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Overview of Policies and Measures to Promote Household Equipment Efficiency

Anne Arquit Niederberger[1], PhD
Policy Solutions

1 Introduction

This report was prepared for the Energy and Transport Branch of the Division for Sustainable Development/UNDESA to serve as a background information and discussion paper for the United Nations Forum on Energy Efficiency and Energy Security: Taking Collaborative Action on Mitigating Climate Change (Seoul, Republic of Korea, 17-18 December 2007).

Local, national, regional, and global policies that promote investments in energy efficiency can make significant contributions to providing energy for sustainable development and avoiding dangerous interference with the global climate system. The International Energy Agency estimates that approximately two-thirds of greenhouse gas emission reductions in its Alternative Policy Scenario will result from end-use efficiency improvements (IEA, 2006a), because of the vast, low-cost mitigation potential of existing, high-efficiency technologies.

This paper provides an overview of policies and measures to promote energy efficient household appliances and equipment. Residential equipment currently consumes more than 3400 TWh of electricity and will rise to at least 4500 TWh by 2030 under a "business as usual" scenario (Ellis, 2007). In OECD countries, household appliances and equipment account for 30% of all electricity consumed and 21% of all energy-related CO_2 emissions. Fortunately, cost-effective appliance energy efficiency policies can make a major contribution to meeting Kyoto Protocol – and future – greenhouse gas emission obligations (IEA, 2003).

The most recent energy outlook published by the International Energy Agency states that more efficient appliances in the residential and service sectors account for most of the 12% decrease in electricity consumption in its Alternative Policy Scenario in 2030 (IEA, 2007), which merely assumes adoption of policies and measures already under consideration in countries around the world[2]. In its Accelerated Technology scenario for 2050, the IEA estimates that more energy efficient end-use technologies across sectors will deliver 45% of the total 32 Gt of carbon dioxide emission reductions (IEA, 2006b). Buildings and appliances will account for about one quarter of these emission reductions, with more efficient appliances alone accounting for 8% of global emission reductions and major contributions also from heating & cooling technologies and lighting (IEA, 2006b).

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[1] Contact information: +1 917 518 5094; policy@optonline.net

[2] The Alternative Policy Scenario is consistent with a stabilization of the CO_2-equivalent concentration of greenhouse gases in the atmosphere at about 550 ppm (IEA, 2007).

2 Policies and Measures to Promote Household Appliance & Equipment Efficiency

The IEA has grouped household electrical equipment into 10 major categories: space heating; space cooling; water heating; refrigeration; lighting; cooking; laundry and dishwashing (wet appliances); home entertainment; information & communication technology (ICT); and other (Ellis, 2007). Globally, the major electrical end-uses are space heating and cooling, refrigeration and lighting, with demand from electronic equipment growing most rapidly, and significant differences between countries (Ellis, 2007).

There are gains to be made both from steering the investment decisions of residential end-users towards more efficient technologies and from changing their habitual energy behaviors through programs that seek to motivate, facilitate or provide positive / negative feedback to end-users (Egmond & Bruel, 2007).

The most efficient equipment and appliances commercially available typically use of the order of half as much energy as the average[3], and the potential for least life-cycle cost energy savings is therefore substantial. In addition, replacing outdated refrigerators and space heating & cooling equipment that rely on fluorinated gases as refrigerants (and in insulation material) offers opportunities for large additional greenhouse gas emission reductions, if proper incentives can be offered for end-of-life refrigerant recovery. There are 1.2 to 1.5 billion domestic refrigerators currently in service, representing an estimated bank of 100 000 tons of CFC-12 (which has a global warming potential of 10 720), and approximately 75% of their service refrigerant demand continues to be CFC-12 (UNEP/TEAP, 2006).

Common barriers that prevent residential end-users from purchasing the top products include:

- Lack of consumer awareness of energy efficiency benefits and technology options
- Electricity billing that does not reflect actual usage
- Split incentives, where developers, building owners or management companies install cheap, inefficient equipment, while owners/renters must pay the electricity bills
- Lack of consumer friendly information on the energy efficiency and life-cycle cost of products, coupled with inertia
- Failure of end-users to consider life-cycle cost, coupled, in some cases, with higher up-front purchase price of efficient technologies (such as in the case of compact fluorescent lamps compared with incandescent lamps)
- Pricing strategies of manufacturers (higher prices for high-efficiency equipment resulting from addition of non-essential, extra-cost features) and retailers (rock bottom price offers on outdated technologies) that make high-efficiency products relatively more expensive for consumers to purchase.

[3] See Bush et al. (2007) for an analysis of the efficiency of products on European markets, based on data obtained from www.topten.info, and IEA (2006b).

- Lack of availability of innovative, high-efficiency models in local markets[4]
- Consumer dissatisfaction with the quality and/or performance of high-efficiency models[5]

Equally important to purchasing behavior in achieving end-use energy efficiency gains is addressing habitual behavior, particularly in the residential sector. This requires breaking the habitual household energy behavior loop by removing incentives that support undesired habitual behavior, making consumers aware of their habitual behavior and enabling them to avoid or control the negative outcomes and provide positive alternatives (Egmond & Bruel, 2007). Communicative behavioral change programs have been particularly popular, but their effectiveness is difficult to evaluate. The Intelligent Energy Europe BEHAVE project (www.energy-behave.net) seeks to tackle this deficit by conducting a meta-anlaysis on the evaluation of behavioural change programs (Bruel, 2007).

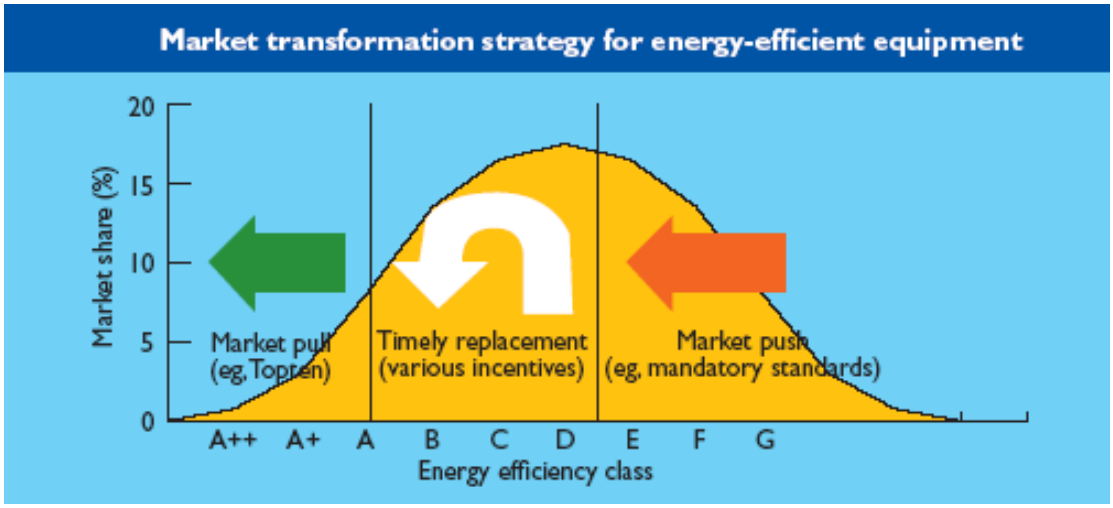

Figure 1. Elements of a Market Transformation Strategy (Arquit Niederberger and Waide, 2007)

[4] Heat pump dryers, for example, which are at least 50% more efficient than conventional condenser dryers, were introduced in Switzerland in 2001. Today there are four models for residential use on the European market, offered by three manufacturers, and three models for semi-professional use from three further brands (www.topten.info). The market share has climbed through concerted market transformation efforts in Switzerland from zero in 2001 to 1.7% in 2004, 4.4% in 2005 and 5.9% in 2006 – exceeding the expectations of the manufacturers. The product range is still small, but the prices decreased by about 20% in 2005, so that life cycle costs are hardly higher than with conventional driers and even significantly lower in the case of semi-professional use (Bush et al., 2007).

[5] According to a June 2007 article, ConsumerReports.org stated: "As of January, the U.S. Department of Energy has required washers to use 21 percent less energy, a goal we wholeheartedly support. But our tests have found that traditional top-loaders, those with the familiar center-post agitators, are having a tough time wringing out those savings without sacrificing cleaning ability, the main reason you buy a washer."

To enable end-users to select the most efficient products and conserve energy, the entire value chain must be involved in a concerted market transformation effort (Figure 1) that addresses technical efficiency, behavioral (e.g., service demand) and economic factors. And governments have a key role to play (IEA, 2007).

3 Household Appliance Efficiency Policies & Measures

This section provides an overview of the major types of policies and measures that are typically employed to overcome one or more of the barriers outlined in the previous section, thereby promoting residential appliance and equipment energy efficiency. The policy toolbox can be grouped into the following basic categories:

- Education and informational instruments
- Legislative, regulatory, and juridical instruments
- Financial and market instruments

Examples of each type of measure are provided for illustrative purposes. The paper does not address economy-wide measures, such as taxes or levies that increase electricity prices, removal of subsidies to fossil fuels or trade-related measures. Furthermore, in focusing on barriers to the widespread uptake of existing, commercially available technologies, the paper does not address essential upstream activities including research, development and demonstration of appliances and building technologies.

3.1 Education and Informational Instruments

Education instruments (e.g., consumer information, public awareness campaigns, professional development) raise awareness and, over time, change societal values. A lack of both market transparency and awareness is an important barrier to the uptake of high-efficiency appliances. Information activities of many kinds are therefore needed to foster informed choices and behavioral change among end-users – as well as to provide policymakers with the data they need to ensure that standards are up-to-date.

3.1.1 Public Outreach / Education

Awareness campaigns, education and training programs (including in schools at all levels) are essential to realizing efficiency gains in the household sector. Nonetheless, they are often under-funded and not sustained over time, in part because their direct impact is difficult to assess.

One long-running initiative is the National Energy Education Development Project, which was launched in 1980 in the United States (www.need.org). The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs. Energy efficiency and conservation are important component of the NEED program.

Students learn to read utility meters, use light meters, investigate phantom loads, evaluate information from energy labels, monitor energy consumption, and explore ways to reduce it at home and school. NEED provides professional training and educational materials to teachers and cooperates with other stakeholders on energy education initiatives.

3.1.2 Label Schemes

Comparative energy labels provide information, often in the form of a ranking to compare the energy performance of an appliance with its peers, and are therefore usually mandatory (to ensure that the poorer performing products will also be labeled). These labels generally provide an estimate of the annual energy consumption of the appliance based on the tested energy consumption, which is often then summarized by use of a discrete ranking and marking scheme (e.g., stars, color-coded A to G scale, numerical). Other information, such as typical running costs, may also be shown on the label. The Collaborative Labeling and Appliance Standards Program database (www.clasponline.org) provides an overview of energy labeling schemes around the world.

Many countries that regulate mandatory energy performance standards (see below) also require energy information labels to be displayed on the same products, illustrating the complimentary nature of the two types of programs: MEPS (mandatory energy performance standards) remove the worst-performing products, while energy labels promote rational decision-making by consumers to promote the better ones. A recent analysis of the impact of labeling schemes in the EU estimates that the improvement in average efficiency of refrigerators and freezers, washing machines and dryers since 1996 was in the range of 20–35% (annual energy savings of 24–34 TWh), with labeling schemes accounting for up to half of the increased uptake, contributing savings of 12–17 TWh annually (Europe Economics and Fraunhofer-ISI, 2007).

The International Energy Agency assumes in its Alternative Policy Scenario that implementing the voluntary Scheme for Energy Efficiency Labeling in India, which went into force in 2006 (http://www.bee-india.nic.in/Label-launch/Scheme.pdf), substitution of incandescent lamps by compact fluorescent lamps and greater penetration of efficient refrigerators, fans and air conditioning will result in an estimated drop in residential electricity consumption of 17% in 2030 compared with the base case (IEA, 2007). The Indian efficiency label scheme lists three increasingly stringent star rating bands for refrigerators and room air conditioners (www.bee-india.nic.in), providing a clear signal to manufacturers[6]. Consumer understanding and awareness of what the label means are prerequisites.

Endorsement labels are a subset of voluntary schemes under which only the best performing products in the marketplace are identified (Ellis, 2007). The most internationally well-known endorsement label in the energy efficiency field is the

[6] Refrigerators must attain nearly 50% lower minimum usage (159 kWh/year) to achieve 5-star status in 2012 than in 2008, for example, and room air conditioners must have a nearly 13% higher minimum energy efficiency ratio (3.50) to attain 5-star status in 2010 compared with 2007.

ENERGY STAR program run jointly by the US Environmental Protection Agency and Department of Energy (www.energystar.gov), which has operated since 1992. Labeled products typically represent the top 25% of a product category in the market at the time the specification becomes effective. Products are 10–25% more efficient than required by federal standards, where established (e.g., National Appliance Energy Conservation Act minimum standards for energy consumption in refrigerators and freezers). International agreements allowing the implementation of Energy Star for selected products are in place in Canada, the EU, Japan, Australia, and New Zealand.

Voluntary labels for green buildings, issued based on independent standards, are also emerging. Two examples are those issued under the Leadership in Energy and Environmental Design Green Building Rating System™ (www.usgbc.org/DisplayPage.aspx?CategoryID=19), which encourages adoption of sustainable green building and development practices, and MINERGIE® (www.minergie.org), which emphasizes user comfort, with specific energy consumption used as the main indicator to quantify the required building quality.

Although the effectiveness of different designs for label schemes may vary from country to country, there is growing recognition that international harmonization of testing procedures and efficiency categories would be advantageous[7].

Adequate market surveillance and enforcement of label schemes is critical. Poor national enforcement of energy labeling and other product rules (e.g., MEPS) facilitates "free-riders" and can undermine other policies and measures. One recent study found that 20-30% of appliances in EU countries (and up to 40% in two Member States) were unlabelled, confirming that a lack of market surveillance and compliance is a serious concern, even in advanced EU countries (ANEC, 2007). As a result, the European Household Appliance Manufacturers' Association (www.ceced.eu) called for legislative measures to ensure future energy performance standards as an alternative to continued updating of the voluntary agreements that industry introduced a decade ago, because "too many governments are not stopping careless or unscrupulous operators from marketing products that claim better energy efficiency than they actually deliver" (CECED, 2007a).

In the context of revising the EU Energy Labeling Directive, the Commission is currently undertaking a consultation on how best to reinforce the impact of energy labeling in order to help the Union to reach its 20% energy saving target by 2020 (http://ec.europa.eu/energy/demand/legislation/domestic_en.htm#consultation).

3.1.3 "Smart" Metering

Smart metering employs electronic meters and communications networks to provide utility customers information on a real time basis about their domestic energy consumption, including data on how much gas and electricity they are consuming, how much it is costing them and what impact their consumption is having on greenhouse gas emissions, as well as historical consumption data for comparison. The majority of existing electricity and gas meters are hidden from view – and most households (and small businesses) receive energy bills only once monthly. Smart meter systems make

[7] See, for example, the CECED Vision on Energy Efficiency (CECED, 2007b).

it possible for final customers to get more information about their energy usage, and pilots have shown that their use can reduce household energy consumption[8].

Real-time data feedback can enhance the awareness of each utility customer to economically achievable resource savings based on personal demand, the grid load confronting the utility company and the environmental costs inherent to generating electrical power (Michel, 2007), as illustrated schematically in Figure 2.

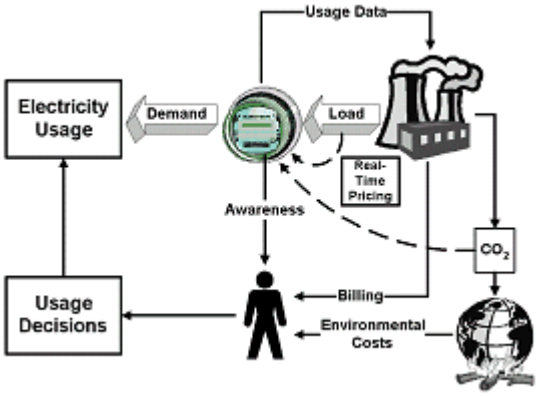

Figure 2. Benefits of Intercommunicative Advanced Metering Infrastructure (Michel, 2007)

The European Smart Metering Alliance (www.esma-home.eu) was formed to define and spread best practice in smart metering across Europe and maximize the resulting energy savings, in support of European Directives. The EU Energy End-Use Efficiency and Energy Services Directive 2006/32/EC prescribes standards of "metering and informative billing of energy consumption" by which final customers are to be provided with "competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use". Billing is to be performed "frequently enough to enable customers to regulate their own energy consumption". In addition, "comparisons of the final customer's current energy consumption with consumption for the same period in the previous year" are specified, "preferably in graphic form", as well as "with an average normalized or benchmarked user of energy in the same user category".

3.1.4 Topten

Topten (www.topten.info) is a web-based information system on the "best" products – with energy efficiency as the central criterion – available to consumers in their local market. The Topten system is actually much more than an information initiative (Bush et al., 2007), as it performs the following functions:

- Market transparency: Topten identifies the most energy efficient appliances, equipment and services available on local markets, based on selection criteria

[8] Smart metering case studies from around the world are being compiled by the European Smart Metering Alliance (www.esma-home.eu/smartMetering/caseStudies.asp). Pacific Gas & Electric has installed over 100,000 advanced meters and is in the process of installing them for all of its 5.2 million electricity and 4.5 million gas customers.

that are clearly stated for each product category, and provides data on energy efficiency, purchase and operating cost and other key criteria. The site is independent of manufacturers.

- Support for MEPS introduction and updating: Each national Topten system provides quasi real-time market data on the energy efficiency of the best products currently available. Coupled with the international benchmarking function (see next point), this is invaluable information to government officials in establishing or updating MEPS levels.
- International benchmarking: The "Best of Europe" comparison of data contained in 13 national European sites (www.topten.info) provides independent up-to-date information on the efficiency level of the top products across Europe. It is planned to expand this function to a "Best of the World" comparison once Topten USA comes online. Such benchmarking encourages international competition among manufacturers and rewards innovation. The system also provides data on the availability of the top products in each market.
- Insights on necessary policies: Because it provides data on the most efficient products available, the Topten International Group can use this data to make policy recommendations to public and private decision-makers tasked with designing energy policies or designing procurement or project incentive schemes (Bush et al., 2007)[9].
- Vehicle for targeting and offering appliance incentive programs with a low level of free-ridership: Since Topten only features the approximately 10 most efficient products in any given category, free-ridership of incentive programs linked to Topten is low, contributing to the cost-effectiveness of incentive programs, such as tax credits offered by government or rebates offered under utility demand-side management programs.
- Vehicle to maximize the market-pull effect of energy efficient equipment procurement programs
- Consumer information: The consumer-friendly website makes it easy for consumers to compare, select and purchase the top products, not the least, because the selection is continuously updated and much narrower than typical label schemes. Information can be sorted by purchase price and other criteria of interest to consumers, including life-cycle cost. Advice is also provided on the proper use of the equipment, such as Eco-Drive® principles and information on alternative mobility options provided under the automobile category.

Topten complements existing mandatory and voluntary standard and label programs by focusing on providing recognition and incentives for the highest efficiency products (Figure 3). One of the main reasons that California utilities are supportive of Topten, for example, is that many ENERGY STAR-endorsed appliances do not meet their minimum requirements for incentives.

[9] See, for example, www.topten.info/index.php?page=refrigerators_rg for recommendations on cold appliances

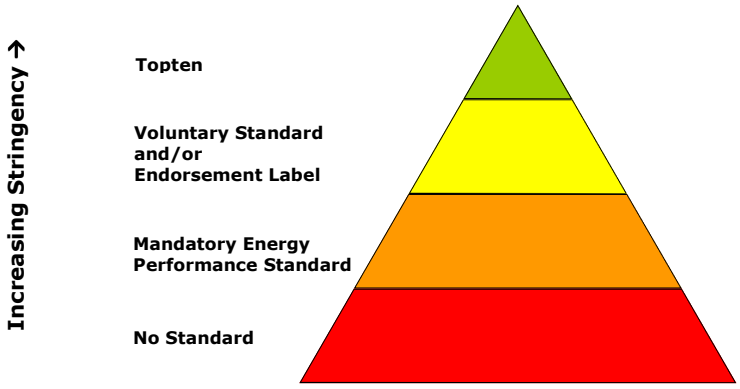

Figure 3. Topten recognition of the very best products

National Topten sites have been established in 12 EU countries and Switzerland since 2000, Topten USA is scheduled to come online by early 2009 and many more countries have expressed interest in launching Topten sites.

3.2 Legislative, Regulatory and Juridical Instruments

Legal instruments set limits and provide sanctions. Mandatory standards, building codes and utility regulation are typical instruments employed to promote energy efficient household appliances and equipment.

3.2.1 Mandatory Product & Building Standards

Minimum Energy Performance Standards

Mandatory minimum energy performance standards (MEPS) are legally enforced thresholds for an individual product or group of products, set at a level to exclude a proportion of the worst performing products in the marketplace (Ellis, 2007). MEPS (and related label schemes, see previous section) can be a cost-effective and powerful tool to eliminate obsolete technology from the market.

MEPS are in place in countries around the globe (see www.clasponline.org for a searchable database or Ellis (2007) for a recent review). They are most common for room air conditioners, refrigeration and wet appliances, but the coverage is broadening. China began implementing MEPS in the late 1980s (Liu, 2006) and has a greater percentage of electricity consumption covered by mandatory policies (i.e., nearly 70%) than any other country, with the US close behind at 65%, followed by Canada, Australia, New Zealand, Korea and Japan at 50% or greater coverage (Ellis, 2007). Under the Chinese system, more ambitious "reach" standards to be implemented in the next five years or so are issued along with MEPS, giving manufacturers a clear indication of future requirements, thereby allowing for the necessary adjustments by industry.

In 2008, the EU plans to begin introducing MEPS on 19 additional product groups and standby power, based on a common methodology, conditions and criteria developed

under framework Directive 2005/32/EC on eco-design requirements for energy-using products (//ec.europa.eu/energy/demand/legislation/eco_design_en.htm). This Ecodesign Directive also allows standards to be set for key environmental aspects of the product besides energy use and provides an opportunity for industry to forestall a mandatory standard for a product by proposing a voluntary agreement (Siderius & Ellis, 2007). In the United States, MEPS will be expanded to or strengthened for 10 product categories under the Energy Independence and Security Act of 2007 (energy.senate.gov/public/_files/getdoc1.pdf), including new federal standards for light bulbs and external power supplies and tougher standards for residential boilers and home appliances (clothes washers, dishwashers, dehumidifiers).

In the field of lighting, MEPS that would essentially eliminate the use of incandescent lamps from the market are being discussed and implemented in a growing number of countries (Australia, Canada, EU, United States) and Global Environment Facility projects around the globe. Simply using compact-fluorescent in place of incandescent lamps, deploying high- in place of low-efficiency ballasts and phasing-out mercury vapor HID lamps would reduce global lighting demand by up to 40% (IEA, 2006c). The success of this strategy will depend to a large extent on complementary steps to ensure the quality of the replacement compact fluorescent lamps. A recent study (IRG, 2007) concluded that "the prevalence of low-quality (i.e. sub-standard, or shoddy) CFLs in the market represents a significant barrier to the full realization of this strategy".

A variation on MEPS is the Japanese Top-Runner program (www.eccj.or.jp/top_runner/index_contents_e.html), under which all manufacturers must aim to achieve a target efficiency (Top Runner Standard) for 18 selected product classes on a weighted average method (per manufacturer and product category) within a specified timeframe. The first sets of targets had to be achieved in 2003 (for TVs, VCRs) and 2004 (room air conditioners, electric refrigerators, electric freezers), and new targets have been set. The national Top Runner Standards are set based on the value of most energy-efficient products in each category available on the Japanese market at the time that the values are established, taking into account potential technological improvements.

As most home appliances are essentially commodity goods, it is important that MEPS be regularly updated to reflect technology innovation, implemented globally and harmonized at appropriate levels. Without global implementation, outdated technology tends to land in the poorest developing countries, which can ill afford the expense of needlessly wasted electricity.

In addition, care must be taken to avoid legislation or policies that prevent jurisdictions from implementing more aggressive standards than national (or, in the case of Europe, regional) MEPS, as this can create a disincentive for innovation. In the United States, the increasing federalization of standards developed initially at the state level prevents states that had initially demonstrated leadership, such as California, from moving forward with aggressive standards[10], thus limiting the potential for

[10] Most recently, California has been denied a waiver from the US Department of Energy for a more aggressive standard on the water use of clothes washing machines, which would also raise their energy efficiency. In its rebuttal to the DOE, the California Energy Commission stated "The comments opposing California's clothes washer petition are a patchwork of factual

mandatory standards to make a significant contribution to energy saving and climate mitigation. Switzerland – long a laboratory for new standards in Europe – has now adopted a policy of not getting ahead of the EU on MEPS, although voluntary standards are still possible.

Ensuring compliance with MEPS (and mandatory energy labels) is also an important challenge. Standards education, training and field work are needed.

Building Codes

As are MEPS for products and equipment, building codes are a crucial tool to ensure minimum energy performance of whole buildings or building technologies, such as lighting and water and space heating/cooling systems (in addition to other aspects of building efficiency that are not the subject of this paper). In contrast to MEPS, building codes can address system efficiency and habitual behavior, thus capturing greater efficiencies. Given the long lifetime of building stock, ensuring that buildings achieve ambitious minimum standards for energy efficiency is important.

The ambitious EU Energy Performance of Buildings Directive 2002/91/EC (http://www.buildingsplatform.org/cms/index.php?id=8), which applies to almost all buildings, residential and non-residential, sets aggregate minimum energy performance standards (both for new build and major refurbishment), to be reviewed regularly. The MEPS are complemented by an energy performance certificate (or energy rating), which must be supplied by the owner to a prospective buyer or tenant when sold or rented and accompanied by recommendations for cost-effective improvements to energy performance.

To be effective, however, building codes must be widely implemented on the ground and regularly updated to ambitious levels. A combination of carrots (incentives for early compliance) and sticks (rigorous enforcement of building codes) can be effective, as can leadership by governments. In China, new building codes require that all new buildings in China cut their energy (heating, lighting and air conditioning) consumption by 50 percent, with the level being raised to 65 percent in more prosperous cities like Beijing and Tianjin. However, the Ministry of Construction acknowledges that compliance with the new standards is a challenge. According to Ministry data, only 53 per cent of new buildings met energy-efficiency rules in 2006 – with Beijing, Shanghai, Tianjin, and Chongqing doing relatively well in implementing energy saving codes, but other regions lagging way behind in technological standards and government supervision – and the Ministry has threatened to revoke developers' business licenses. Policy makers need to make compliance a much higher priority if they are to reap the full potential benefits of modern building energy codes (IEA, 2006c).

California has the most stringent building codes for new residential buildings in North America, with the updated California Building Standards Code planned to be effective from April 2009. In addition, the California Building Standards Commission and the Department of Housing and Community Development, with the assistance of a Green

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mischaracterizations, legal misstatements, and analytic errors. They provide no valid reason for DOE to deny the Petition."
www.eere.energy.gov/buildings/appliance_standards/pdfs/ca_petition_comments/79_cec.pdf.

Building Focus Group, are developing green building standards for new construction of buildings under their respective authorities, state buildings and homes. The standards will primarily be voluntary and use existing green building standards, best practices, guidelines, or other published material in their development.

One way of promoting progressive building codes is through government leadership to increase the energy efficiency of government buildings; however, to have the desired effect and reward innovation, such initiatives must be ambitious.

3.2.2 Energy Sector Regulation & Residential Efficiency Programs

Utility Demand-Side Management Programs

Utility demand-side management (DSM) programs encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. A prerequisite for such programs is that regulations are in place to enable utilities to profit from investment in demand reduction – as opposed to depending on electricity sales alone. Many OECD countries began to adopt or experiment with utility DSM following the first oil crisis in 1973, and developing country utilities have begun to implement both load-shifting and energy-saving programs, often in response to energy shortages and blackouts. The IEA Demand-Side Management Program is an international collaboration of 18 countries working together to develop and promote opportunities for demand-side management (http://dsm.iea.org).

California has been a leader in utility DSM from the outset, not the least because of the favorable regulatory framework in the state, under which utility profit is decoupled from electricity sales. In California, utility DSM programs are financed through a public benefit charge levied on energy end-users, which for the period 2009-11 amounts to approximately USD 1 billion annually (current programs in the 2006-08 funding cycle can be accessed at www.californiaenergyefficiency.com/matrix.html). In October 2007, CPUC Commissioners adopted a groundbreaking decision mandating California's investor owned utilities (IOUs), working in collaboration with publicly-owned utilities, state agencies, and other stakeholders to prepare a single, statewide energy efficiency Strategic Plan for the period 2009-2020 (www.californiaenergyefficiency.com/index.shtml). One of the main objectives of the Plan is to better integrate delivery to customers of the full range of DSM options (energy efficiency, distributed generation and solar, and demand response).

In 1985, the Brazilian government established by law a national electricity conservation program, PROCEL (www.eletrobras.com/pci/main.asp). In July 1998, as Brazil underwent utility sector restructuring, the new federal regulatory agency ANEEL (National Agency for Electrical Energy, which had been created the previous year as a quasi-governmental organization), announced it would require all distribution utilities to spend at least 1% of revenues on energy efficiency improvements (25 to 50% on the demand side, with the amount of funds invested in residential programs having shown large volatility). ANEEL is responsible for defining efficiency priorities and approving utilities' annual plans. PROCEL (housed in Eletrobras) now assists utilities with preparation of EE plans and certifying that utilities are carrying out adequate programs, as well as conducting efficiency, training and information programs itself. Planning is underway for a program to replace 1 million outdated domestic refrigerators in low-income households with higher-efficiency, CFC-free models. Taking

advantage of DSM opportunities can allow for a gradual reduction in (or phasing out of) energy subsidy levels for low-income households, with minimal impacts on the consumer's bill (Jannuzzi, 2006); such innovative models can contribute to the sustainability of low-income support programs.

Regulatory frameworks in many developing countries are just being developed or expanded to include utility DSM and public benefit charges. The Bureau of Energy Efficiency in India, for example, is planning to develop a National Roadmap for DSM in India, and Jiangsu Province in China and the California Public Utility Commission are cooperating on legal and regulatory requirements, funding and incentive mechanisms related to DSM, as well as the full suite of DSM program design and implementation issues. In June 2007, China hosted the first annual "International Forum on Power DSM in China". Numerous examples even in the poorest countries have shown that large energy savings can be achieved at no net cost to utilities or end-users (Prayas, 2005). This is an important area for international cooperation.

If not undertaken with the goal of realizing end-use energy efficiency potential in mind, energy liberalization and competitive energy markets can lead to falling energy prices and increased consumption, as well as fading incentives for the energy industry to invest in end-use energy efficiency (Skoczkowski, 2007), as has been the case in Europe. Prior to energy liberalization in the late 1980s and early 1990s, many national/regional utilities in Europe ran extensive DSM programs. But the increasing consolidation of energy companies has led to a situation where these have become transnational corporations, so that regulation at the EU level is becoming increasingly important, if policy interventions are to be effective.

Energy Efficiency Portfolio Standards

Following on the introduction of Renewable Portfolio Standards, some countries (France, Italy, United Kingdom), a growing number of US States and other jurisdictions (Flanders in Belgium) have begun to experiment with energy-saving obligations (Bertoldi & Rezessy, 2006; Nadel, 2006). Such mandates (which are referred to as "energy efficiency resource standards" (EERS) in the United States) set a target for electric or gas utility companies for end-use energy savings, expressed in terms of energy units, percentage of load growth forecast, or percentage of total energy sales. They are one of the most promising vehicles for capturing cost-effective energy savings, particularly in the residential sector, and are sometimes combined with traditional DSM activities funded via public benefit charges (see above).

There is great diversity in the legal basis for energy saving requirements and how they are operationalized (Nadel, 2006). Thirteen US states currently have EERS, with other states pending (ACEEE, 2007). The Texas program, established in 1999, is the longest running and has proven successful, with energy savings exceeding targets (Frontier, 2007). To comply with this law, all utilities partner with energy efficiency service contractors to install energy efficiency measures that result in peak demand reductions and electricity savings (Figure 4).

Contractors install a variety of savings measures at homes and businesses within a utility's service area. Each utility contracts with national and local firms who contact electricity consumers (residential, commercial, or industrial) about performing work to save energy and reduce their electric bills. Customers select the contractor, decide what equipment will be installed, and choose what work the contractor will do. Price,

warranty, financing, and other purchasing matters are entirely between the contractor and customer. This institutional structure supports typical market transformation functions and programs. A key challenge is the quantification and verification of the energy savings achieved.

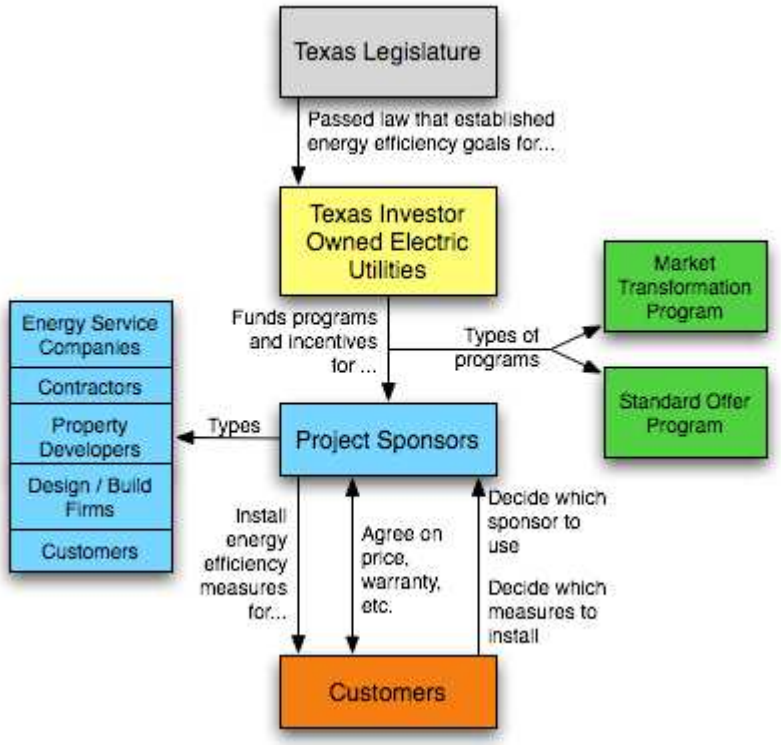

Figure 4. Overview of Texas Energy Efficiency Programs (Frontier, 2007)

In Europe, a number of regions and countries are adopting energy efficiency mandates for electricity and gas suppliers/distributors (Bertoldi & Rezessy, 2006; Nadel, 2006; ACEEE, 2007). Under the Energy Efficiency Commitment (EEC), electricity and gas suppliers are required to achieve targets for the promotion of improvements in domestic energy efficiency in Great Britain (www.defra.gov.uk/environment/climatechange/uk/household/eec/index.htm). Since at least 50% of energy savings must be focused on a priority group of low-income consumers, it is expected that the EEC will also contribute to the eradication of fuel poverty. Furthermore, the EU Energy End-Use Efficiency and Energy Services Directive 2006/32/EC contains a supply-side obligation for energy distributors and retailers to offer efficiency improvement measures to their customers.

Some of these schemes are coupled with (tradable) white certificate schemes, which are discussed in the next section.

3.3 Financial and Market Instruments

Fiscal policies, financial incentives and market instruments can influence behavior by overcoming the up-front cost barrier faced by end-users and sending price signals to the market.

3.3.1 Financial Incentives & Mechanisms

It is not uncommon for some of the most efficient appliances to have a purchase price premium compared with an average product, particularly when innovative technologies are first introduced to the market, so incentives or special-purpose funding mechanisms can sometimes be helpful to overcome this barrier. Several incentives for residential end-users were described in the context of utility programs above.

Financial Incentives

Financial incentives for home appliances typically take the form of subsidy, rebate or tax credit/deduction schemes. They can be administered by governments or under utility EERS or DSM programs (see above). They may target manufacturers, retailers or end-users.

A wide range of financial incentives is also available for green or energy-efficient buildings, including energy efficient mortgages, free home audits or tax credits, and may target property developers or managers, owners or renters. If low or zero energy buildings are to be achieved beyond a niche market for "early adopters" and the wealthy, it is necessary to adopt market forces that will enhance the demand for such buildings. Financing practices that monetize long-term energy costs in near-term investment decisions can make a major contribution to this effort (Baden et al., 2007).

The Tax Incentives Assistance Project (TIAP, www.energytaxincentives.org) is a cooperative effort by public interest nonprofit groups, government agencies, trade associations, energy efficiency program administrators, and other organizations in the energy efficiency field to assist with implementation of the federal tax incentives in the United States so that they achieve their market transformation objectives. TIAP is a one-stop shop to locate federal tax and State and utility financial incentives (www.energytaxincentives.org/general/incentives.php) for residential appliances and building technologies.

Financing Mechanisms

Providing access to concessional (micro-) finance can be another means of overcoming investment barriers facing residential end-users. Under an innovative program in India to encourage households to replace incandescent lamps with more efficient compact fluorescent lamps, the Bangalore Electricity Supply Company (BESCOM) allowed customers with no arrears on electricity bills to purchase CFLs from approved retailers, either via direct purchase at a discounted price or via payment in installments over 9 months through electricity bills (Gooneratne, 2005), and similar utility-administered programs have been implemented in other countries.

Various US states have created a variety of mechanisms – ranging from grants and energy-efficiency improvements for low-income households to different types of loan schemes – to encourage investment in residential energy efficiency (www.ase.org/content/article/detail/2601).

Such financial services can theoretically also be provided via other market intermediaries, such as energy service companies, and an increasing number of dedicated energy efficiency financing facilities have been created (see, for example, information on facilities established by the International Finance Corporation www.ifc.org/ceef and www.ifc.org/chuee), but these typically target businesses, institutions, commercial buildings or municipalities, rather than households.

3.3.2 Voluntary Market Transformation Efforts

Procurement Programs

Large organizations, including government housing authorities, property developers, utilities, or professional/homeowner associations, can operate procurement programs that seek to increase the efficiency of the equipment installed in their residential properties and premises. The large quantity of equipment purchased through these channels lowers the information-gathering and –processing costs for each product specification compared with those of individual market actors, facilitates bulk procurement and competitive bidding (thus reducing capital cost) and allows the participants to obtain more attractive borrowing terms (IEA, 2006c).

Governments are the largest consumers in an economy. The public sector on average spends over half of their budgets on public procurement, which amounts to about 15 per cent of GDP, and the fraction is likely higher in many developing countries (IISD, 2007). Many governments around the world have adopted procurement rules that obligate the use of energy efficiency criteria in tendering procedures for public procurement[11]. If governments make a concerted effort to purchase environmentally- and socially-preferable products and services, their substantial buying power will stimulate markets for sustainable products and services in the residential (and other) sectors.

Procura+ (www.procuraplus.org) is an initiative designed to help support public authorities across Europe in implementing Sustainable Procurement – and help promote their achievements. The Campaign was established in 2004 by ICLEI – Local Governments for Sustainability to help drive the mainstreaming of sustainable public procurement throughout Europe. Public authorities in seven countries are currently participating in the Campaign, which offers a library of sustainable procurement tenders and a toolkit to help public authorities in tackling energy efficiency through procurement. One area of overlap with the residential sector is IT products (PCs, laptops, monitors, photocopiers, printers, multifunctional devices, scanners).

[11] See Perera, Chowdhury & Goswami (2007) for an extensive status report on sustainable public procurement programs worldwide, all of which include energy efficiency as a criterion.

Voluntary Agreements

Voluntary agreements can include covenants, negotiated agreements, self-regulation, codes of conduct, and eco-contracts (IEA, 2006c), and have been used widely in OECD countries and increasingly in other regions, with mixed results. They can present advantages compared with regulation, such as rapid and cost-effective implementation and ability to adapt readily to technological options and market sensitivities. Yet self-regulation is not always feasible or effective, since voluntary agreements are not binding on all industry members and may be difficult to enforce, depending on compliance provisions.

Equipment manufacturers and governments have entered into voluntary agreements to improve the energy efficiency of home appliances and equipment, such as reducing stand-by losses of televisions and videocassette recorders or improving the efficiency of domestic washing machines, refrigerators and freezers.

One example is the series of voluntary agreements on stand-by losses of consumer electronics, beginning in 1997 with a negotiated agreement between the European Commission and individual consumer electronic manufacturers and the EU trade association EACEM to reduce the stand-by losses of TVs and VCRs. Agreements for reducing stand-by losses of audio equipment (2000) and TVs/DVDs (2003) were subsequently added. A Commission Communication to the Council and the European Parliament on Policy Instruments to Reduce Stand-by Losses of Consumer Electronic Equipment in 1999 then established a political framework for further actions in this field. As a result of the Council Conclusions on the Communication, a growing number of "Codes of Conduct" – for example, for external power supplies and digital TV services and broadband communication equipment – were introduced[12].

Another is the commitment between the European Committee of Manufacturers of Domestic Equipment and the European Commission, approved in December 1998. The overall saving target of the Commitment was to reduce the specific energy consumption of domestic washing machines by 20% over the period 1994 – 2000 (i.e., lowering the specific electricity consumption from 0.30 kWh/kg to 0.24 kWh/kg within 6 years). The target of this Commitment was achieved at the end of 1999 (specific electricity consumption: 0.228 kWh/kg). The CECED has since abandoned the voluntary approach, however, instead calling for government regulation (CECED, 2007b).

White Tag or Certificate Schemes

Energy efficiency trading programs are market mechanisms to acquire energy savings at least cost. A number of the energy efficiency performance standard programs described above also include a trading feature.

The world's first operational trading scheme for energy efficiency certificates ("white certificates") was launched in New South Wales, Australia, on 1 January 2003 (and has since expanded to include Australian Capital Territory). Unlike the trading schemes that evolved from utility energy efficiency mandates, however, the Australian scheme is linked to benchmark targets for greenhouse gas emissions established

[12] See http://re.jrc.ec.europa.eu/energyefficiency/index.htm

under the Greenhouse Gas Reduction Scheme. The overall electricity sector targets are implemented by setting individual benchmark emissions levels for certain liable parties, including electricity retailers, certain electricity generators and some end-use customers (Crossley, in prep). Benchmark participants are required to reduce their emissions of greenhouse gases to the level of their greenhouse gas benchmark by offsetting any excess emissions through the surrender of abatement certificates. These certificates are created by accredited abatement certificate providers, such as energy service companies, and can be traded to benchmark participants. One means of generating abatement certificates is by reducing electricity consumption (demand-side abatement, for details see www.greenhousegas.nsw.gov.au/acp/energy_efficiency.asp). Demand-side abatement has contributed one-third of all certificates since program inception (GGAS, 2007), and projects in which compact fluorescent lamps and water efficient showerheads were sold at a discount or given away free of charge to households have been the most common type (Crossley, in prep).

Details on the Italian and French (Bertoldi & Rezessy, 2006) and US State schemes (Nadel, 2006) have been reported on elsewhere.

As energy-saving (or greenhouse gas reduction) obligations coupled with tradable certificates are relatively new, their potential, cost-effectiveness and integration with other types of policies and measures are being explored in "learning by doing" mode, and programs are being adapted, based on the experience gained.

Carbon Markets

The Kyoto Protocol (which entered into force in 2005) established three market mechanisms to put a price on carbon: allowance trading among industrialized countries (the stimulus for the EU Emission Trading Scheme, which has been in operation since 2005), joint implementation (JI) of climate protection projects by two or more industrialized countries and the Clean Development Mechanism (CDM), which is similar to JI, but involves a developing country as the project host. Efforts have been made to tap carbon markets to co-finance lighting and appliance efficiency measures, but with little success so far.

The most prominent example was a proposal by Ghana to gain CDM approval for the introduction of mandatory MEPS for room air conditioners, which would have raised the average energy efficiency ratio (EER) from 2.55 to 2.8 and reduced electricity demand by 3 TWh between 2005-11 (or 8% of total power generation). However, the Clean Development Mechanism Executive Board ruled that emission reductions could not be unambiguously traced to the introduction of the standard, so the proposed project was rejected. In general, the CDM hasn't proven to be much of an incentive to end-use energy efficiency, because of a lack of suitable methodologies to quantify energy and emissions savings from small, dispersed projects and a lack of recognition of barriers that prevent the uptake of efficient equipment, even if it is cost-effective on a life-cycle cost basis (Arquit Niederberger & Spalding-Fecher, 2006; Arquit Niederberger, 2007).

The CDM Executive Board has taken several actions that could make it easier to leverage carbon finance for investment in end-use energy efficiency going forward. First of all, the Board has begun to consider how it can facilitate the registration of end-use efficiency projects and has mandated the UNFCCC secretariat to initiate and

expedite this work. In addition, it adopted rules for CDM Programs of Activities (PoA), which could facilitate registration of energy efficiency programs that reach many dispersed end-users (Figueres & Philips, 2007), such as those implemented under utility demand side management programs (Arquit Niederberger & Fry, 2007), although many crucial implementation issues remain unclear.

A number of refrigerator replacement, air conditioner and lighting programs around the world are in various stages of preparation for CDM approval. Koizumi (2007) investigated the CDM potential for improving the efficiency of air conditioners in China and Ghana and concluded that a better design for carbon finance is needed to allow carbon markets to scale-up investment from the low level that the Global Environment Facility can deliver (for further information on GEF market transformation efforts for residential equipment and appliances, see next section).

The integration of demand-side energy efficiency with cap-and-trade schemes and utility regulation is a complex issue. Since the EU-Emission Trading Scheme only covers major emitters and allowances were grandfathered, no significant impact on residential energy efficiency has been documented. Plans for the Regional Greenhouse Gas Initiative in the United States exclude the electricity demand side from selling offsets into the utility cap-and-trade scheme, leaving it up to utilities to decide whether to make additional investments in energy efficiency programs to benefit their residential customers.

Comprehensive Market Transformation Programs

Market-transformation programs combine and complement many of the policy instruments discussed above to create lasting change in markets to narrow the gap between best available technology and what is actually "business as usual" in practice. As such, they are more comprehensive than traditional DSM programs in that they aim to positively influence the market for energy efficiency on a voluntary basis through a mixture of information, proactive engagement, capacity building and incentives (IEA, 2006c). An in-depth review of 28 market transformation activities implemented in the United States since 1992 (Nadel et al., 2003) drew lessons learned from a decade of experience and pointed to the complementarities between voluntary market transformation initiatives and mandatory codes and standards. Market transformation activities are not always formalized in programs, as the example of the successful introduction of heat pump dryers in the Swiss market demonstrates (refer to section on Topten above).

A number of Global Environment Facility Climate Focal Area Programs aim at market transformation in developing countries, by addressing multiple barriers to the speedier adoption of energy-efficient technologies and practices. One example is the energy-efficient CFC-free refrigerator project in China, which ran from 1998-2003 (http://gefonline.org/projectDetails.cfm?projID=445). The project addressed the key market, technological, social, and commercial barriers both to:

- adoption of high-efficiency refrigerator technology by Chinese manufacturers
- acceptance of high-efficient refrigerators by Chinese consumers.

Activities included technical assistance and training for compressor and refrigerator manufacturers, incentives for energy efficient product design or modification and conversion of factory production lines, national efficiency standards, a national

labeling program, consumer education and outreach, dealer and manufacturer incentive programs, and a consumer buyback/recycling program. Projects to transform refrigerator markets have also been implemented in a number of other countries, including Tunisia and India (which also involved air conditioners). Other examples of GEF market transformation activities include energy efficiency in buildings in Brazil, biomass stoves in Kenya and efficient residential lighting in China, Mexico and the Philippines (see http://gefonline.org/home.cfm to search the GEF Project Database).

The UK Market Transformation Program (www.mtprog.com), which was launched in 1997, supports the development and implementation of UK Government policy on sustainable products. The Program seeks to reduce the environmental impact of products across the product life cycle by collecting information (stock, sales, usage and resource consumption data on household products, such as televisions, fridges and electrical motors); ensuring a robust base of evidence and product information on market evolution of products and their future environmental impacts; working with industry and other stakeholders to set standards, agree action plans and implement measures that encourage product innovation.

Professional training and qualification are important elements in most market transformation efforts. Without architects, builders, manufacturers, lenders, retailers, and other market intermediaries having the necessary knowledge and skills to advise residential customers on energy saving options, it will be difficult for even the most motivated end-users to direct their appliance purchases and building technology decisions to efficient technologies that make sense on a least life-cycle cost basis.

4 Outlook on International Energy Efficiency Cooperation

The 192 Parties to the UN Framework Convention on Climate Change aim to finalize an international framework for future climate change mitigation by the 15th Conference of the Parties, which will take place in Denmark in late 2009. The Bali Roadmap just concluded on 15 December 2007 highlighted the need to consider ways to accelerate deployment, diffusion and transfer of affordable, environmentally sound technologies, including "effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties".

Whereas the Kyoto Protocol emphasized cap-and-trade and project-based market mechanisms that have done little to scale-up investment in energy efficiency or to transform markets, this new negotiation mandate is broad enough to accommodate provisions to ensure the widespread uptake of existing efficient and low-carbon technologies in the short term – and to stimulate continuous innovation. This time around, it appears that policymakers have recognized that "market instruments that set a price on carbon emissions…should be complemented by an adequate set of policies including clear regulatory frameworks" (as the Chair of the October 2007 climate meeting of representatives of the G8 +5 countries and the European Commission concluded).

Proposals to overcome the massive market failure to deliver high-efficiency technologies and associated public goods under the future climate change regime are beginning to emerge. The US Government announced at the Major Economies Meeting

in Washington in September 2007 that it is developing plans for a "clean technology fund". The European Commission has proposed to establish a Platform for International Cooperation on Energy Efficiency for which the International Energy Agency (IEA) would serve as the secretariat (Santamato, 2007). A new IEA Technology Agreement on Efficient Electrical End-use Equipment (4E) is currently under preparation. And there are a wide range of proposals for mitigation commitments that specifically target energy efficiency improvements.

Ensuring that the global agreement to operationalize the Bali Roadmap will deliver on removal of barriers to high-efficiency, low-carbon technologies are of the utmost importance and urgency. The energy efficiency community must inform this process. And Parties must commit to do the hard work of capitalizing on cost-effective efficiency potential, perhaps through a requirement to prepare, implement, evaluate, and regularly update national Energy Efficiency Action Plans – and to participate in a peer review process to share experience[13].

Market transformation means making best available technology the "business-as-usual" choice for end-users – as well as stimulating manufacturers to continuously innovate to raise the bar rapidly over time. To truly transform markets in a sustainable way requires a multi-pronged approach that changes the way that manufacturers, distributors, retailers, financial intermediaries, and end-users think and act, including the following elements:

- Political will and government leadership
- Human capacity development
- Enabling strategic, institutional and regulatory frameworks
- Energy efficiency targets and implementation plans
- Information
- Incentives
- Appropriate funding mechanisms and stable sources
- Enforcement
- Research, development, demonstration, and deployment
- Multi-stakeholder market transformation partnerships
- International cooperation

[13] The EU Energy End-Use Efficiency and Energy Services Directive (2006/32/EC) already obligates Member States to establish national indicative energy saving targets of 9% by the end of 2016 and produce National Energy Efficiency Action Plans for submission to the European Commission. National energy efficiency plans are also required under the Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects. A number of individual countries have also adopted domestic action plans of various types, such as the US National Action Plan for Energy Efficiency, China's Medium- and Long-Term Energy Conservation Plan and the set of action plans developed under India's Energy Conservation Act of 2001.

National Energy Efficiency Action Plans should be comprehensive in addressing these issues. One important theme of the Bali talks – and the heart of the Bali Roadmap – was the need for long-term cooperative action. There are numerous areas for international implementation partnerships that would benefit from inclusion in the post-2012 climate change regime. Successful market transformation efforts will lead to benefits for energy security, economic development and climate change that we can no longer afford to forego, given the challenges we face today.

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