Accelerating the Deployment of Super-Efficient Appliances and Equipment with Multi Country Collaboration

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ABSTRACT

In this paper, we analyze the feasibility of a multi country collaboration to accelerate the deployment of super-efficient appliances and equipment[1] by providing financial incentives to manufactures in addition to collaboration on labeling of super efficient products and minimum energy performance standards. Given that only about fifteen manufactures produce more than 70% of the world's major energy consuming appliances and equipment, many of these appliances and equipment are very similar across multiple countries, and a few appliances and equipment constitute a large portion of the residential and commercial electricity consumption, we lay out key benefits and options for multi country collaboration on accelerating the penetration of super efficient appliances and equipment. We conclude that there are many benefits of such multi country collaboration which could lead to a rapid and much required scale-up in capturing the vast cost effective energy efficiency potential. We argue that the Super-efficient Equipment and Appliances Deployment program (SEAD) announced by U.S. Energy Secretary Steven Chu on December 14 Copenhagen, which draws its key elements on the analysis presented in the paper, is a step in the right direction to foster such multi country collaboration and needs to be supported by the energy efficiency community.

Introduction

Despite intense efforts by all parties, the recent United Nations Conference of Parties (COP-15) failed to create a legally binding treaty accepted by all nations for reducing their greenhouse gas emissions (GHGs) that could limit the global temperature rise by 2 degrees C (or 3.6 degrees F) above pre-industrial levels.[2] It is becoming increasingly clear that in order to achieve the target GHG reductions (i.e. 35% by 2030 as compared with 1990) a substantial financial commitment would have to be made by the world.

One of the key outcomes of COP-15 was the announcement of voluntary pledges by several large countries on reducing greenhouse gas emissions. For example, the United States pledged to reduce carbon emission levels "in the range" of 17 percent reduction below 2005 by 2020, rising to 83 percent in 2050. China has pledged to reduce their carbon intensity (carbon

[1] A super-efficient appliance is the commercially available best technology or better in terms of energy efficiency. For refrigerators, it is a refrigerator which typically has vacuum insulated panels and a compressor with an inverter (variable speed drive) .See Panasonic super efficient refrigerator as an example http://www.panasonic.co.uk/html/en_GB/Products/Fridge-Freezers/NR-B30FX1/Overview/2134311/index.html

[2] As of March 9, 2010, ~100 countries have signed the COP-15 Accord.

output per unit GDP) by 40-45% from 2005 levels by 2020 while India has pledged to reduce its carbon intensity by 25% from 2005 levels by 2020.

Reducing the carbon content of the energy supply – i.e. renewable (e.g. wind, solar, geothermal, wave, etc.) energy – is one of the major elements of the portfolio of strategies that are being pursued by various nations. However, with a few exceptions, the technologies for harnessing renewable sources are not yet economical when compared with existing fossil fuel technologies (e.g. coal, gas, oil). Consequently, governments are forced to offer substantial subsidies to these technologies with the hope that economies-of-scale, learning-by-doing, and research would make the renewable energy technologies increasingly economical over time.[3] Given the recent global financial crisis, there is increasing pressure on governments to reduce these subsidies as they compete with other social expenditures such as public health, education, development, and others.

Unlike renewable energy, energy efficiency (EE) is largely a "negative" cost option for achieving GHG reductions. McKinsey (2009) estimates that many of the EE programs – e.g. switching incandescent lamps to LED technology, improving efficiency of residential electronics and appliances, and improving efficiency of cooling/heating systems for both residential and commercial facilities – can yield reductions of ~14 $GtCO_2e$ by 2030 as compared with 2005 – all at no cost to the society over the lifetime of the efficient technology. Consequently, several countries have identified an aggressive roll-out of energy efficiency (EE) programs and policies as one of the key strategies for meeting their pledged targets.[4] Compared with renewable energy, global collaboration on EE may be more feasible given that it is negative cost option and because there is more support for EE within most nations. Consequently, this may well turn out to be the only global initiative where the possibility of near-term success is substantially higher than attempting to achieve consensus on a broader and far more expensive climate treaty.

Although EE programs, which attempt to address various barriers faced by consumers in adopting cost effective energy efficiency measures, have a lot of potential for achieving savings, their large scale implementation has been challenge, especially in non OECD countries. Even in OCED countries, only a few states or countries have been able to scale-up energy efficiency programs up to a point that is somewhere close to the total cost effective energy efficiency potential. Lack of capacity to design, implement, and evaluate EE programs, lack of incentives to implement programs, and lack of recognition of EE as resource to meet energy services demands similar to other supply side resources are some of the reasons why the progress on EE programs has been relatively slow. Given the large potential of CO2 mitigation net economic benefits, it is critical to seek innovative solutions to address these barriers faced in the rapid scale-up of EE programs. One potential option to address the barriers of the lack of capacity to design, implement, and evaluate EE programs is to have common or similar programs for end-use appliances and equipment which are similar across states, regions, or even countries. Common or similar programs also have additional advantages in terms economies of scale achieved by manufactures leading to cost reductions and higher bargaining power for the entities implementing the programs.

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[3] See for example, subsidies offered for solar power by Germany, Spain, UK, US, Australia, India, and others. The mechanisms for offering subsidies vary by region and nation but consist of direct financial assistance, reduction in cost of capital, grants, reduction in taxes, and others.

[4] See for example, India's recently launched National Mission for Enhanced Energy Efficiency (NMEEE), US ramp-up in EE spending at both national and state levels, China's investments, and others.

In this paper, we analyze the feasibility of multi country collaboration on EE programs to accelerate the deployment of super-efficient appliances and equipment (such as televisions, refrigerators, room air conditioners) which are similar across countries (primarily targeting the energy savings in the residential and commercial sectors). This multi-country program envisioned aims at providing a coordinated message to manufacturers and consumers through coordinated labeling, financial incentives, and standards programs. We argue that this multi country co-ordination is especially valuable given that only fifteen global manufacturers account for more than 70% of major energy consuming appliances and equipment in the world. [5] We assess the potential electricity and CO_2 savings, cost and sources of funds, implementation options, and institutional requirements of this strategy. We show that such program focused on a select few appliances and equipment would result into large savings given that only a handful of appliances and equipment constitute a large portion of the electricity consumption in residential and commercial sectors. We argue that the Super-efficient Equipment and Appliances Deployment program (SEAD) announced by U.S. Energy Secretary Steven Chu on December 14 Copenhagen, which draws its key elements on the analysis presented in the paper, is a step in the right direction to foster such multi country collaboration and needs to be supported by the energy efficiency community.

Current Approaches to Market Transformation (MT)

Even though many EE measures are cost effective, barriers such has higher upfront costs of efficient appliances as compared with inefficient ones, lack of access to efficient technology, lack of awareness, lack of technical capability of assessing costs and benefits of investing in EE, and others need to be surmounted to ensure all socially cost-effective energy savings are achieved.

Market Transformation

Market transformation (MT) is defined as "long-lasting sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where further publicly-funded intervention is no longer appropriate in that specific market."[6] In order to address the enormous challenge of climate change, it is not only necessary to achieve MT for EE, but it is equally important to achieve it in the fastest and cheapest manner.

MT is, typically, illustrated with a bell-shaped curve as shown in Figure 1. There are primarily three market interventions used to increase the penetration of efficient end-use devices: providing information about the energy use (labeling programs), financial incentives, and MEPS.

Appliance labeling programs address the two barriers of lack of awareness, and lack of technical capability of assessing costs and benefits of investing in EE. Typically, appliance labels are sufficient for at least a small portion of the customers (referred to as "early adopters) to "try out" the new efficient technology even if the cost of the efficient technology is higher than the inefficient one. It should be noted that – due to low market penetration of the efficient technology, the

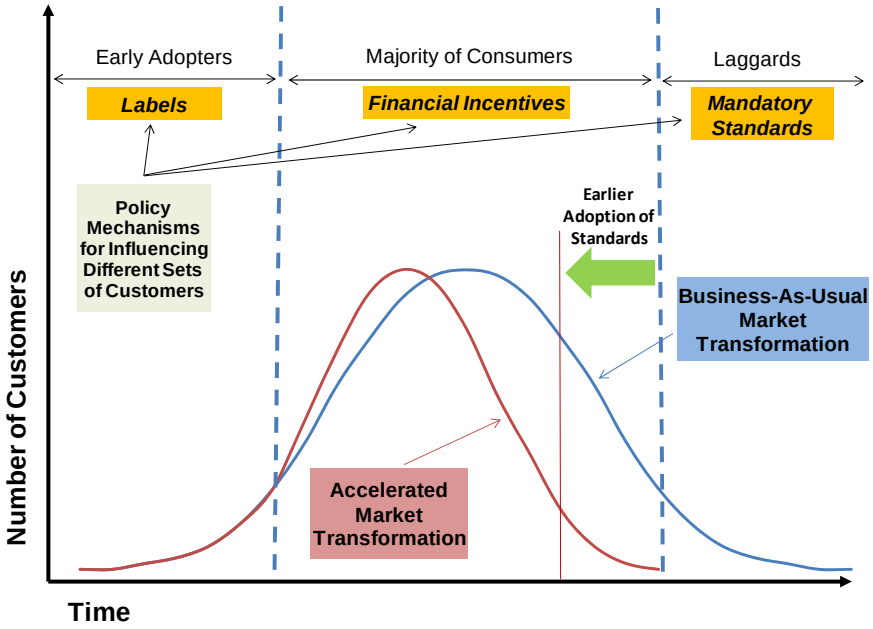
[5] The Super-efficient Equipment and Appliances Deployment program (SEAD) program announced by U.S. Energy Secretary Steven Chu on December 14, 2009 at the COP-15 meeting draws some of the key elements of the program from our analysis.

[6] http://uc-ciee.org/energyeff/documents/mrkt_effts_wp.pdf

supply chain (i.e. manufacturers, wholesalers, and retailers) has not yet had the opportunity to eke out cost reductions through research, economies-of-scale, and learning-by-doing.

In contrast to the "early adopters", the customers that do not adopt the efficient technology even after all the barriers mentioned above are surmounted are referred to as the "laggards". Traditionally, government agencies then institute minimum energy performance standards (MEPS) to "lock in" MT and ensure that the market does not slide back to inefficient appliances.

Figure 1: Accelerating Market Penetration of Super-efficient Appliances and Equipment



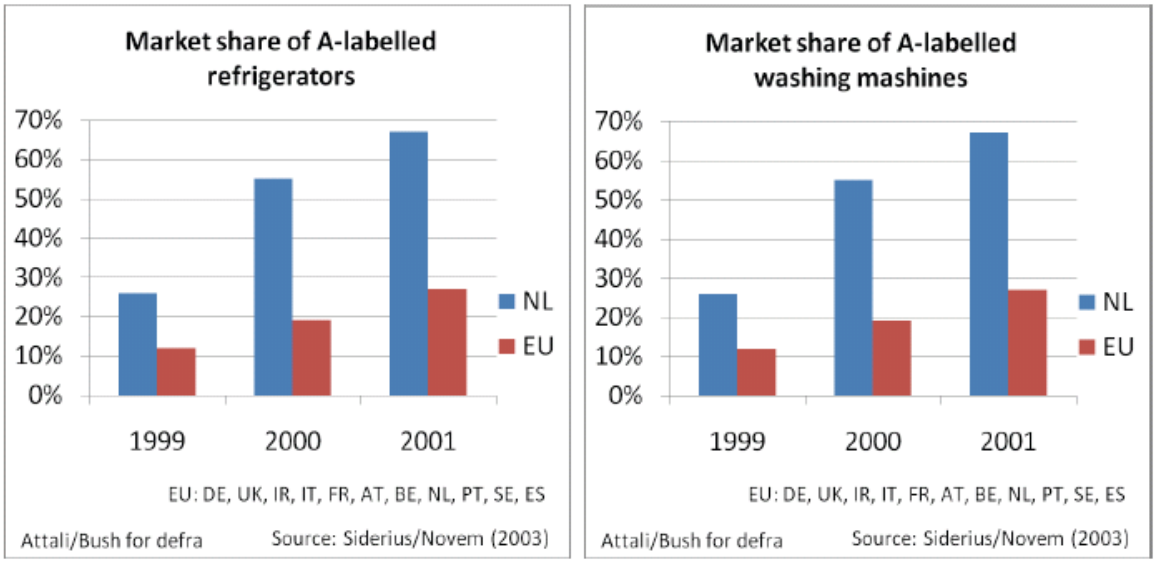
McNeil et al (2008) find that if best current practices of labels and MEPS were adopted by every country then 1339 TWh of electricity and 388 TWh of fuels per year by 2020, and 3860 TWh of electricity and 1041 TWh of fuels by 2030 can be achieved. These energy savings would reduce cumulative CO_2 emissions from 2010 through 2030 by a total of 21.3 Gt. However, the high first cost of energy efficient appliances limit the extent to which the best practices in MEPS can be practically adopted, as the these programs need to take into account concerns of consumers about increases in first costs.

Neither labels nor MEPS programs attempt to address the high upfront cost barrier that the vast majority of the customers face. On one hand, if the first-cost barrier is not too high, the labeling and standards programs are sufficient to achieve MT. Utility EE programs use financial incentives as one of the key strategies for accelerating the penetration energy efficient devices. For example, utilities in California, which run one of the world's largest EE programs, provide more than $ 500 million annually (about 60% of their total EE program budget) as financial incentives, primarily as rebates on energy efficient appliances and equipment. These programs have resulted into substantial savings at a cost less than half of that of new supply (~87,000 GWh of lifetime savings at an average societal cost less than 3.5 cents/kWh due to programs implemented during 2006-08)(Phadke, Shin, and Sathaye, 2010).

The provision of the financial incentives also ensures that the pace of MT is increased substantially. For example, a rebate program in the Netherlands, called "Energy Premium

Scheme (EPR) for domestic appliances" was started in January 2000 and has been a success in transforming the market for household appliances: sales of A-labelled appliances went up to about 70% in 2001 and even higher in 2002. This success stimulated the revision of the EU labelling scheme for cold appliances (see Figure 2).

Figure 2: Impact of Financial Incentives on Accelerated Penetration of Efficient Appliances



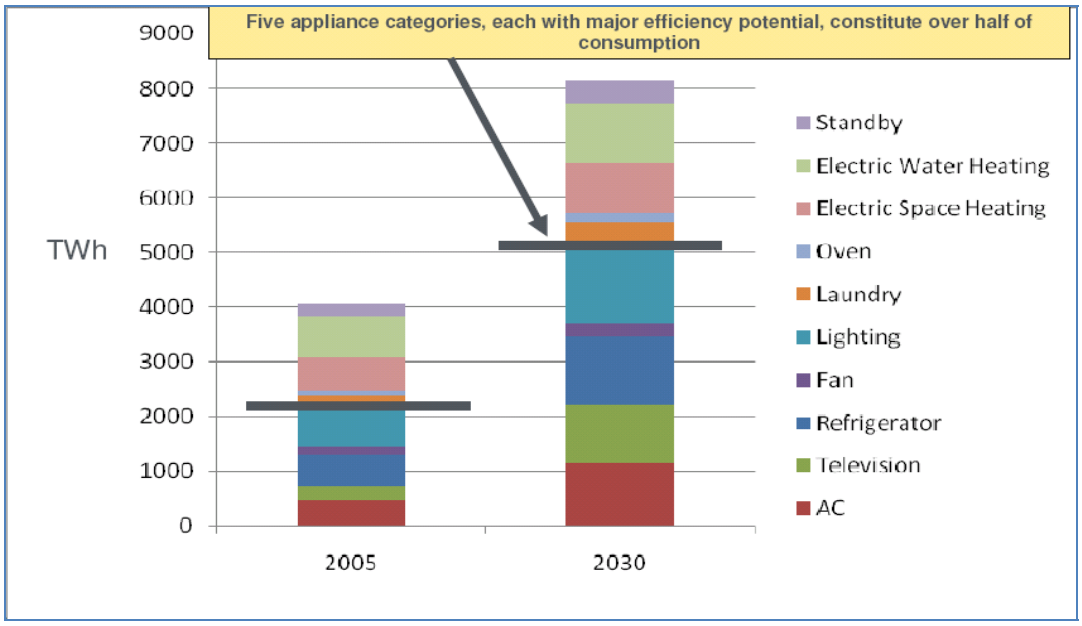
Similar examples are found in Italy (Attali, Bush, Michael, 2009). In many cases, the increase in penetration leads to reduction in the first-cost barriers as manufacturers achieve cost reductions through economies of scale.

Rationale for Multi Country Collaboration

Typically standards and labeling programs have been implemented at the state or national level while financial incentive programs, which in a lot of instances are implemented by utilities, have been implemented at the utility service territory level. There are many products such as televisions, room air conditioners, lights, refrigerators, and fans that are very similar across utility service territories, states, regions, and in some instances countries. These select products constitute a large fraction of the residential electricity consumption (see Figure 3) and have a large and cost effective efficiency improvement potential. For example, in the US consumption of refrigerators can be reduced by 45% at a an average cost of less than 7 cents/kWh which is typically lower or comparable to the cost of supplying electricity even from conventional fossil fuel source.[7]

[7] Authors' calculation based on data presented in US DOE, 2009.

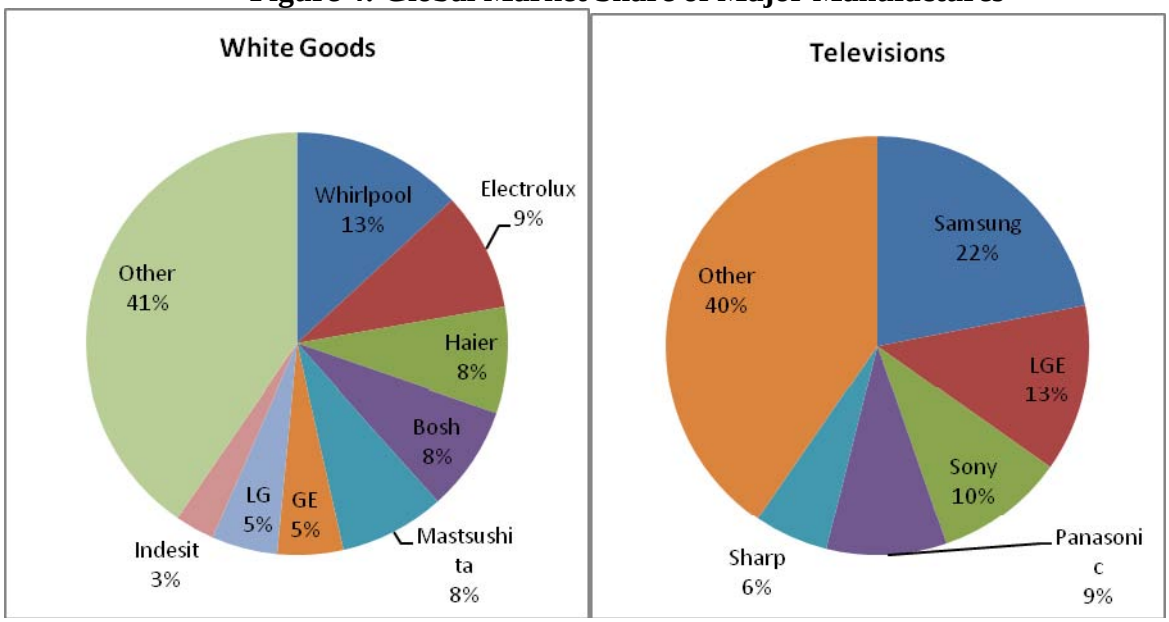
Figure 3: Global Consumption of Key Energy Consuming Appliances and Equipment in the Residential Sector



Source: Authors compilation based on McNeil et al, 2008

Further, the market for some of the major energy consuming appliances and equipment is highly concentrated. For example, for white goods like refrigerators, dish washers, and clothes washers, eight global manufactures constitute about 60% of the market, while fifteen players constitute about 70% of the market. Market for televisions is even more concentrated; with five manufactures constitute more than 60% of the market (Figure 4). Given the similarities in major energy consuming products across countries and given that limited number of global manufactures produce a large fraction of appliances and equipment, following are some of the advantages of increasing the geographic scope of labeling, financial incentives, and standards programs, potentially to multiple countries, to accelerate the penetration of super efficient appliances and equipment. The geographic scope of these programs can be increased either by coordinating individual programs or by having common programs.

Figure 4: Global Market Share of Major Manufactures



Source: Fredonia, 2008 and Display Search, 2010: http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/100222_gobal_lcd_tv_shipments_reached_146m_units_in_2009_faster_growth_than_2008.asp

Leveraging Global Expertise Will Be Valuable Given that Many Utilities, States, and Countries Face Severe Technical Capacity Constraints

Substantial amount of preparatory technical analysis is needed to implement labeling, standards, and financial incentive programs. Some of the key tasks include evaluating various efficiency improvement options and associated incremental costs, manufacturing capacity to produce higher efficiency products, and factors affecting consumer choice of energy efficient products. In many instances, these programs require negotiations with manufactures. All these tasks require substantial technical capacity within entities involved in designing and implementing these programs which has been identified as a major hurdle in rapid scale-up of market transformation programs, especially in developing and least developed countries.[8] Hence, on one hand, aggressive efforts need to be undertaken to build capacity to implement MT programs, at the same time, it is important to leverage the existing technical capacity optimally. For products which are similar across utilities, states, regions, or countries, there is significant overlap in the technical work required to design and implement MT programs where collaboration will lead to clear benefits

Economies of Scale and Co-Ordination

One of the main reasons of the high incremental capital cost of super efficient appliances and equipment is that they are not produced at the scale comparable to regular appliances and equipment whose production enjoys significant economies of scale. If multiple countries collaborate on various MT programs to accelerate the deployment of super efficient appliances

[8] Based on author's conversation with the staff from these entities and also an opinion typically expressed by experts in the field.

and equipment, manufactures will be able to plan for much bigger volumes which are likely to lead cost reductions due to economies of scale.

Higher Negotiating Power

This benefit primarily applies in the case of a program where multiple countries jointly negotiate with appliance manufacturers. Analogous to a monopoly where a single seller is able to dictate the terms of the trade to many buyers; in a multi country MT program - the aggregation of consumer demand in multiple countries for efficient appliances can be leveraged to dictate better terms of trade to the manufacturers. Instead of each national/state/local government attempting to negotiate individually with manufacturers (that are better organized than consumers – in any case); multiple countries can negotiate with manufacturers jointly.

Reduction in Programmatic Transaction Costs in Implementing MT Programs

This benefit primarily applies to implementing common financial incentive programs. There are benefits of moving from a utility scale to a regional or a national scale in terms of reducing transaction costs. In large countries like India and US, there are at least a couple of dozen utilities which implies that there will be significant transaction costs if each of these utilities negotiates with manufactures individually. Increasing the geographic scope of financial incentive programs will reduce transaction costs and time required to implement these programs. There are examples of ongoing efforts in the US where multiple utilities have pooled a part of their DSM funds to implement common financial incentives programs. Similarly, instead of more than hundred countries negotiating with manufactures individually, if it is done jointly, it is likely to reduce transaction costs for the manufactures as well as for participating countries leading to a faster and cheaper market transformation.

Other Indirect Benefits

Increasing the stature of the appliance and equipment MT programs at the national and global level. Multi country collaboration on appliance and equipment MT program will potentially help raise the stature of these programs within respective countries. Increased attention at the national level could lead to better realization of the vast cost effective energy efficiency potential. Further, multi country collaboration could create peer support and a healthy competition among participating countries to more these programs forward.

Creating an influential stakeholder to advocate for EE. RE and conventional energy supply companies, project developers, and equipment manufacturers around the world are large in size and have significant influence on energy policy. One of the reasons of a greater focus on RE compared to EE in many countries in spite of the fact that EE has tremendous untapped potential which is substantially cheaper than RE is that EE does not have sufficiently large and influential industry advocates comparable those for RE. Energy service companies (ESCOs) in most countries are either non-existent or too small to have any influence on policy. Unlike ESCO companies, appliance manufacturers (especially global manufactures) are large and potentially influential (for example, some of the global manufactures have a turnover of more than $ 10 billion and have operations in more than fifty countries) and could become a strong advocate of efficiency if multiple countries are aiming at providing financial incentives to promote super

efficient products. Given various potential advantages of increasing the geographic scope of MT programs, we discuss key elements and options for multi country collaboration next section.

Key Elements and Options for Multi-Country Collaboration on MT

Table 1: Key Elements of Multi Country Collaboration on MT Efforts on Appliances and Equipment of Mutual Interest

	Extent of Collaboration		
Elements of MT Programs	**Sharing of expertise**	**Coordinated programs**	**Common programs**
Recognizing Super Efficient Products	Sharing expertise on -super efficient product availability, performance, and cost -design and implementation of MT programs	Simultaneously initiate labeling (or other recognition methods) programs which recognize super efficient products	Developing a common super efficient label that is recognized in multiple countries
Financial Incentive Programs		Simultaneously initiate similar financial incentives programs for super efficient products	Having a common financial incentive program countries multiple countries (A group of countries jointly negotiates with manufactures to produce super efficient products)
Standards		Simultaneously announce plans to lock in the savings form super efficient products by setting standards at similar super efficient level at a future date	Have a common standard taking into effect at a future date at the current super efficient level
Advantages	-Leveraging global expertise	-Leveraging global expertise; Manufactures can exploit economies of scale; Somewhat increased negotiating power with manufactures	-Leveraging global expertise; -Manufactures can exploit economies of scale; large negotiating power with manufactures; -Reduce programmatic transaction costs

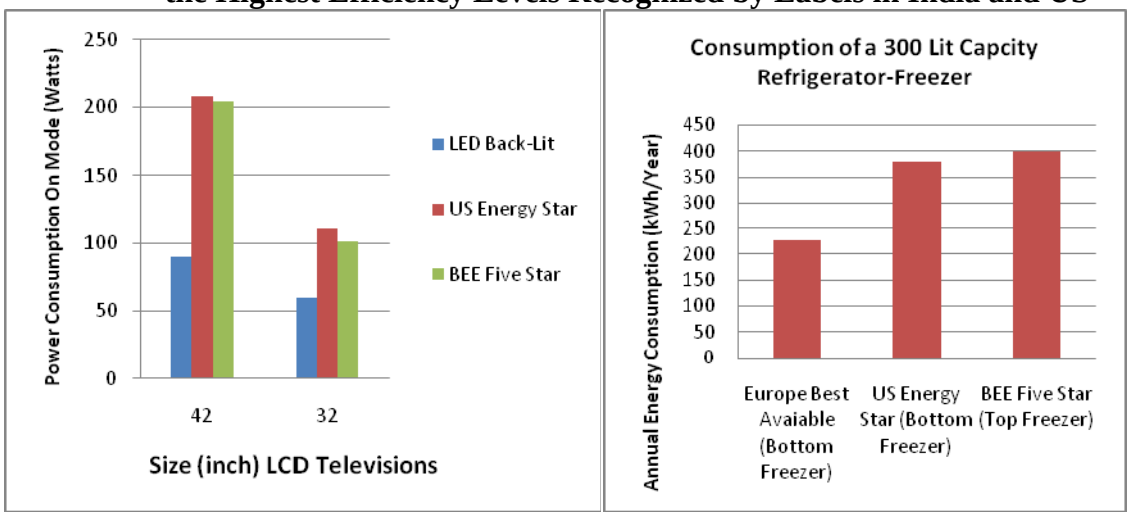
As discussed earlier, labeling (or other methods to recognize efficient appliances), financial incentives, and minimum energy performance standards are typically the three key strategies for MT programs. There are various options for multi country collaboration on all these three aspects which are described next.

Jointly Recognizing Super Efficient Appliances and Equipment of Mutual Interest

For products of potential mutual interest such as televisions, room ACs, and refrigerators, there are commercially available products which have much superior performance in terms of

energy efficiency than what is recognized as the highest performance level by most labeling programs. For example, there are commercially available refrigerators in EU that consume 30%-50% below the US Energy Star and BEE India Five Star level (for comparable refrigerator size and type). Similarly LED back lit LCD televisions consume 30% to 50% less compared to regular LCD televisions which typically obtain the US Energy Star and BEE India Five Star label (see Figure 5). Labels only in a few countries recognize this higher efficiency level of LED back lit LCD televisions.

Figure 5: Comparison of Efficiency Levels of Commercially Best Available Products and the Highest Efficiency Levels Recognized by Labels in India and US



Source: US Energy Star website (*www.**energystar**.gov/)*, Bureau of Energy Efficiency (BEE) website (http://www.bee-india.nic.in/), TopTen program web site (http://www.topten.info/)

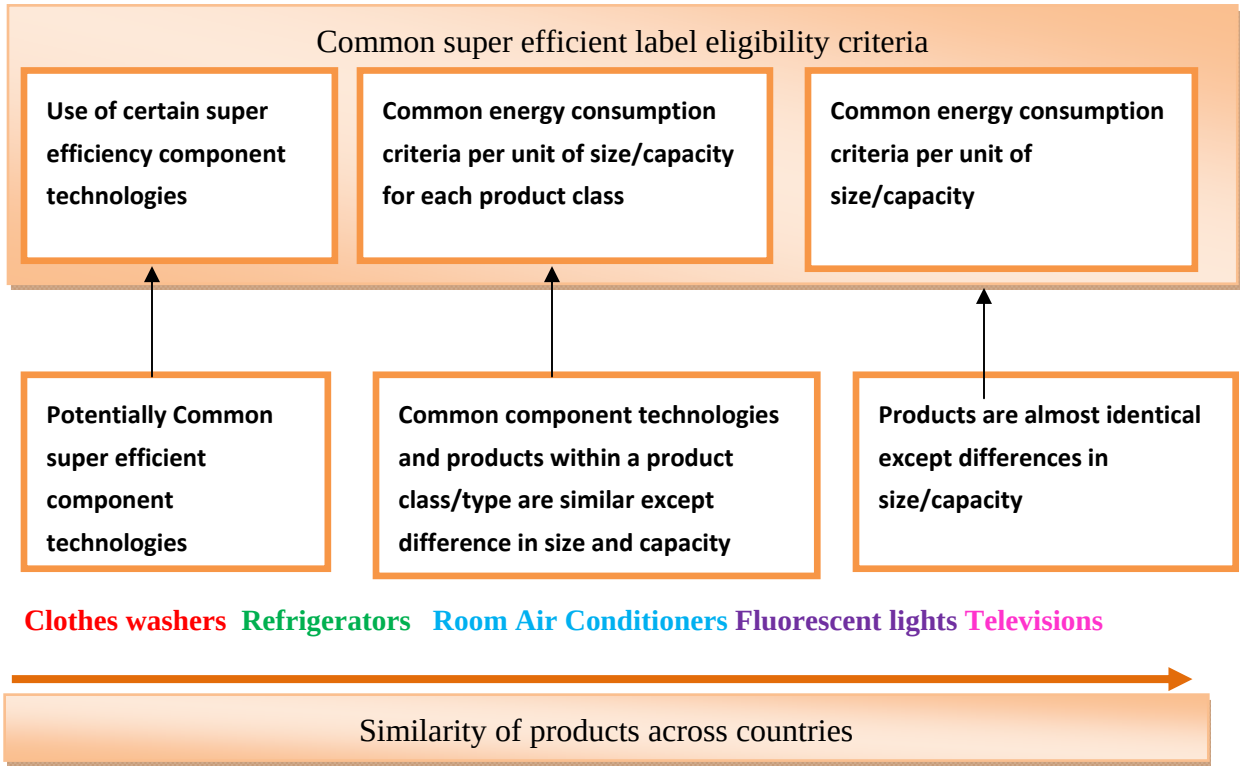
Recognizing super efficient appliances and equipment will enable manufactures credibly differentiate their super efficient products and facilitate faster adoption. If multiple countries simultaneously recognize super efficient appliances and equipment of mutual interest, manufacturers can plan for larger volumes leading to cost reductions. There are various options for recognizing super efficient products which are discussed next.

Recognizing Top Performing Models in Respective Countries

Each country can identify and recognize a certain number of top performing models in terms of energy efficiency. For example, the TopTen program (http://www.topten.info/) is a nongovernmental effort to recognize top ten energy efficient models for each product type. The credibility of such raking needs to be improved to make it more effective.

Developing a Super Efficient Label

Figure 6: Extent of Product Similarity and Criteria for a Common Super Efficient Label



There are two options for developing a super efficient label: a common label across countries or a different label for each country which builds on their existing labeling program. The later will work as effectively as the former if the super efficient label in each country has identical or similar efficiency performance criteria. For example, if a super efficient label in respective countries (which could be a Energy Super Star label in the US and BEE Super Star label in India) is given to LCD TVs which consume at least 40% below the current consumption of LCD TVs per unit area of display, a significant scale-up in the production of LED back lit LCD TVs can be expected (this performance is typically achieved by using LED backlighting in LCD TVs) because of potential simultaneous increase in demand in multiple countries which is likely to reduce costs creating virtuous cycle of cost reduction and increase in sales. Alternatively, countries can agree on a common super efficient label. Various approaches can be followed for defining the criteria for obtaining the super efficient label depending on the extent of similarity in products across countries (see Figure 6 for a conceptual representation of this approach).

Coordinated or Common Financial Incentives to Accelerate the Penetration of Super Efficient Appliances and Equipment

As discussed previously, labeling addresses the information barrier but does not address the barrier of higher initial costs of super-efficient products. Financial incentive programs have shown to increase the pace of MT significantly as they address the first cost barrier to a

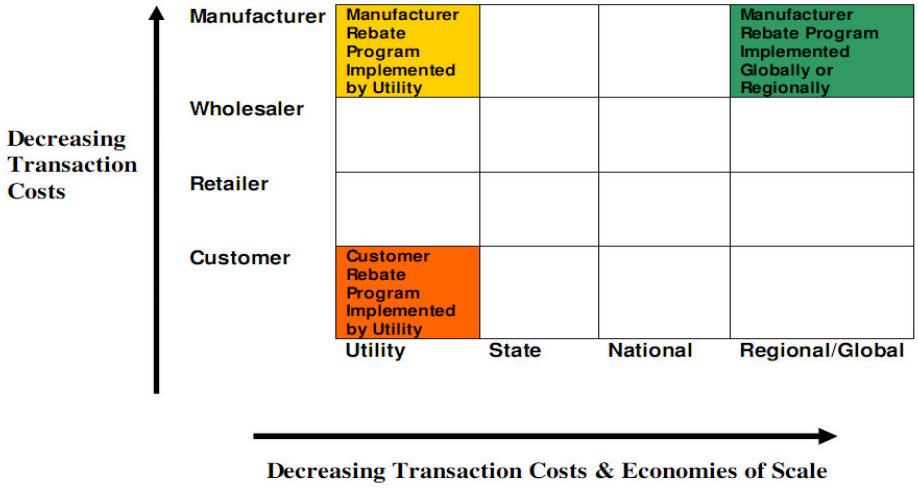
significant extent. Resources spend on financial incentives have been shown to be very cost effective as the cost of saving electricity with these financial incentives is typically less than half of the cost of obtaining new supply.

Countries can either coordinate on providing financial incentives or have a common financial program which is implemented jointly. The latter option, although complicated to implement, provides an additional advantage of greater negotiating power with the manufactures. As reductions in initial costs will increase the acceptability of super-efficient products, manufacturers can plan for much larger volumes of super-efficient products, further driving down their costs, creating a virtuous cycle of increased volumes and cost reductions. If countries with large or rapidly rising sales volumes such as the US, China, and India coordinate on providing financial incentives, manufacturers will get a strong and consistent message that will help them retool rapidly to increase the production of super-efficient products (see Figure 7).

Provision of financial incentives: upstream vs downstream. The provision of financial incentive to achieve market transformation can occur at various stages in the supply chain of product distribution cycle. On one end, the financial incentive can be provided to the customer (i.e. downstream) thereby creating the "pull" for efficient products that product suppliers (i.e. retail, wholesale, and manufacturer) meet by changing the product mix that they offer. On the other end, the financial incentive can be provided to the manufacturer (i.e. upstream) to "push" the efficient products to the customers. Provision of financial incentives upstream to the manufacturer has two advantages over providing incentives downstream to consumers. First, providing financial incentives upstream reduces transaction costs. For example, when a utility provides rebates to individual consumers, they have to provide and process a large number of rebates incurring significant transaction costs. Instead, when the rebates are provided to manufactures, which are typically a much smaller number than the number of consumers, transactions costs are reduced significantly.

Second, incremental manufacturing cost of efficient appliances results into a retail price difference between efficient and regular appliances more than the incremental cost because of wholesale and retail mark-ups and taxes added to the incremental cost which are typically 30% to 50% of the incremental cost (US DOE, 2009). Hence if the rebate is provided upstream to the manufacturer, one avoids paying these mark-ups and taxes for the portion of the incremental cost provided by the rebate.

Figure 7: Reducing Transaction Costs and Harnessing Economies of Scale in Financial Incentive Programs



Potential Sources of Funds for Financial Incentive Programs

Countries coordinating on financial incentive programs first need to identify sources of funds for the same within their own country.[9] Following are some potential sources of these funds.

Aggregation of a portion of utility DSM funds. Utilities implementing DSM programs use significant portion of their DSM budget to provide financial incentives. A part of these funds can be pooled at the regional or national level for implementing programs for appliances and equipment such as televisions, room ACs, and lighting (as discussed previously, some regional organizations in the US pool utility DSM resources and implement common programs). Key challenges in taking this approach include: a. if a significant section of the utilities do not have DSM programs or funds, this approach may not be effective b. it requires to a large number of utilities agree to pool their DSM resources and agree to common programs which may not be feasible.

National level DSM funds sourced from electricity sector revenues. In many countries, both, state and central government share jurisdiction over the electricity sector. Central governments can potentially create a fund at the national level by allocating a part of the electricity sector revenue regulated by them. This could take the form of a surcharge on interstate transmission or generation revenues (for example, the Federal Electricity Regulatory Commission in the US can potentially levy a transmission wires charge on the transmission revenues regulated by them or the Central Electricity Regulatory Commission in India can levy a surcharge on interstate generation and transmission revenues regulated by them). These surcharges can be justified based on the rationale that they result into reduction in the consumer expenditure on the meeting their electricity services demand.

[9] It is possible that in the case of least developed countries, these funds can potentially come from other OCED countries.

Potential auction revenues from the cap and trade programs. Many OCED countries are implementing or are considering implementing cap and trade programs to limit GHG emissions. Typically, in cap and trade programs, at least a part of the emission permits are auctioned generating revenues at the national level. These revenues can be a source of funds for financial incentive programs for super efficient appliances and equipment.

National level budgetary support. National level budgetary support can be given either directly or through fiscal policies. Examples of the use of fiscal policies to provide financial incentives include reduction on taxes and duties on super efficient products, production tax credit to appliance and equipment manufactures for the production of super efficient products, and tax credits to individual consumers for the purchase of super efficient products (as discussed in the previous section, all these policies have been previously used around the globe). Options which include collecting a pool of funds and then disbursing them to either manufactures or consumers (which primarily applies to the first three options discussed above) also create a possibility of creating a joint pool of funds across countries for developing some common financial incentive programs. Alternatively countries can co-ordinate on financial incentive programs irrespective of the in country sources of funds for the financial incentive program

Evaluation, Monitoring, and Verification of Savings

A deemed savings approach can be used where total savings can be estimated primarily based on the incremental sale of super efficient products due to the financial incentive programs and the deemed value of energy saving per super efficient product sold. The deemed savings value can be estimated based on lab test and field measurement results of a sample of products. Random testing of super efficient products purchased on the market can be done to check the compliance of manufacturer participating in the program.

Preliminary Indication of the Global Cost, Benefit, and Potential of Financial Incentive Program for Efficient Refrigerators

Table 2 below shows preliminary estimates of the **total potential savings** and corresponding costs and benefits of a refrigerator market transformation program in different regions of the world, assuming that the program reaches all new sales, and a rough estimate of the funds needed for financial incentives over a five year period. These estimates only provide an order of magnitude of the potential costs and benefits. Costs are overestimated since we have not assumed any decrease in incremental costs of efficient refrigerators over time. These estimates will be revised in the future.

Coordination on MEPS

Once the market penetration of super-efficient products has reached a certain level and the costs have sufficiently come down, the savings can be locked in by increasing the stringency of the MEPS to the super-efficient level (which will be the dominant technology after a few years of the labeling and financial incentives program). At the country level, financial incentive programs and MEPs can be negotiated as package with the manufactures. If multiple countries jointly announce that they intend to increase the MEPS to the super efficient level at a future

date, they are likely to have more negotiating power with the manufactures and manufactures will have more certainty about the stringency level they have to meet in the future.

Table 2: Cumulative Costs and Benefits of a Fully-Effective, Five-Year, Global Coordinated Incentives and Labeling Program Targeting Refrigerators (2009 US $)

	OECD	LDC	China	SAS-PAS	Other	Total
NPV of Incremental Societal Cost (ISC) ($ Billions)	**8**	**2**	**9**	**8**	**8**	**35**
NPV of Financial Incentive to Manufactures: 50% of ISC ($ Billions)	**4**	**1**	**4**	**4**	**4**	**17**
Lifetime Electricity Savings from Efficient Refrigerators Sold (TWh)	**408**	**127**	**443**	**407**	**415**	**1800**
NPV of Avoided Cost of Conventional Supply Corresponding to Lifetime Savings ($ Billions)	**29**	**9**	**31**	**28**	**29**	**126**
NPV of Net Societal Benefit ($ Billions)	**21**	**6**	**22**	**21**	**21**	**91**
Lifetime CO_2 Savings (Mt CO_2)	**203**	**121**	**454**	**338**	**251**	**1367**

Baseline consumption estimates for refrigerators are based on McNeil et al, 2008.
Incremental Societal Cost (ISC) is the cost difference between an efficient and average refrigerator sold in each region. Costs and savings are estimated for about 30% reduction in electricity consumption from the baseline. Super-efficient refrigerators can reduce consumption by 40% to 60%. We do not consider these aggressive saving targets because the corresponding cost estimates are uncertain. However, our preliminary analysis shows that the super-efficient efficiency levels can be achieved at a net negative societal cost even considering current costs. These costs are likely to go down in the future with economies of scale and learning. Avoided cost of supply is based on an average avoided cost of 7 cents/kWh.
Financial incentive costs are estimated to be 50% of the ISE because consumers pay part of the incremental cost of efficient refrigerators.
SAS-PAS includes countries such as India, Vietnam, Thailand, Pakistan, etc. Other includes Russia, non-OECD countries in Eastern Europe, Latin America, and the Middle East.

Conclusions

Certain appliances and equipment such as refrigerators, air conditioners, dish and clothes washers, televisions, and fans account for more than half of the global residential electricity consumption.

In this paper, we analyze the feasibility of a multi country collaboration to accelerate the deployment of super-efficient appliances and equipment by providing financial incentives to manufactures in addition to collaboration on labeling of super efficient products and minimum energy performance standards. Given that only about fifteen manufactures produce more than 70% of the world's major energy consuming appliances and equipment and given that many of these appliances and equipment are very similar across multiple countries, we lay out key benefits and options for multi country collaboration on accelerating the penetration of super efficient appliances and equipment. We assess the potential electricity and CO_2 savings, cost and sources of funds, and implementation options for the same. We find that there are many benefits of such multi country collaboration which could lead to a rapid and much required scale-up in capturing the vast cost effective energy efficiency potential.

The Super-efficient Equipment and Appliances Deployment program (SEAD) announced by U.S. Energy Secretary Steven Chu on December 14 in Copenhagen has significantly drawn

on the analysis presented in this paper. SEAD will provide technical support for national efforts to develop appliance efficiency programs, including standards, labeling, and incentives and will foster multi country collaboration on the same. By encouraging a virtuous cycle between incentives for the latest high-efficiency devices, labeling to better inform consumers of their options, and ratcheting up of minimum energy performance standards (MEPS) over time, SEAD aims to substantially accelerate on-going global progress in appliance and equipment efficiency. SEAD program is certainly a step in the right direction to foster multi country collaboration to accelerate the development of super efficient appliances and equipment.

Acknowledgements

We thank Maithili Iyer, Michael McNeil, James McMahon, Louis-Benoit Desroches, and Asa Hopkins of LBNL's Appliance Standards Group for sharing critical information and insights. We thank Rick Duke and Robert Kopp of U.S. DOE for the help in formulating ideas presented this paper. We thank Cathie Murray of the Regulatory Assistance Project for her insightful comments and edits.

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