Bringing North American Clothes Dryers into the 21st Century: A Case Study in Moving Markets

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ABSTRACT

Most major household appliances, including refrigerators, dishwashers and clothes washers have become 50-80% more energy efficient over the last two decades as a result of ENERGY STAR, stricter federal efficiency standards, and energy efficiency programs. This success only serves to highlight the lack of change in clothes dryer efficiency during this same period. Clothes dryers are now in over 80% of US and Canadian homes, and represent the single largest remaining household appliance efficiency opportunity.

Historically, clothes dryers were considered to be simple machines with little potential for energy savings, but new technologies, including heat pump clothes dryers in Europe, have opened the door for 30-40% efficiency gains in the North American market. Manufacturers will need to make significant capital investments to bring new products to market and building the necessary confidence in a market for advanced dryers requires cooperation between federal agencies, industry and energy efficiency programs to ignite and sustain customer demand.

In 2010 New Jersey's Clean Energy Program launched the Super Efficient Dryer Initiative (SEDI) to support the successful market introduction of advanced clothes dryers through key stakeholder engagement and coordination. SEDI's progress was recently highlighted by the announcement of a scoping process for an ENERGY STAR clothes dryer label and the selection of advanced clothes dryers for the 2012 ENERGY STAR Emerging Technology award.

This paper will provide an overview of SEDI's work to date to bring highly efficient clothes dryers to the North American market and provide an example of an active market transformation initiative.

Introduction

SEDI was designed to explore the potential for commercializing and propagating recent efficiency improvements in residential electric clothes dryer technology throughout the U.S. and Canada[1]. The project topic had been inspired by several years of work by the Swiss Agency for Efficient Energy Use (SAFE) which, since 2005, has documented the entry of advanced clothes dryers using heat pump technology into the European market, and the energy savings associated with these new products. Although initiated under the New Jersey Clean Energy Program, SEDI partnered with the Collaborative Labeling and Appliance Standards Program (CLASP) in 2011 to fortify both the initiative's technical and policy efforts.

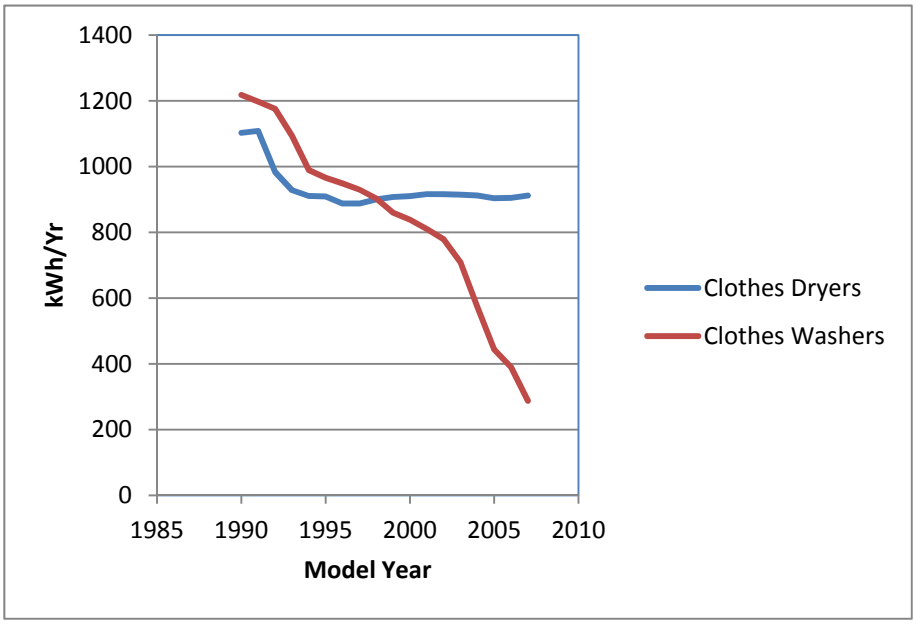
Despite the rapid advancement in the energy efficiency of clothes washers over the last 20 years, clothes dryers have lagged significantly behind. Due to the absence of significant technology improvements by the industry, the lack of an ENERGY STAR product labeling

[1] Opportunities for increases in gas dryer energy efficiency were outside of SEDI's initial scope.

program for clothes dryers, no incentives for efficient clothes dryers from energy efficiency program sponsors, and long-overdue updates to the federal energy conservation standard for clothes dryers there has been surprisingly little change in energy efficiency of clothes dryers for many years.

Figure 1 highlights the dramatic decrease in the average shipment-weighted annual energy consumption of clothes washers with respect to clothes dryers over the last 20 years.

Figure 1. Average Shipment-weighted Annual Energy Consumption of Clothes Washers and Electric Clothes Dryers in Canada



Source: NRCan 2007

To remedy this situation, SEDI developed a phased plan designed to address recognized market barriers, as well as the needs of efficiency programs and the laundry manufacturers with regards to introducing a new technology to the market. SEDI was strongly influenced by the framework for the Consortium for Energy Efficiency's Super Efficient Home Appliances Initiative (SEHA), building on the previous successes of collaborative efforts to improve the efficiency of household appliances. During 2010-2011, SEDI focused on addressing three underlying questions:

- Does the technical and market energy savings potential of the technology support the development of a North American residential advanced clothes dryer initiative?
- Is there a group of stakeholders willing to support the development of a North American market for advanced clothes dryers by participating in the design of a multi-country initiative?
- Will stakeholders and new sponsors provide sufficient resources to support an initiative that builds consensus support for the market introduction of advanced clothes dryers?

The process of answering these questions have set the stage for the current efforts by SEDI to deploy the first highly efficient advanced clothes dryers in the US and Canada during 2013.

Defining the Energy Saving Potential for Advanced Dryers

The first task of SEDI was to understand the existing market for clothes dryers in North America, the short term technology options and market barriers for energy savings, and ultimately an estimate of the savings potential for the introduction of new, high efficiency clothes dryer technology.

North American Clothes Dryer Market

The penetration of clothes dryers into homes in North America has trailed the penetration of clothes washers, though the difference between the two has narrowed over time. **Table 1** presents clothes dryer stock data from the 2009 Residential Energy Consumption Survey conducted by the U.S. Energy Information Agency, and 2007 data from the Canadian NRCan ”2007 Survey of Household Energy Use”.

Table 1. North American Clothes Dryer Stock (2009)

Market Penetration	US	Canada	Both
Total households	113.6 mil	12.9 mil	126.5 mil
% electric	63.2%	81%	65.2%
Total with electric	71.8 mil	10.7 mil	82.5 mil
% natural gas or propane	16.3%	3.9%	15.0%
Total natural gas or propane	18.5 mil	486,692	19.0 mil
% without dryers	20.6%	12.0%	19.7%
Homes without dryers	23.4 mil	1.5 mil	24.9 mil

There are more than 80 million residential electric clothes dryers in use in North America today. DOE’s technical assessment document for residential clothes dryers estimates US shipments at approximately 7 million for 2008, 80% of which were electric. (US DOE, 2010)

Current Test Procedures and Standards

The simplicity of the tumble clothes drying process is one reason why little attention has been paid to dryer energy efficiency over the years. It was widely believed that there was little that could be done to reduce residential clothes dryer energy use. Both the U.S. and Canada have minimum efficiency standards and energy efficiency test procedures in place for residential clothes dryers. Starting in 1994, the effective U.S. efficiency standard for residential electric clothes dryers was set at 3.01 lbs of water removed per kWh through the National Appliance Energy Conservation Act (NAECA). The baseline unit electricity consumption (UEC) was set at 967 kWh per annum, based on a 7 lb standard laundry load and 416 cycles/year as defined in the 1981 DOE test procedure for dryers. Prior to 2011 no additional changes had been made either to the minimum efficiency requirements or to the energy consumption test methodology.

In addition to the lack of technical innovation, shortcomings in the 1994 DOE clothes dryer test procedure presented barriers to progress in energy efficiency. In a recently released

study sponsored by the Natural Resources Defense Council (NRDC, 2011), Ecova identified deficiencies in the existing DOE test procedure and recommended changes including:

- Specific testing of dryer moisture sensing capability and determination of end-of-cycle
- Testing of a greater diversity of laundry load size and clothing types and materials
- Lowering the remaining moisture content levels based on current clothes washer technology
- HVAC impacts from the reduction or elimination of externally vented dryer exhaust
- Change efficiency metric to reflect capacity for removal of water content and source energy

The NRDC report highlights that by incorporating these changes to the testing procedure the result would be a broader differentiation of efficiency levels across clothes dryers currently available in the North American market and new highly efficient advanced dryers that may be introduced in the future. The inclusion of HVAC savings would also specifically support the future promotion of ventless (condensing and heat pump) clothes dryers in the North American market. Another important change requested by multiple stakeholders (manufacturers and efficiency programs) is the expansion of the existing product categories to include standard size (>4.4 cu. ft) ventless dryers in addition to compact versions.

In its final rule for a new test procedure in 2011 and its standard for energy conservation of residential clothes dryers, DOE addressed updates to appropriate levels of moisture content and load size, but did not appropriately address end-of-cycle moisture sensing or HVAC impacts when comparing vented and ventless dryers. (US DOE, 2011)

Sample Cost-Effectiveness Analysis for North America

The European experience with heat pump clothes dryers shows us that at least one technology option for a significantly more energy efficient residential electric clothes dryer can be commercially viable and provides an indicator of the potential savings for the U.S. and Canada. Advanced clothes dryers, utilizing heat pump technology, have gained significant market share in Europe. For example, in Switzerland there are more than 50 models of heat pump clothes dryers are available for residential consumers and 3 for semi-professional use.

SEDI developed a model to estimate the energy saving potential of a hypothetical North American heat pump clothes dryer compared to both existing standard and efficient electric clothes dryers currently in the market. Existing efficient electric clothes dryers, although technologically similar to a standard version, often utilize advanced temperature and moisture sensing to automatically terminate a cycle early. Results from this modeling are presented in Tables 2 and 3 below.

Table 2. Clothes Dryer Energy Consumption and Costs

Electric Clothes Dryer		Standard Dryer	Efficient Dryer	Heat Pump Dryer
Annual Consumption (kWh/yr)	Direct	775	646	370
	HVAC	57	57	0
	Total	832	703	370

Installed Cost	**$564**	**$716**	**$969**
Annual Cost of Operation ($/yr)	**$136**	**$115**	**$61**

Table 3. Heat Pump Clothes Dryer Cost-Effectiveness[2]

Electric Clothes Dryer	Relative to a Standard Dryer	Relative to a an Efficient Dryer
Annual Savings (kWh/yr)	**462**	**332**
Annual Savings ($/yr)	**$76**	**$54**
Lifetime Savings (kWh)*	**5,541**	**3,987**
Lifetime Savings ($)	**$909**	**$654**
Price Premium ($)	**$405**	**$253**
Payback on Price Premium (yr)	**5.3**	**4.6**
Present Value of Net Benefits ($)	**$297**	**$235**
Benefit-to-Cost Ratio	**1.86**	**2.09**

This analysis uses New Jersey's 2009 average residential electric rate of US $0.16/kWh, which is higher than the US $0.149/kWh rate for a large state that DOE used in its pre-analysis. In order to account for avoided generation and transmission costs, efficiency program managers will need to custom tailor these avoided costs and calculate their own per-unit savings. The size and relative importance of HVAC savings from a ventless dryer design are very dependent upon climate. As part of the analysis, SEDI developed a spreadsheet tool to calculate HVAC savings taking into account variables including heating and cooling degree days and the prices of heating fuels and electricity.

The total energy efficiency savings generated by the successful commercialization of residential advanced clothes dryers in North America will be a function of the efficiency of the new technology, and its popularity with U.S. and Canadian consumers.

Overview of cost effectiveness analysis. These two scenarios were developed by SEDI based on estimates of total cycle energy consumption derived through recent laboratory testing performed for the Natural Resource Defense Council by Ecova (NRDC, 2011). The Ecova testing included both a sample of clothes dryers currently available on the North American market and a single model of European heat pump clothes dryer. Since that report was released, the DOE has established a draft of recommended changes to the existing clothes dryer test procedure. (US DOE, 2011) In order to evaluate the impacts of the DOE final rule for clothes dryer on the existing test results, the following factors were incorporated in SEDI's analysis:

- *Reduction in initial moisture content of laundry coming from washer from 70% to 47%*
- *Increase in laundry test load weight from 7lbs to 8.45 lbs*
- *Reduction in the average number of household annual laundry cycles from 416 to 283*

[2] High efficiency clothes dryers were not included in this part of the analysis.

SEDI also estimated home space heating and cooling (HVAC) impacts from the elimination of externally vented dryer exhaust. In North America, most clothes dryers draw conditioned air from inside homes, heat it, use it to dry clothes and then exhaust it outside through a vent; which can have an impact on home HVAC energy consumption. On the other hand, most European clothes dryers are unvented; instead they draw air from inside homes, heat it, use it to dry clothes, and then condense the moisture out of the air and expel it as liquid water. There are other clothes dryer designs that are partially vented (TIAX/Whirlpool, 2005), though these were not included in our analysis. Estimates for the savings from eliminating venting vary significantly based on the seasonal heating and cooling requirements of different homes in different climates. The NRDC study does not explicitly estimate the HVAC impacts from eliminating venting, but does incorporate savings from the direct ducting into the dryer cabinet of makeup air from outside the house.

The calculation used in this report is based on extrapolating the dryer ventilation impacts from the heating degree days (HDD) and cooling degree days (CDD) for a region and the heat capacity of the volume of air that is moved. This provided a simple method for the various stakeholders to estimate HVAC impacts. Based on an ASHRAE rule of thumb, only half of the added ventilation from the clothes dryer (based on the cfm rating of the blower fan) is added to the existing natural infiltration for most existing homes.

Impact of demand reduction on avoided utility costs. SEDI developed its own estimate of demand reduction and avoided costs, because DOE used a different methodology than efficiency programs when it estimated life cycle costs of more efficient dryers for a recent rulemaking. Specifically, DOE utilized the Annual Energy Outlook 2008 residential energy price projection for electricity price trends. Because this electricity price is for energy only, and has no demand component, it significantly understates the value of energy efficiency measures in reducing the growth of electricity demand. On the other hand, the utility total resource net benefits test included in this analysis quantifies both the energy and capacity saved in avoiding any generation or transmission upgrades.

Incremental costs, lifetimes and residential rates. The projected cost of a "standard," "high efficiency", or hypothetical North American heat pump clothes dryer used in this analysis are similar to both DOE's incremental cost estimates and the proportional price premium for heat pump dryers in the European market.

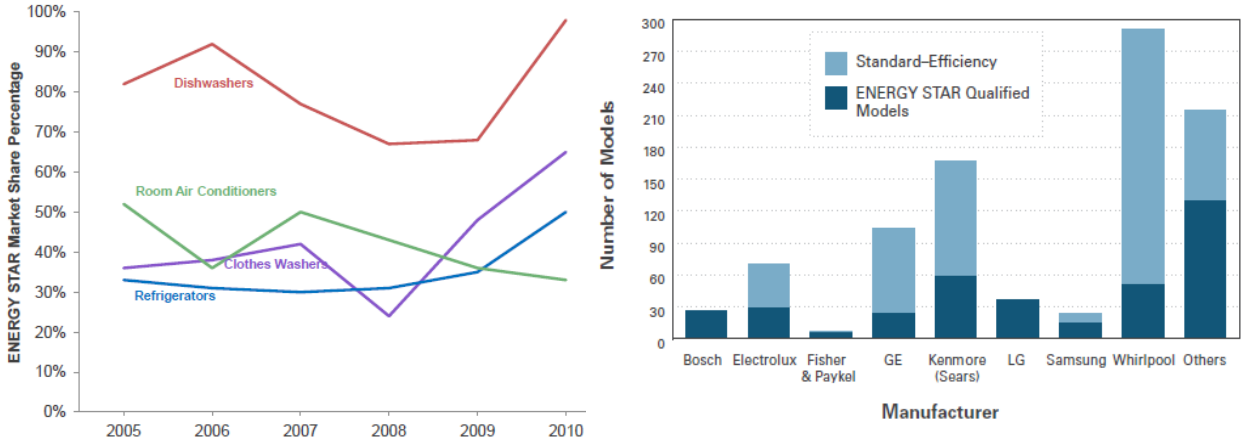
Building a Collaborative Initiative for High Efficiency Dryers

After analyzing the market and savings opportunity, SEDI began work to build a collaborative program model for supporting the introduction of advanced dryers into the North American market. SEDI looked to the residential clothes washer initiative (RECI) sponsored by the Consortium for Energy Efficiency (CEE) as a model. RECI created a close partnership between efficiency programs and manufacturers and helped to introduce European-style front-loading washing machines to the US market. Between 1996 and 1999, the initiative supported a 5% gain in market share for high efficiency clothes washers with over 200 participating utilities and efficiency programs, 14 manufacturers and 35 qualifying models. Subsequent, significant upgrades in the energy efficiency specifications for qualified ENERGY STAR clothes washers

(1997, 2001, 2004, 2007 and 2011), has increased the market share of ENERYG STAR qualifying products to 64% by 2010 (US EPA, 2010).

As experienced with clothes washers in RECI, the synergistic effects of ENERGY STAR specifications and technology advancements with a coordinated energy efficiency program effort to drive demand can create a positive feedback loop leading to greater demand for more efficient products supported by increased ENERGY STAR specifications.

Figures 2 & 3. ENERGY STAR Clothes Washer 2010 Market Share and 2008 Product Snapshot



Engaging U.S. EPA

The ENERGY STAR program will play an important role in the introduction of advanced clothes dryers into the North American market. As manager of the influential ENERGY STAR program, EPA was a primary target of SEDI activity in 2011. In 2011, EPA took two very important steps towards clothes dryer efficiency; EPA announced the ENERGY STAR Emerging Technology Award for Advanced Clothes Dryers and assessed the opportunity for an ENERGY STAR label.

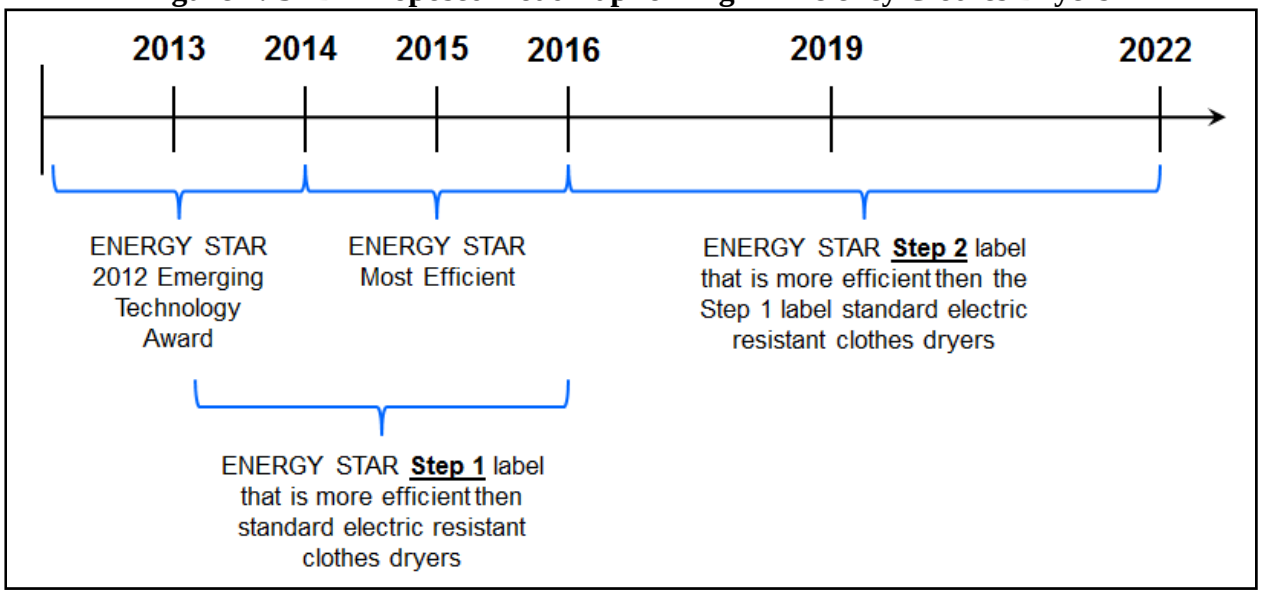
Emerging technology award. Early in 2011, SEDI responded to an EPA solicitation for nominations for the 2012 ENERGY STAR Emerging Technology (ET) Award and proposed the nomination of advanced clothes dryers for the 2012 product category. The ENERGY STAR Emerging Technology Award "raises the profile of innovative technologies that may not yet meet key principles associated with the ENERGY STAR program (e.g. widely available, cost-effective), but have the potential to significantly reduce greenhouse gas emission once they are more widely adopted." (US EPA, 2011) In September 2011, after discussions with both SEDI and domestic and international clothes dryer manufacturers, EPA announced that Advanced Clothes Dryers were selected for the 2012 Emerging Technology Award. The award would be given to any manufacturer that brings a residential electric clothes dryer to the US market in 2012 or 2013 that meets a performance level approximately 30% higher than the current federal standard.

ENERGY STAR label for clothes dryers. In the same timeframe, SEDI, manufacturers, and several other key stakeholders were actively engaging EPA to initiate a scoping process for the development of an ENERGY STAR clothes dryer specification. SEDI proposed a two-step approach to EPA, suggesting that they first label the clothes dryers currently on the market that are more efficient than the standard clothes dryer and raise the specification level to recognize the higher performance of advanced clothes dryers once they are brought to market. SEDI argued that these steps were both necessary towards achieving market transformation for clothes dryers in North America. EPA began the ENERGY STAR scoping process and recently shared its results, which align with SEDI's recommendations. EPA sees both a short term opportunity for modest energy savings by labeling more efficient clothes dryers that are currently in the market and a longer term opportunity for more dramatic energy savings from advanced clothes dryers anticipated to enter the market in 2013.

SEDI Proposed Roadmap

EPA's announcement of an Emerging Technology Award and a specification-development process for ENERGY STAR clothes dryers has established the framework and longer term roadmap for the introduction of advanced clothes dryers in the North American market. Figure 4 presents a proposed roadmap for advanced clothes dryers, as the evolution of the market and the ENERGY STAR specification progresses. SEDI supports the identification of tiered efficiency specifications with defined end points, as these are important for the continued improvements of clothes dryer efficiency.

Figure 4: SEDI Proposed Roadmap for High Efficiency Clothes Dryers



Investing in the Future of High Efficiency Dryers

In Switzerland, heat pump clothes dryers went from zero to 16% market share in about five years, or about 3% annual market share growth. Starting in 2012, the market share of heat pump dryers is estimated at 100% with the adoption of an aggressive new Swiss minimum

energy performance standard for tumble dryers. (TopTen, 2012) SEDI anticipates a more moderate increase in North American market share through a combination of utility incentives and the ENERGY STAR voluntary labeling program. If we assume that in the US and Canada it would be possible to achieve a 2% increase in market share per year starting in 2013, by 2018 SEDI will have helped save over 35,000 cumulative lifetime GWh of electricity.

During 2011, SEDI focused on engaging manufacturers and efficiency programs in introducing advanced clothes dryers to the North American market. SEDI also launched important research that will support the energy saving potential of advanced clothes dryers.

Manufacturer Interviews

In the third quarter of 2011, SEDI conducted interviews with major manufacturers of clothes dryers to assess their interest in introducing more energy efficiency products to the North American market. Twelve manufacturers were contacted and resulted in interviews with Arcelik AS, Bosch & Siemens, Electrolux, General Electric, LG, Miele, Samsung, and Whirlpool. All but GE, LG, and Samsung currently offer heat pump clothes dryers either directly or through sub-brands on the European market. An additional interview was held with the engineering design and development firm, Porticos.

All manufacturers reported that they were, in some way, responding to perceived changes in the market by introducing more energy efficient clothes dryers. Several are already marketing "Eco" models on the North American market. None are currently selling clothes dryers using heat pump technology in the US or Canada. Results of manufacturer surveys and retailer engagement in 2011 have demonstrated a clear indication that there is an opportunity for partnership with efficiency programs in supporting the market introduction of advanced clothes dryers.

In November 2011, SEDI presented at the ENERGY STAR Partner Meeting in Charlotte, NC to further engage manufacturers, retailers and efficiency programs. The SEDI presentation was part of a two hour session entitled, "Focus on Laundry: Residential Clothes Dryer Opportunities" which was attended by both major US and international manufacturers, energy efficiency program managers and the EPA to discuss activity around promoting advanced clothes dryers.

Laboratory Testing

That same month, SEDI undertook laboratory testing of European heat pump and North American electric resistance dryers. Testing data will validate the energy saving potential of heat pump technology and help U.S. utilities and ENERGY STAR better understand the energy saving potential this technology may have in North America. This project was directly funded by CLASP and with testing conducted by Ecova at its Durango, CO facility. Test results and a final report will be available in mid-2012.

Mobilizing the Support of Efficiency Programs

In 2011, SEDI engaged efficiency programs. Appropriate incentives to offset the higher incremental cost of the ENERGY STAR clothes dryers and consumer outreach are critically needed for new technologies to be successful. Several regional efficiency programs that are core

stakeholders in SEDI (including National Grid, Efficiency Vermont, NYSERDA, New Jersey Clean Energy Program, and LIPA) have indicated strong support for developing incentive programs in 2012-2013 to support any new products brought to market.

With over one million households with electric clothes dryers, New Jersey has already taken the next step in leading other programs towards direct market support of advanced clothes dryers, highlighted in the 2012 program filing for New Jersey's Clean Energy Program (NJCEP):

> "During 2010 and 2011, the Program was successful in advancing a consortium of efficiency programs, manufacturers, and the EPA on behalf of ENERGY STAR in the introduction of super-efficient clothes dryers to the North American market, under the banner of the Super-Efficient Dryer Initiative (SEDI). As a result of SEDI, heat pump clothes dryers have been selected for the 2012 ENERGY STAR Emerging Technology Award, which will support manufacturers bringing this technology to the North American market. Although no new R&D initiatives will be introduced for energy efficient products in 2012, the Program will look to continue its leadership role in SEDI by supporting these manufacturers and providing upstream incentives for field testing heat pump clothes dryers in New Jersey."

Per the language in the filing, it is anticipated that New Jersey's engagement of trade allies in 2012 and beyond will inform both the state's longer term planning and ENERGY STAR's development of a clothes dryer specification for 2013. With several appliance manufacturers headquartered in New Jersey, including Miele, LG and Samsung, the state has a strong presence in a potentially growing industry for advanced clothes dryers.

Next Steps

During the latter part of 2011, SEDI began identifying stakeholders willing to support SEDI's aims. While the ENERGY STAR Emerging Technology Award is a powerful incentive for manufacturers and retailers, deciding to bring a new product to market is no small undertaking. Based on its efforts to date, SEDI has developed a scope of work intended to continue the momentum that has been built since the beginning of the initiative in 2010. This scope of work includes industry support (manufacturer and retailer communications), efficiency program support (development of inputs for cost effectiveness screening and help with program design models for supporting new products), and continued technical research to better understand baseline clothes dryer efficiency use in North America and the savings that heat pump dryers can deliver. SEDI is seeking commitments from efficiency programs to support advanced clothes dryers in anticipation of the 2012-2013 market introductions of the Emerging Technology Award winners.

Conclusion

Since 2010 with the founding of SEDI, New Jersey's Clean Energy Program, CLASP and other key stakeholders have played prominent and critical roles in coalescing support of efficiency programs and providing guidance to EPA and the industry to ensure a rapid introduction of advanced clothes dryers in to the North American market. The process taken was to first understand and quantify the savings potential and market opportunities/barriers, then to begin building a collaborative initiative to mitigate risk to all stakeholders, and lastly to work to

overcome specific barriers and put into place "carrots" like incentive programs to keep the momentum going. While the work to bring a new generation of advanced clothes dryers to the North American market is not yet complete, much has been accomplished and a path has been laid out to achieve that goal in 2013.

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