steel, amorphous metal and copper;
- High prices of low-loss CRGO steel, amorphous metal and copper;
- Lack of financing and/or incentives to improve processes for making efficient DTs.

As for the barriers faced by customers, the long period required for achieving return on incremental investments (ROI) for highly efficient DTs and the procurement rules (specifications for purchases/standards) were both identified as the main barriers to purchasing more efficient DTs.

Market Enablers

As for suggestions on enablers to facilitate setting out more stringent MEPS for DTs, the manufacturer from Chinese Taipei proposed the following measures:

- Provide more information/information sessions;
- More marketing efforts;
- Increase R&D;
- Increase/better incentives.

3.11 UNITED STATES

3.11.1 Current S&L Programs for DTs

United States has been working on the improvement of high-efficiency DTs for over 20 years. The US Department of Energy (DOE) has been regulating the energy efficiency level of low-voltage dry-type DTs since 2002, when the US Congress adopted the National Electrical Manufacturers Association (NEMA) standards (NEMA TP-1-2002) as mandatory efficiency requirements for low-voltage dry-type DTs. This standard was later extended to liquid-immersed and medium-voltage dry-type DTs in 2010.Standards covering DTs are defined in the Code of Federal Regulations (COF), 10 CFR 431.192[33]. The full standard can be found in the Code of Federal Regulations, 10 CFR 431.196 [34].

The term “distribution transformer” does not include any transformer that is:

- An autotransformer;
- A drive (isolation) transformer;

[32] It is to be noted that this section of the report is not statically relevant due to the low number of respondents. Results should be used and interpreted with caution.
[33] Government printing office, http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec431-192.pdf, 2013.
[34] Government printing office, http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec431-196.pdf, 2013.

- A grounding transformer;
- A machine-tool (control) transformer;
- A non-ventilated transformer;
- A rectifier transformer;
- A regulating transformer;
- A sealed transformer;
- A special-impedance transformer;
- A testing transformer;
- A transformer with tap range of 20 percent or more;
- An uninterruptible power supply transformer; or
- A welding transformer.

In addition of the currently effective MEPS, the DOE published, in 2013, a final rule (78 FR 23335) regarding amended energy efficiency standards for liquid-immersed, medium-voltage dry-type, and low-voltage dry-type DTs[35]. The DTs final rule was the DOE's first "negotiated rulemaking," conducted under the Federal Advisory Committee Act and the Negotiated Rulemaking Act.[36] Compliance with the amended standards established for DTs in this final rule is required as of January 1, 2016.

3.11.2 Successes and Failures

Market Barriers

One US manufacturer completed the survey regarding market barriers and enablers for buying high-efficiency DTs. It declared that the two major market barriers to introducing high-efficiency DTs were that 1) several APEC member economies do not have MEPS and 2) the method for calculating profitability often excluded EE parameters for financial decisions both constituted.

Market Enablers

When questioned on enablers to facilitate introducing or raising the mandatory MEPS for DTs, the US manufacturer declared that providing more information sessions to improve awareness about high-efficiency DTs, along with better financing option/low-rate credit would certainly help improve the penetration of energy efficient DTs in the market.

3.12 VIET NAM

3.12.1 Current S&L Programs for DTs

The Directorate for Standards, Metrology and Quality (STAMEQ) implemented, in 2010, a labeling program for DTs under the name TCVN 6306-1 (IEC 60076-1). This label specifies the accepted

[35] Department of Energy, http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0048-0762, 2013.
[36] US Department of Energy, http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/44, 2013.

power efficiency of DTs and method for determining energy efficiency and includes a roadmap for developing MEPS. It applies to oil-immersed and three-phase power transformers.[37]

Starting from January 1, 2015, the Vietnamese Ministry of Industry and Trade (MOIT) will implement a more stringent program for industrial, office and commercial equipment including DTs by implementing MEPS for three-phase liquid filled distribution transformers.[38] Other MEPS will also be applied to other technologies, such as household appliances, office and commercial equipment, electric motors and transport vehicles, including passenger cars with of 7 or fewer seats.

Comparative Label

The Vietnamese MOIT also encourages the labeling of distribution transformers with a comparative labeling scheme (51/2011/QD-TTg), which was launched in 2013. For household appliances and industrial equipment, energy labeling has been mandatory since January 1, 2013.

Endorsement Label

The MOIT is also considering implementing a voluntary Vietnamese Energy Star label, which could apply to a wide range of products across Viet Nam.

3.12.2 Successes and Failures

When questioned on market barriers to introducing more stringent mandatory MEPS for DTs[39], a Vietnamese manufacturer identified two major market barriers: 1) the too high production cost of high-efficiency DTs and 2) the lack of financing and/or incentives by the government to improve processes for making efficient DTs. It also stated that there were no international or widely accepted definitions of energy-efficient DTs and the time period required for achieving ROI with energy efficient DTs was too long.

As for the barriers faced by customers when buying high-efficiency DTs, the manufacturer mentioned product prices as a main barrier, stating that the lowest price always wins in the market of DTs and that loss evaluation and control of actual performance were not concerns shared among the stakeholders involved in the DT market.

3.13 OTHER APEC MEMBER ECONOMIES

As for the other APEC member economies, they have not enforced any EESL for DTs or power conversion technologies, including transformers and power supply systems. Although the information is scarce, an assessment of the national benefits of cost-effective improvements in energy efficiency of DTs is presented in the LBNL report for these economies.

Papua New Guinea is the only APEC member economy with no implemented EESL. Brunei Darussalam and Hong Kong, China have already introduced labels in their regulations. Like Chile,

[37] Distribution transformers: Minimum energy performance and method for determination of energy efficiency, Hanoi, Vietnam, 2010, pp. 5-6
[38] http://asemconnectvietnam.gov.vn/lawdetail.aspx?lawid=2011
[39] It is to be noted that this section of the report is not statically relevant due to the low number of respondents. Results should be used and interpreted with caution.

Indonesia; Malaysia; Philippines; Russia; Singapore and Thailand have enforced both MEPS and labels for other technologies.

This shows that most of them are active in the field of energy efficiency, but have not focused on power conversion technologies until now. The roadmap presented in Section 5.1 has been developed to cover these economies.

4 BARRIERS AND ENABLERS ANALYSIS

Based on the survey data and literature review, this section makes a qualitative analysis of the barriers and enablers related to introducing or raising stringency of MEPS for DTs in the APEC economies.

The analysis is structured by theme using the same categories as in the survey questions, as outlined below:

- The Definitions include the issues related to the lack harmonized definition of DTs.
- The Technology section deals with high-efficiency DTs and their availability.
- The paragraph talking about Cost presents the barriers related to high cost.
- The Financing section describes the access to financing or incentive to buy energy efficient DTs.
- The Economic Analysis section talks about the barriers related to the economic performance calculation of DTs used in tendering.
- The procurement process barriers are analyzed in the Section 4.6.
- To complete the barriers analysis, the awareness-related issues are described as well as the solutions to overcome them.

The findings of the survey conducted among manufacturers and utilities allowed the assessment of the most relevant current market barriers regarding introducing or raising MEPS for DTs in each APEC member. These survey results are reported in the discussion of each theme.

4.1 DEFINITION

The literature review shows that currently, there is no harmonized definition of DTs that is accepted worldwide. Several elements can help explain this situation. Mainly, the electrical networks use different frequencies and tensions, which has led to different ranges of power.

The Commercial and Industrial Distribution Transformers Initiative[40] confirms our survey results by stating that the absence of a widely accepted definition of energy efficient DTs is one of the main barriers to developing the market for high performance DTs.

Establishing a clear definition of high efficiency for program managers and DT consumers could help increase the market share of energy-efficient DTs.

Moreover, the information on nameplates or in detailed technical specifications has not been harmonized among manufacturers. The losses (non-load and load) are not systematically written on nameplates. This information is essential to correctly select a high-efficiency DT. Consequently, to increase transparency, a requirement regarding losses should be incorporated in each DT nameplate.

But since frequency affects losses, in particular no-load losses, networks with different frequency levels cannot be compared with one another. For example, this means that DTs in the US cannot

[40] CEE, consortium for EE, 2011

be directly compared to those in Asia due to different network categorization. Therefore, the absence of harmonized test standards has made it difficult to effectively determine the losses of each DT.

IEC is building a new project team (IEC 60076-20) to deal with energy efficiency. There could therefore be an opportunity to develop worldwide testing standards for transformers since the IEC 60076 is the most widely used test standard in the APEC member economies.

In short, the lack of a worldwide-recognized definition and a standard test is a major barrier to the importation and local manufacturing of DTs, which cannot be tested according to the same standards and therefore, cannot be easily compared.

The manufacturers mentioned that the introduction of MEPS using a new test standard can make it complicated to implement the MEPS. The market would be more accessible and competition would be stronger if the same definition and standard test were used.

4.2 TECHNOLOGY

In the survey, one manufacturer mentioned that increasing availability of material supply to support higher efficiency would help lower the cost for the manufacturer as well as for the buyer. This barrier cannot be overcome by only introducing EESL because it depends rather on the raw material market and R&D, which could help reduce the amount of required material.

The European Commercial and Industrial Distribution Transformers Initiative assists its members (consumers) in developing demonstration or pilot projects and support R&D. On an industry-by-industry basis, the initiative encourages manufacturers to identify new products and emerging technologies, share results, and promote high performance. Although the existing DT technology is mature and has already achieved high performance, there is still room for improvement.

4.3 COST

High prices for materials were chosen by a large majority of survey respondents. The manufacturers considered cost for materials as a barrier and logically, the utilities considered the higher cost for high-efficiency DTs as a barrier to buying them. The first cost of high performance equipment can be a huge barrier for customers with limited resources.

When introducing MEPS, it is necessary that for public utilities to make sure that “the regulation of electricity distribution acknowledges the higher investment costs needed for the more efficient DTs”.[41]

Also, the high cost can be due to a market that is not fully competitive. American Council for an Energy-Efficient Economy (ACEEE) stated that “Imperfect competition occurs when there is not a fully competitive market for a product or service, so prices may be inefficient or availability may be limited. In some energy efficiency markets there is a limited number of producers or sellers, either

[41] Commercial and Industrial Distribution Transformers Initiative, CEE, consortium for EE, 2011.

an oligopoly or monopoly (in some cases a natural monopoly of necessity), and barriers to entry, such as high start-up costs or patents."[42]

4.4 FINANCING

The most mentioned barrier in the survey was the lack of financing or incentives to improve processes for making efficient DTs. On this matter, one manufacturer notified that the lowest price usually wins the market. According to this manufacturer:

"The major obstacle is always to obtain the available funds to purchase higher efficiency transformers along with procurement practices of buying the lowest cost even at the expense of efficiency."

The solution for the survey participant to overcome this barrier was to develop better financing option with low-rate credit. An increase in incentives was also identified as an effective strategy to stimulate the penetration of high efficiency DTs on their respective market. As stated by one of them, cost and financing enablers were particularly important in introducing high-efficiency DTs, since the market was price-driven.

ACEEE proposes a solution to remove financing-related market barriers by capitalizing energy efficiency investment. Nevertheless, it is currently challenging to do so. Usually, energy efficiency equipment is cost-effective in the long run. But the higher initial cost is a major obstacle. So financing solutions should be offered to facilitate the purchase of high performance DTs. The limited availability of financing is the first barrier. Moreover, when financing is available, "it can be difficult and expensive, due in part to high risk premiums and interest rates."[43]

To overcome this barrier, specific financing mechanisms exist but they require more experience with Property Assessed Clean Energy (PACE), on-bill financing, and energy service agreements.

4.5 ECONOMIC ANALYSIS

On this matter, one manufacturer reported that the lowest price usually won the market. According to this manufacturer, "The purchase decision should be based on the total energy savings and financial benefit received over the product lifecycle. To make this happen, governments have to step in mandating higher efficiency and even providing an incentive to make the conversion ahead of regulation as it ultimately saves money in deferring investment in new generation DTs leading to decreased CO_2 emissions".

The same manufacturer also declared that awareness of economic analyses was a very important factor, as procurement staff did not always have to carry out full economic studies when buying higher efficiency products. According to this manufacturer, "awareness of how to make an economic decision on total ownership cost would be helpful to those making a purchase decision while incentives help compensate the additional up-front cost to help lower payback period and raise return on investment".

[42] Overcoming Market Barriers and Using Market Forces to Advance Energy Efficiency, ACEEE, 2013.
[43] Overcoming Market Barriers and Using Market Forces to Advance Energy Efficiency, ACEEE, 2013.

One US manufacturer mentioned that a major market barriers was that the method for calculating profitability often excluded EE parameters for financial decisions. Also, the EECA of New-Zealand stated the concern for energy efficiency could be diminished by using the optimized deprival value calculation process.[44] Finally, the Equipment Energy Efficiency Program in Australia mentioned that "utilities that follow good industry practice should be able to convince the regulator of the need for an appropriate return on the incremental investment". [45]

The depreciation period to take into account in the calculation should be revised to be based on the average useful lives of different types of equipment. This solution would address the depreciation period barrier. [46]

To address the situations where the entity that purchases transformers or set out specifications is not the entity ultimately responsible for electricity costs, the whole regulatory scheme has to be considered when redesigning it to reduce transformer losses to reduce life cycle costs of distribution transformers.

4.6 PROCUREMENT

Procurement rules (standards/specifications for purchase) and country policies (where no national MEPS for DTs exist) were mentioned as a major barrier in the survey. A great majority of respondents mentioned that preparing standard specifications for procurement and developing guidelines for purchasers were the two most important enablers to facilitate introducing or raising MEPS for DTs.

The Energy Efficiency and Conservation Authority of New Zealand[47], in its first analysis to prepare the introduction of MEPS, stated the following: "With the present structure the network companies, which buy distribution transformers, have no financial interest in the electricity expended within them. Consequently the profit maximizing option for network companies is to purchase the transformer with the lowest capital cost, without regard for efficiency. The consequent costs are incurred by consumers, who have no means to avoid them. "

Then, Australia and New-Zealand changed these rules. The current regulatory framework for public electricity supply does not promote the use of highly efficient DTs. All public electricity networks in Australia are heavily regulated due to their monopolistic characteristics. Under this regulatory system, the costs of losses incurred while distributing electricity, including load and no-load transformer losses, are allowed to be passed on to consumers.

Several studies[48] have pointed out that the transformer sizing is an issue to be addressed. Because energy losses vary by load, transformer efficiency also varies according to load. In general, optimum efficiency is achieved at the point at which core losses and winding losses are equal. It is important that the entity that sets out specifications for DTs understands the load shape

[44] Minimum Energy Performance Standards for Distribution Transformers, Murray Ellis, 2003.
[45] Consultation Regulatory Impact Statement, Equipment Energy Efficiency Program, 2011.
[46] Overcoming Market Barriers and Using Market Forces to Advance Energy Efficiency, ACEEE, 2013.
[47] Minimum Energy Performance Standards for Distribution Transformers, Murray Ellis, 2003.
[48] Natural Resources Canada, "Study: Metered Load Factors for Low-Voltage, Dry-type Transformers in Commercial, Industrial and Public Buildings", 2006.

to purchase a transformer that will regularly perform at its best efficiency level. Also, DTs have a longer lifetime if they are fully loaded, compared with an under-loaded charge.

Strategies for development and diffusion of energy-efficient distribution transformers European project[49] stated that to facilitate the procurement of energy efficient DTs by utilities, stimulation of co-operative procurement is a good instrument. Several utilities, even from different economies, could perform joint purchase to reduce their investment costs.

It is obvious that the regulation could be a real obstacle for utilities to install efficient DTs. Some regulations do not limit the set for inclusion of loss costs in tariffs. So, no adjustments can be made when the grid losses diminish and create a disincentive to investment in energy efficiency. Also, the importance of the length of the regulatory period could affect the market penetration of high efficient DTs. In both cases, the regulation should be modified to facilitate the purchase of high performance equipment.

4.7 AWARENESS

The awareness was stated, at different level, as a huge barrier to the market development for energy efficient DTs in the survey answers and in the literature review.

The Department of Resources, Energy and Tourism of Australia pointed out that the lack of current repositories or commercial companies collecting data on DT numbers, typical rating, typical loading etc., was identified as one important barrier.

In addition, one respondent mentioned a lack of awareness among local engineers, electrical contractors and end-users regarding the energy benefits of high-efficiency DTs as a barrier.

ACEEE explains that “imperfect information may be the most widespread barrier to energy efficiency”. To improve the quality of information made available to manufacturers and utilities can help overcome this barrier. The labels are one good option to inform the consumers. Thanks to the label information, they can include product operating costs in their purchase decisions.

The EU document, “Strategies for development and diffusion of energy-efficient distribution transformers”[50] also mentioned that buyers should be properly informed to allow them choose transformers according to the size needed and their efficiency.

Existing channels should be used to spread the information through certification programs, promotion events, campaigns (labeling campaigns) and newsletters by national, local or regional energy agencies or similar actors, websites and software tools. Furthermore, manufacturers themselves could increasingly inform their customers about advantages of energy-efficient distribution transformers and give advice how to identify least-cost solutions aimed at minimizing lifecycle costs.

[49] Policies and Measures Fostering Energy-Efficient Distribution Transformers Report (Final version of Deliverable No. 6) from the EUIEE project, “Strategies for Development and Diffusion of energy-efficient distribution transformers – SEEDT”, 2005.
[50] Policies and Measures Fostering Energy-Efficient Distribution Transformers Report (Final version of Deliverable No. 6) from the EUIEE project, “Strategies for Development and Diffusion of Energy-efficient Distribution Transformers – SEEDT”, 2005.

5 STRATEGIC FRAMEWORK FOR DEVELOPING ROADMAPS FOR FUTURE POLICIES IN APEC MEMBER ECONOMIES

Based on our analysis of the barriers, we have noticed that MEPS can help increase the market penetration of energy-efficient DTs. The MEPS would not specifically address many of the identified barriers, but as far as awareness issues are concerned, the standards and activities carried out to introduce them would directly inform the stakeholders involved, thereby increasing awareness levels among consumers.

The process to develop or raise the level of MEPS does not consist of the exact same phases. Consequently, a generic framework for developing roadmaps is presented for the APEC member economies that have no MEPS for DTs or are developing them. A separate generic strategic framework for developing roadmaps has been developed for the APEC member economies with MEPS for DTs. The two roadmaps have been prepared based on the typical steps for developing mandatory MEPS stated by CLASP in its guidebook on EE labels and standards[51].

Due to the low response rate of the survey, member economy-specific roadmaps have not been defined.

5.1 STRATEGIC FRAMEWORK FOR DEVELOPING ROADMAPS FOR APEC MEMBER ECONOMIES WITHOUT MEPS FOR DTS

The APEC member economies which should follow this roadmap are the following:

- Brunei Darussalam;
- Chile;
- Hong Kong, China;
- Indonesia;
- Malaysia;
- Papua New Guinea;
- Philippines;
- Russia;
- Singapore;
- Chinese Taipei;
- Thailand;

Every member economy, except Papua New Guinea, has already developed a set of MEPS for a kind of technology other than DTs. So they know the process to develop such regulations. Due to the size of Papua New Guinea's market, this economy could collaborate with another leading economy to develop MEPS by following the same test standards and even using the same laboratories, such as in the way that New-Zealand has collaborated with Australia.

[51] Stephen Weil and James E. McMahon, CLASP, "Energy-Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting", 2005.

Since energy efficiency regulations for DTs are new in these economies, introducing a set of MEPS should be done in a careful manner by taking into account issues such as challenges related to compliance-checking.

Useful insights can be drawn from the experience of India, which has managed to develop and implement a complete S&L program by tackling many similar challenges. India decided to roll out its S&L program for DTs in phases, by starting introducing labels first on a voluntary basis and then mandatory labeling. After a period of 1 or 2 years, labeling could become mandatory for all products being sold. Throughout these stages, India's Bureau of Energy Efficiency carefully monitored the market to make sure that there were sufficient supplies of energy-efficient products and to choose the optimal timing for introducing the mandatory minimum energy performance standards (MEPS), which had already been prepared in the initial analysis.

A national strategic framework for developing roadmaps for introducing MEPS for DTs should include the following actions:

1 Decision on developing mandatory MEPS for DTs. If the government decides to implement the MEPS, it has to take into account many factors and stakeholders. From a technical point of view, a life cycle analysis of energy-efficient DTs may provide the required information to help decide on the level of EE that can be handled by the sector, depending on the electricity rates, DT costs and types. Also, the capacity to develop and implement the MEPS is evaluated. The analysis shall determine the appropriate label classes and MEPS level, ideally set at one of the label class thresholds when developing a set of S&L regulations. At this stage, an agency or a government body should monitor the market to determine if there are sufficient supplies of energy-efficient DTs.
2 Developing testing capability. The test structure to evaluate the DTs efficiency performance is created based on the existing testing facilities in the economy and even outside the economy since many DTs are imported.
3 Developing a MEPS implementation strategy. Design of the MEPS may be modeled on international standards. The economy needs to customize existing MEPS to fit its own needs. Such customization requires making an analysis of various aspects, including engineering, market, national impact, consumers and manufacturers. At this step, various stakeholders concerned with the introduction of the MEPS, such as manufacturers, utilities, laboratories and the customs are involved to collect their comments and take them into account to develop the MEPS implementation plan. As far as DTs are concerned, stakeholders can be easily identified and the enforcing body can carry out a communication campaign exclusively targeting these stakeholders. The effective date of the mandatory MEPS should be announced to suppliers in advance, e.g., at least 6 months and ideally 1 year in advance. This phase can involve the following steps:
   - Initial study
   - Developing the draft standard
   - Circulation for comments
   - Studying the comments
   - Approval: The final draft standard is submitted to the relevant organization for approval.
4 Regulation enforcement. The organization in charge of introducing the MEPS in the economy develops the regulation to make the MEPS mandatory in the economy's legislation. The

enforcement process also involves providing training to certain stakeholders who will be involved in MEPS compliance. This action involves developing a communication and outreach strategy based on international experience and best practices, with a particular focus on disseminating information.

5 Evaluation of the MEPS program. The government conducts periodic reviews to adjust the test procedures and, when possible and convenient, raise the MEPS. Market tracking is carried out to follow up on compliance of mandatory MEPS in the economy. Guidelines should be prepared for compliance-checking activities by consulting experience of those economies which have already evaluated their MEPS for DTs.

5.2 STRATEGIC FRAMEWORK FOR DEVELOPING ROADMAPS FOR APEC MEMBER ECONOMIES WITH MEPS FOR DTS

The APEC member economies which should follow this roadmap are the following:

- Australia;
- Canada;
- Japan;
- Korea;
- Mexico;
- New Zealand;
- Peru;
- United States;
- Viet Nam

These economies are at a different stage of MEPS development for DTs. As for Mexico and Viet Nam, their initial MEPS are still being developed, so it will be unlikely for them to decide to raise their MEPS level in the coming years. Most other economies have already raised the level of their initial MEPS, so they know the steps to be taken.

A national strategic framework for developing roadmaps for raising the level of the MEPS for DTs should include the following steps:

1 Decision on raising the mandatory MEPS for DTs. If the government decides to raise the level of the MEPS, it has to take into account at least the same factors and stakeholders as those when developing their initial MEPS. This step involves holding consultations with industry associations.

2 Developing an MEPS implementation strategy. Design of the MEPS may be modeled on the existing MEPS. At this step, various stakeholders concerned with raising the level of the MEPS, such as manufacturers, utilities, laboratories and customs should be involved to collect their comments and take them into account when developing the MEPS implementation plan. The stakeholders should have already been identified when developing the first MEPS and the enforcing body can carry out a communication campaign exclusively targeting these stakeholders. The effective date of mandatory MEPS should be

announced to suppliers in advance, e.g., at least 6 months and ideally 1 year in advance. This phase can involve the following steps:
- Initial Study
- Developing the draft standard
- Circulation for comments
- Studying the comments
- Approval: The final draft standard is submitted to the relevant organization for approval.

3 Regulation enforcement. The public body in charge of the MEPS in the economy modifies the existing regulation in the economy's legislation. The enforcement process also involves providing training to certain stakeholders that will be involved in MEPS compliance.

4 Evaluation of the MEPS program. The government conducts periodic reviews to adjust the test procedures and, when possible and convenient, raise the MEPS. Market tracking is carried out to follow up on compliance of mandatory MEPS in the economy.

5.3 RECOMMENDATIONS

This section makes general recommendations for DT EESL implementation in APEC member economies.

5.3.1 Recommendations on Setting up a National Strategic Framework for Developing Roadmaps

Communication

An S&L program requires making effective communication with consumers, market actors and governmental stakeholders. Further development of communications strategies is needed to help ensure an effective MEPS implementation.

Compliance-checking and Enforcement

Compliance-checking and enforcement in accordance with regulations is an important element in any S&L program. It is a national prerogative to decide how enforcement will be organized, how many resources will be made available for compliance-checking on appliances and what penalties will be imposed for failure to comply. Several organizations which have already developed MEPS for DTs could help provide guidance on developing compliance-checking guidelines, which could help the economies determine the minimum amounts of staff and resources needed for effective compliance-checking, as well as the structure for compliance-checking and enforcement. They could also help in practical aspects, e.g., how to organize a warehouse visit.

Some tools should be developed at APEC regional scale to facilitate and help each member develop a set of MEPS for DTs. The tools could include, for example, laboratory test results analysis guidelines, product registration and database input structures, etc. The tools developed can also cover the following enforcement activities:

› Visits to warehouses of importers and distributors (by the Ministry of Commerce, State Inspectorate, trade officers or the consumer protection authority): Check whether any banned products are present.

- Visits to manufacturer facilities (by state inspectorate or similar agencies): To check product design documentation records and the correct MEPS usage on manufactured products.
- Customs officer (the Ministry of Finance) operation guide: To verify the products imported according to a list of approved products.
- Monitoring of promotional materials checklist (the Ministry of Energy, Environment or Industry or the Energy Efficiency Agency): Check whether promotional materials of manufacturers and retailers comply with the regulation (websites, brochures, mass media campaigns, newspaper advertising, trade fairs, etc.)

Databases of approved products

Databases of approved products have proven to be effective in monitoring the market for efficient products as well as for compliance-checking. To reduce the burden of manufacturers, importers, and governments in managing databases, a product database should be maintained at the regional level to be used by the relevant authorities in the APEC member economies.

To be effective, this type of database should collect the following kinds of information:

- product characteristics
- country of origin
- test results and the laboratory where that test was conducted
- a copy of the laboratory test report
- economies in which the product will be sold
- the model numbers or names under which it is sold
- manufacturer or importer contact details

The Australian product registration database and the US EPA Energy Star database are good examples of comprehensive databases and could be studied, examined and used as models for an APEC regional database. If a regional database is not the preferred option, the APCE should at least specify the essential data fields and database structure so that results can become interchangeable between APEC member economies.

An additional benefit in constructing and maintaining a regional database would be that the APEC could employ technical experts to monitor the data entered into the database and identify products that do not comply with the regulations. Technical experts could then follow up with a manufacturer or importer to resolve the issues, or ask the manufacturer or importer to voluntarily change their energy label or product offering, or refer the cases to national authorities for further actions.

National Capacity-building

Capacity-building in MEPS program design, implementation and enforcement is needed for the various actors involved in future MEPS activities. Some economies have already gone through the implementation process for DTs and can share their experience with other economies through information dissemination and twinning arrangements. The APEC should, with help from training specialists (if possible), support the development of capacity-building materials for the following categories of stakeholder:

- S&L program managers;
- Test laboratory technical experts and managers;
- Enforcement agents (inspectors who are to perform manufacturer and importer visits, as well as point-of-sales visits and customs officers);
- Importers and purchasing managers (who decide on the line of products to sell).

Preparing enforcement tools should be closely linked to the capacity-building program for MEPS program managers in the APEC member economies because a healthy balance should be established between the financial and human resources available for enforcement and the robustness of the system. A MEPS system without enforcement is useless since some market actors can quickly learn that there can be no consequence for failure to comply, thereby discouraging other market actors from following the program rules so as to avoid losing their competitive advantages.

Training materials should be disseminated in all the participating economies as part of the initial training program. Econoler also recommends creating a network of MEPS program managers that can meet at regular intervals and exchange information through workshops to share success stories and the most effective strategies for cost-effective and efficient program enforcement. Training materials and information exchange should also cover communication strategies to support the rollout of MEPS for DTs in APEC member economies.

Support to Manufacturers

Manufacturers, in particular those not operating internationally, might be struggling to meet new MEPS requirements since they often lack the technical resources and R&D capacity that international competitors have. To make sure that the regulations will not create undue pressure on local manufacturers, MEPS often include a component to support local manufacturers in improving product designs and manufacturing practices, thus making it feasible for them to meet MEPS requirements as well.

5.3.2 Best Practice Examples

The Australian case, presented briefly here below, is a good example showing the importance of involving manufacturers in the process of MEPS development. This case is a best practice example showing how to introduce or raise the level of MEPS.

In 2011, the Australian government decided to increase the level of its first MEPS for DTs[52]. As defined in the Standards Australia processes, the MEPS was developed by involving industry stakeholders. However, the stakeholders raised the following issues:

- The difficulty for manufacturers to comply with the existing MEPS. This means that the regulation cannot push too high the efficiency of DTs in the first MEPS to avoid difficulties for the manufacturer.
- Problems with availability of materials, including low-loss core material. This issue can lead to cost increases of DTs.

[52] Equipment Energy Efficiency Program Consultation Regulatory Impact Statement, Equipment Energy Efficiency Program, 2011

- Lack of local manufactures of high-grade low-loss core steel. The organization in charge of developing the MEPS should ensure that local manufacturers can produce the energy-efficient DTs required by the MEPS.
- Potential contract problems for long-term, multi-year supply contracts with utilities.
- MEPS should apply to all transformers installed in the economy; surveillance on imported DTs should be put in place.

These issues must be taken into account when developing or raising the level of MEPS for DTs.

The European project, "Strategies for development and diffusion of energy-efficient distribution transformers"[53] and the Best Practices countries, such as Korea or Mexico, seem to agree that a policy mix is needed to adequately address the different barriers and obstacles. The introduction of MEPS should be accompanied by a labeling scheme to harmonize and visualize the information and by measures to inform participating stakeholders.

An effective regulatory framework is the most crucial element in overcoming the existing market barriers. According to DRET, reviewing and revising the regulatory framework is a key priority in increasing the market penetration of high efficiency DTs. It will be important, however, to ensure that the changes to the market do not create negative unintended consequences, especially those regarding greenhouse gas abatement and consumer electricity costs.[54]

[53] Policies and Measures Fostering Energy-Efficient Distribution Transformers Report (Final version of Deliverable No. 6) from the EUIEE project "Strategies for development and diffusion of energy-efficient distribution transformers – SEEDT", 2005.
[54] Department of Resources, Energy and Tourism, Appliance Energy Efficiency Branch, Australia.

APPENDIX I
MANUFACTURER'S QUESTIONNAIRE

General Information on Distribution Transformers Customers (DT) [A Series]

Contact Details

Please provide us with the contact details of the person in charge of energy efficient DT development or of the Standard and Label certification in your company.

Company:

Country:

Name:

Surname:

Position:

Telephone:

E-mail:

A1. Who are your customers for DTs?

a) direct procurement by utilities,

b) direct procurement by industries,

c) building developers,

d) contractors

e) others

A2. We would like to conduct the survey with the customers; could you provide us the contact of your main customers?

Interest in Increasing the Development of Energy Efficient Distribution Transformers [B Series]

B1. On a scale of 1 to 5, where 1 = 'not at all important' and 5 = 'very important', how important it is for your company to reduce the energy losses in DTs?

B2. Do you think that energy efficiency in DTs is relevant for your customers?

B3. Do you think that energy efficiency in DTs is relevant for your country?

B4. How do you evaluate your awareness about energy efficiency in DTs?

High, Moderate, Low

B5. In your opinion, should the market of energy efficient DTs be developed as a standard? Can you explain why?

Energy Efficiency Standards & Labeling for Distribution Transformers Awareness [C Series]

C1. In your market, does your company currently comply with any Energy Efficiency Standards & Labeling[55] (EESL) program related to Distribution Transformers[56] (DTs)?

1. Yes
2. No (Go to B4)

C2. Are there any standards for DT energy efficiency or DT losses in your domestic market and other countries to which you export? If yes, can you list such energy efficiency standards and indicate whether these are mandatory or voluntary as below?

Energy Efficiency Standard and Test Procedure Issuing Authority/ Standard Number	Range of Capacities (kVA)	Market or Country	Mandatory (Yes/No)	Are the Voluntary Standards Used / Referred to by Manufacturers & Customers? Rarely / Frequently / Always?

C3. Is your company facing any constraints in complying with the mandatory energy efficiency standards listed above?

C4. Are other manufacturers in your country able to comply?

C5. Which are the agencies involved in monitoring compliances?

C6. Is there a penalty for non-compliance with mandatory standards? How significant is it?

C7. In your market, does your company currently comply with energy efficiency labels for DTs?

[55] Energy-efficiency standards & labeling (EESL) programs are public policy tools for transforming country markets towards energy efficient appliances, equipment, and lighting products.
[56] Distribution transformers provide the necessary voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by customers.

C8. Are there any labels for DT energy efficiency or DT losses in your domestic market and other countries to which you export? If yes, can you list such energy efficiency labels and indicate whether these are mandatory or voluntary as below?

Energy Efficiency Label Issuing Authority / Standard Number	Range of Capacities (kVA)	Market or Country	Mandatory (Yes/No)	Are the Voluntary Labels Used / Referred to by Manufacturers & Customers? Rarely / Frequently / Always?

C9. Is your company facing any constraints in complying with the mandatory energy efficiency labels listed above?

C10. Are other manufacturers in your country able to comply?

C11. Which are the agencies involved in monitoring compliances?

C12. Is there a penalty for non-compliance with mandatory standards? How significant is it?

Market Barriers and Enablers for High-Efficiency Distribution Transformers – Mandatory Minimum Energy Performance Standard [D Series]

Manufacturers' Points of View

D1. In your opinion, what are the barriers to introducing or raising mandatory minimum energy performance standards for DTs among each of the categories outlined in the following table? For each of the chosen barriers, can you explain why you have chosen it in the following blank space?

Manufacturers' Points of View	
Definitions	
No international or widely accepted definitions of energy-efficient DTs.	☐
Absence of harmonized test standards	☐
Technology	
Lack of local availability of low-cost cold-rolled grain-oriented (CRGO), amorphous metal and copper	☐
Barriers to the imports (tariff and non-tariff) of low-loss CRGO steel, amorphous metal and copper	☐
Low demand for energy efficient technology.	☐
Inadequate design and manufacturing capacity for producing high-efficiency DTs.	☐
Cost	
Production costs for high-performance DTs are too high.	☐
High prices of low-loss CRGO steel, amorphous metal and copper"	☐
Financing	
Lack of financing and/or incentives to improve processes for making efficient DTs.	☐
Economic Analysis (For Manufacturers Producing Economic Analyses for Their Clients)	
Time required for achieving return on incremental investments (ROI) in EE too long.	☐
Method of calculating profitability excluding EE parameters for financial decisions	☐
Procurement	
Procurement rules (specifications for purchases/standards).	☐
Geographic constraints (plant site).	☐
Manufacturer stock management.	☐
Country policies (No National minimum energy performance standards for DTs exist.).	☐
Others	
Specify:	☐

Manufacturers' Points of View regarding Their Customers

D2. In your opinion, what are your customers' barriers to buying high-efficiency DTs among

each of the categories outlined in the following table? For each of the chosen barriers, can you explain why you have chosen it in the following blank space?

Manufacturers' Points of View regarding Their Customers	
Awareness	
Engineers, electrical contractors and end-users are not aware of the energy benefits of high-efficiency DTs.	☐
No international or widely accepted definitions of high-efficiency DTs.	☐
Technology	
Customers think that the technology of high-efficiency DTs needs to be improved.	☐
Cost	
Selling cost for high-efficiency DTs is too high.	☐
Financing	
Lack of financing and/or incentives for buying high-efficiency DTs.	☐
Economic Analysis	
Time required for achieving return on incremental investments (ROI) in EE too long.	☐
Method of calculating profitability of financial decisions (excluding energy efficiency parameters).	☐
Procurement	
Procurement rules (specifications for purchases/standards).	☐
Procurement rules are lowest price gets the award irrespective of energy efficiency	☐
Geographic constraints.	☐
Stock management.	☐
Country policies (no minimum national energy performance standards for DTs exist).	☐
Others	
Specify:	☐

D3. Can you identify the No. 1 and No. 2 most important barriers to introducing or raising mandatory minimum energy performance standards for DTs among the choices you made at D1 and D2?

D4. Do you have any suggestions on enablers to facilitate introducing or raising the mandatory minimum energy performance standards for DTs? Could you please explain why you have chosen these solutions and identify the stakeholders concerned for each of them in the following blank space?

Introducing or Raising the Mandatory Minimum Energy Performance Standards for DTs		
Awareness	Provide more information/information sessions.	☐
	More marketing efforts.	☐
Technology	Increase R&D.	☐
Cost	Increase/better incentives.	☐
Financing	Better financing options/low-rate credit.	☐
Procurement	Prepare standard specifications for procurement and guidelines for purchasers.	☐
Others		☐

Market Data for Distribution Transformers [E Series]

E1. Which kind of energy efficient DT does your company produce? (Grade 1, Level 1, TSL-1, or minimum)

E2. Which is the percentage of each kind of energy efficient DTs in your production?
Type of energy efficient DTs (%)

E3. What is the local market sale share of liquid-immersed and dry-type DT for your company?
Liquid-immersed DT (%):
Dry-type DT (%):

E4. For liquid-immersed DT, please provide the following sales market shares by kVA:
25 kVA (%)
60 kVA(%)
100 kVA (%)
160 kVA (%)
200 kVA (%)

E5. For liquid-immersed DT, what's the percentage of 3-ph DT and 1-ph DT in your local market?
3-phase liquid-immersed DT (%)
1-phase liquid-immersed DT (%)

APPENDIX II
UTILITIES' QUESTIONNAIRE

General Information [A Series]

Contact Details

Please provide us with the contact details of the person in charge of energy efficient DT purchase in your organization.

Company:

Country:

Name:

Position:

Telephone:

E-mail:

A1. We would like to conduct the survey with the DTs manufacturers as well; could you provide us the contact of your main DTs suppliers?

Interest in Increasing the Development of Energy Efficient Distribution Transformers (DT) [B Series]

B1. On a scale of 1 to 5, where 1 = 'not at all important' and 5 = 'very important', how important is it for your organization to reduce the energy losses in DTs?

B2. Do you think that energy efficiency in DTs is relevant for your country?

B3. How do you evaluate your awareness about energy efficiency in DTs?

High, Moderate, Low

B4. In your opinion, would mandatory MEPS for DTs be beneficial? If yes, in what way?

Energy Efficiency Standards & Labeling for Distribution Transformers Awareness [C Series]

C1. Are there any standards for DT energy efficiency or DT losses in your country? If yes, can you list such energy efficiency standards and indicate whether these are mandatory or voluntary as below?

Energy Efficiency Standard and Test Procedure Issuing Authority / Standard Number	Range of Capacities (kVA)	Mandatory (Yes/No)	Are the Voluntary Standards Used by Your Organization? Rarely / Frequently / Always?

C2. Does your organization currently buy DTs in compliance with any Energy Efficiency Standards & Labeling (EESL) program?

1. Yes
2. No

C3. Is your organization facing any constraints in buying DTs in compliance with the mandatory energy efficiency standards listed above?

C4. Which are the agencies involved in monitoring compliances of these standards?

C5. Is there a penalty for non-compliance with mandatory standards? How significant is it?

C6. Are there any labels for DT energy efficiency or DT losses in your domestic market? If yes, can you list such energy efficiency labels and indicate whether these are mandatory or voluntary as below?

Energy Efficiency Label Issuing Authority / Standard Number	Range of Capacities (kVA)	Mandatory (Yes/No)	Are the Voluntary Labels Used by Your Organization? Rarely / Frequently / Always?

C7. Does your organization currently buy DTs with energy efficiency labels?

C8. Is your organization facing any constraints in buying DTs in compliance with the mandatory energy efficiency labels listed above?

C9. Which are the agencies involved in monitoring compliances of these labels?

C10. Is there a penalty for non-compliance with mandatory labels? How significant is it?

Market Barriers and Enablers for High-Efficiency Distribution Transformers – Mandatory Minimum Energy Performance Standard [D Series]

D1. In your opinion, what are your organization's barriers to buying high-efficiency DTs among each of the categories outlined in the following table? For each of the chosen barriers, can you explain why you have chosen it in the following blank space?

Mandatory Minimum Energy Performance Standard [D Series]	
Awareness	
Engineers, electrical contractors and end-users are not aware of the energy benefits of high-efficiency DTs.	☐
No international or widely accepted definitions of high-efficiency DTs.	☐
Technology	
The technology of high-efficiency DTs needs to be improved.	☐
Cost	
Selling price for high-efficiency DTs is too high.	☐
Financing	
Lack of financing and/or incentives for buying high-efficiency DTs.	☐
Economic Analysis	
Time required for achieving return on incremental investments (ROI) in EE too long.	☐
Method of calculating profitability of financial decisions (excluding energy efficiency parameters).	☐
Procurement	
Procurement rules (specifications for purchases/standards).	☐
Procurement rules are lowest price gets the award irrespective of energy efficiency	☐
Geographic constraints.	☐
Stock management.	☐
Country policies (no minimum national energy performance standards for DTs exist).	☐
Regulation	
Regulations do not support procurement of high efficiency DTs	☐
Others	
Specify:	☐

D2. Can you identify the No. 1 and No. 2 most important barriers to introducing or raising mandatory minimum energy performance standards for DTs among the choices you made at D1?

D3. Do you have any suggestions on enablers to facilitate introducing or raising the mandatory minimum energy performance standards for DTs? Could you please explain why you have chosen these solutions and identify the stakeholders concerned for each of them in the following blank space?

introducing or raising the mandatory minimum energy performance standards for DTs		
Awareness	Provide more information/information sessions.	☐
	More marketing efforts.	☐
Technology	Increase R&D.	☐
Cost	Increase/better incentives.	☐
Financing	Better financing options/low-rate credit.	☐
Procurement	Prepare standard specifications for procurement and guidelines for purchasers.	☐
Others		☐

Distribution Transformers Characteristics and Usage [E Series]

E1. Which kind of energy efficient DT does your organization buy? (Grade 1, Level 1, TSL-1, or minimum)

E2. In term of quantity, what percentage do you attribute to each kind of energy efficient DTs you buy?
Type of energy efficient DTs (%)

E3. For liquid-immersed DT, please provide the following market shares your organization buys by capacity (kVA):
25 kVA (%)
60 kVA(%)
100 kVA (%)
160 kVA (%)
200 kVA (%)

E4. For liquid-immersed DT, what's the percentage of 3-ph DT and 1-ph DT in your stock?
3-phase liquid-immersed DT (%)
1-phase liquid-immersed DT (%)

E5. What is the load profile or RMS load on the distribution transformers that you own? (%)

APPENDIX III
SURVEY RESULTS

All answers from the survey with DTs manufacturers and end-user utilities have been compiled on a confidential basis.

SURVEY PARTICIPATION

A total of five manufacturers (respectively from Korea; Mexico; Peru; Viet Nam and one international manufacturer) completed the main version of the questionnaire and three others (Malaysia; Singapore and Chinese Taipei) completed the shorter version of the questionnaire, which only included the questions related to Energy Efficiency Standard and Labeling (EESL) and market barriers and enablers for DTs[57].

Therefore, eight respondents (n=8) provided answers to questions about Energy Efficiency Standard and Labeling (EESL) and market barriers and enablers for DTs. Only five respondents (n=5) provided answers to the other questions that were only included in the main questionnaire.

As for the utilities, one respondent (Canada) completed the main version of the questionnaire and another (Papua New Guinea) the shorter version.[58]

The results are presented for each question in numbers only (and not in percentages) since there were not enough participants in the survey to be statistically significant to show results in percentages. It should be noted that the total of responses for some questions exceeded the number of respondents due to multiple-mention questions. In addition, due to the low number of respondents, the survey results for the utilities are only summarized and not presented in diagrams.

RESEARCH THEMES

This section presents the survey results by the main research themes surveyed in the questionnaires. The questions were developed on the basis of the latest technology development and respondents' interest and awareness in the development of high efficiency DTs, the existing EESLs, the usual barriers and enablers to the introduction of EESLs and similar S&L projects. The themes were selected to qualitatively analyze the DT market and EESL implementation. Generally, survey results should be interpreted with caution, given the small number of respondents. Some findings are outlined in diagrams to facilitate the comprehension of results.

Manufacturer Interest and Awareness regarding Development of Energy-efficient DTs

DT manufacturers (N=5) were asked to determine on a scale of 1 to 5 (with 1 indicating "not at all important" and 5 "very important") the relevance of developing and distributing energy-efficient DTs in their markets. The objective was to better understand the importance of energy efficiency in DTs in every APEC member economy.

[57] The main version of the questionnaire for manufacturer is included in the Appendix.
[58] The main version of the questionnaire for utilities is included in the Appendix.

Table 4: Manufacturer Interest and Awareness regarding Energy-efficient DT Development

Answer Options	1	2	3	4	5
How important it is for your company to reduce the energy losses in DTs?	0	3	0	0	1
How do you think energy efficiency in DTs is relevant for your customers?	0	1	2	1	0
How do you think energy efficiency in DTs is relevant for your country?	0	0	2	2	0

The majority of respondents declared that reducing energy losses in DTs was not really important for their company. Only one respondent affirmed it was very important. Besides, when asked about the importance of energy efficiency for their customers, results show mixed opinions with two respondents stating their customers were more or less concerned with high efficiency DTs. Finally, respondents were more optimistic when questioned about the relevance of energy efficiency for their economies, with two respondents declaring that it was important.

Manufacturer Opinion about the Market for High-efficiency DTs

Manufacturers (n=5) were also asked if they believed the market for DTs should be developed as a standardized one.

Table 5: Opinions about the Market for High-efficiency DTs

Answer Options	Response Count
Yes	3
No	1

The majority of respondents declared that they were in favor of a standardized energy efficiency market to allow for competitive options of DTs to be made available to customers. One respondent even stated that: “beyond just setting an efficiency target at 50% loading, standards should also recommend methods by which buyers can make a total ownership cost decision based on their cost of energy, money and loading as impacted by the particular transformer no-load and load losses.”

Current Energy Efficiency Standards & Labeling in the APEC Member Economies

Manufacturers (n=8) were questioned on their knowledge of EESL programs related to DTs in their own areas and other nearby markets and if their company was complying with those EESL.

Table 6: Energy Efficiency Standards & Labeling in the APEC Member Economies

Answer Options	Response Count
Yes	4
No	2

The majority of respondents (four) declared that their company was currently complying with Energy Efficiency Standards & Labeling, while two others (from Singapore and Viet Nam) located

in the same area said they were not. In addition, the survey revealed that in APEC member economies with existing EESLs, the majority of respondents were well aware of them and able to identify them.

Penalty for Non-compliance with Mandatory Standards and Labels

Manufacturers were questioned on the existence of a penalty system in their own member economy for non-compliance with mandatory standards or labels. Two respondents said there was an existing monetary penalty system in their market for non-compliance with mandatory standards in cases of exceeded guaranteed losses. For example, the U.S. Department of Energy (DOE) does have a penalty clause requiring the manufacturer to discontinue manufacturing a specific "model" until a dispute is resolved with the government.

As for labels for DTs, two respondents said there were not any constraints for not-complying with existing labels for DTs.

Market Barriers and Enablers

This section identifies the most relevant existing market barriers and enablers regarding introducing or raising mandatory MEPS for DTs in individual APEC member economies. In each market, both manufacturers and end-user utilities were questioned.

Barriers Facing Manufacturers

Manufacturers (n=8)[59] were asked about the main barriers to introducing or raising mandatory MEPS for DTs they faced in their markets. The following table presents the survey results.

[59] The total exceeded the number of respondents due to multiple mentions.

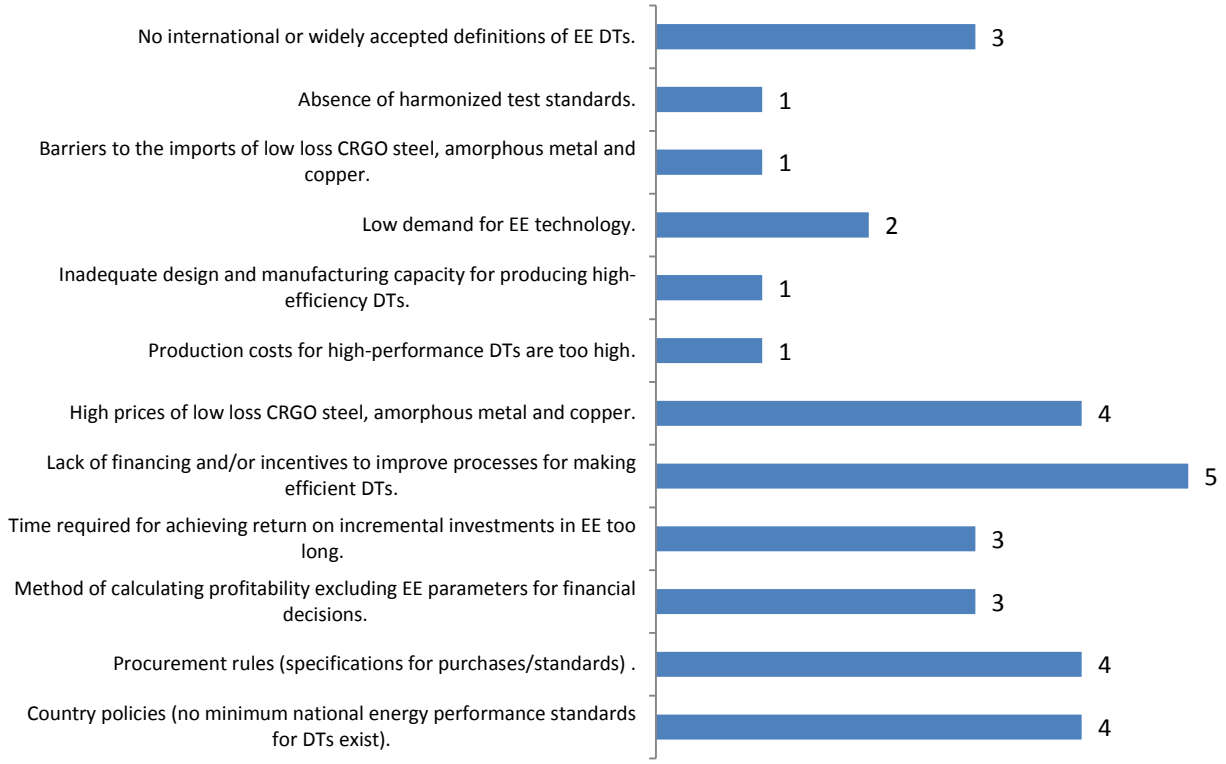


Figure 1: Barriers to Introducing/Raising Mandatory Minimum Energy Performance Standards

The most mentioned barrier was the lack of financing or incentives to improve processes for making efficient DTs, with five manufacturers having selected it. High prices for materials, procurement rules (specifications for purchase/standards) and member policies (no national MEPS for DTs exist) were also chosen by four manufacturers respectively.

Interestingly, geographic constraints or manufacturer stock management did not seem to represent a market barrier, with no respondents having chosen these market obstacles.

Barriers Facing Customers

Manufacturers (n=5)[60] were asked to identify the main barriers faced by their customer regarding introducing or raising mandatory MEPS for DTs in their markets. The survey results are presented in the following table.

[60] The total exceeded the number of respondents due to multiple mentions.

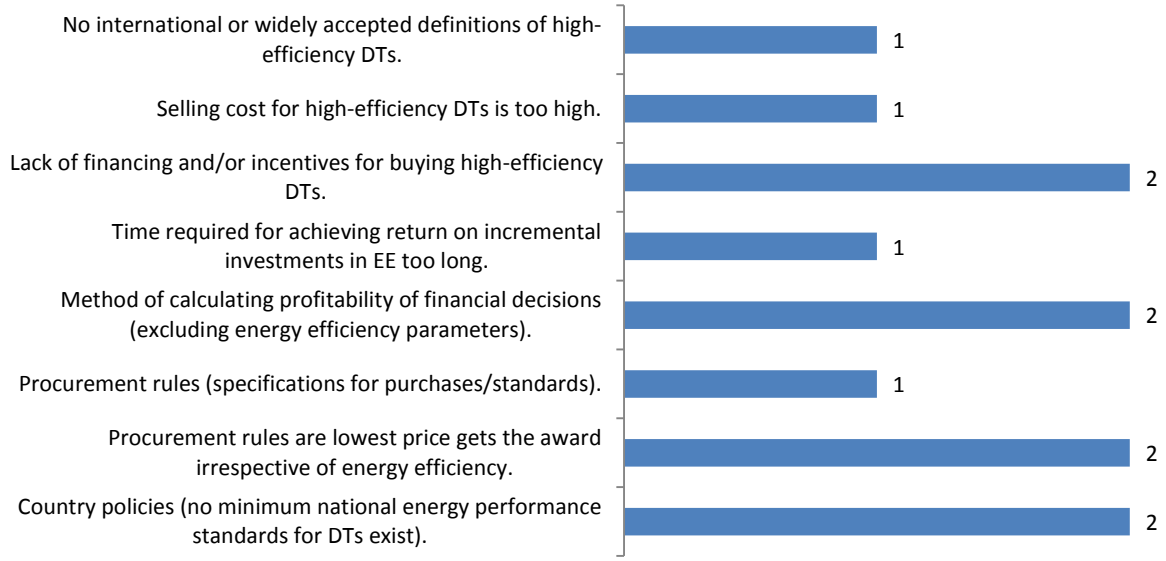
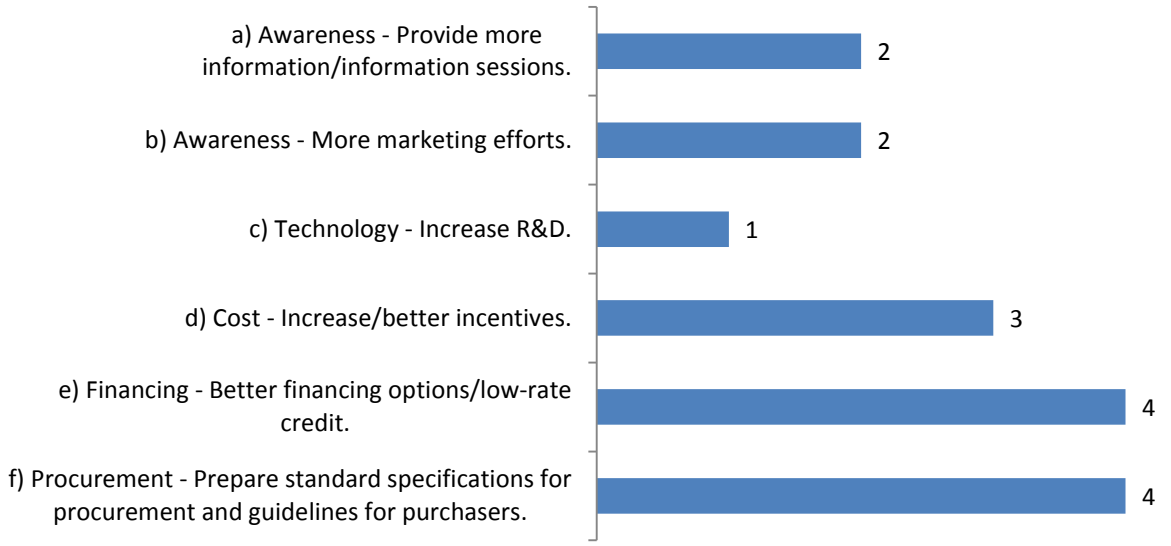


Figure 2: Barriers Facing Customers in Buying High-efficiency DTs

The above results show similar barriers facing both customers and manufacturers. Indeed, the lack of financing and incentives and the fact that the method of calculating profitability often excluded EE from financial decisions were both selected twice. According to manufacturers, the initial cost was a key parameter for manufacturers' and customers' alike when making decisions on whether or not to buy DTs.

Manufacturers' Market Enablers

Manufacturers (n=8)[61] were asked about their suggestions on enablers that would facilitate introducing or raising the mandatory MEPS for DTs in their respective markets. Results are presented in the following table.



[61] The total exceeded the number of respondents due to multiple mentions.

Figure 3: Enablers that Would Facilitate Introducing or Raising the Mandatory Minimum Energy Performance Standards

The majority of respondents (four) chose both "better financing options/low-rate credit" and "prepare standard specifications for procurement and guideline for purchasers" as the two most important enablers to facilitate introducing or raising MEPS for DTs. An "increase in incentives" was chosen by three manufacturers.

Market Barriers Facing Utilities

Utilities were asked to identify the main barriers to introducing or raising mandatory MEPS for DTs in their markets. One respondent noted that the lack of awareness among engineers, electrical contractors and end-users about the energy benefits of efficient DTs constituted an important barrier. In addition, excessively high prices of high-efficiency DTs and the fact that the method of calculating profitability of financial decisions excluded energy efficiency parameters were also selected as main barriers. Finally, the absence of existing minimum national energy performance standards for DTs was also chosen as a main barrier.

Utilities' Market Enablers

Utilities were asked to identify enablers that would facilitate introducing or raising the mandatory MEPS for DTs in their respective markets. One respondent said that providing more information sessions and increasing incentives could help encourage the development and distribution of more energy-efficient DTs in the APEC member economies.

Utilities Interest and Awareness about the Development of Energy-efficient DTs

End-user utilities were asked to indicate on a scale of 1 to 5 (with 1 indicating "not at all important" and 5 "very important") the relevance of developing and distributing energy-efficient DTs in their markets.

One utility declared that reducing energy losses in DTs was really important for it. This same utility was also optimistic when questioned about the relevance of energy efficiency for its economy, stating that it was important.

Utilities' Opinions about the Market for High-efficiency DTs

Utilities were also asked if they believed the market for DTs should be developed as a standardized one.

The one utility which completed the questionnaire declared that it was in favor of a standardized energy efficient market so as to make sure that there is a minimum level of standardization for efficiency, designs and overall energy saving. According to the utility, "the government should put more pressure on establishing a set of minimum energy performance requirements for high voltage transmission and generation transformers".

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