PATH TECHNOLOGY ROADMAPPING

ENERGY EFFICIENCY IN EXISTING HOMES

BACKGROUND PAPER

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1. Introduction

This paper has been prepared for participants in an "Existing Homes" technology brainstorming session organized by the NAHB Research Center in conjunction with the "Partnership for Advancing Technology in Housing" (PATH). PATH is a public-private partnership that was created to improve new and existing American homes in several important ways between now and the year 2010.

PATH Program Goals

- *reduce the monthly cost of new housing by 20 percent or more*
- *cut the environmental impact and energy use of new housing by 50 percent or more and reduce energy use in at least 15 million existing homes by 30 percent or more*
- *improve durability and reduce maintenance costs by 50 percent, and*
- *reduce by at least 10 percent the risk of loss of life, injury, and property destruction from natural hazards and decrease by at least 20 percent residential construction work illnesses and injuries.*

The PATH program has adopted an ambitious set of performance goals to improve the affordability, durability, energy efficiency and environmental performance, disaster resistance and worker safety record of U.S. housing. While most of the focus of the program is on new homes, one PATH goal specifically calls for *reducing energy use by 30 percent or more in at least 15 million existing homes* over the life of the program. This paper describes the different activities underway in connection with PATH and summarizes background information related to the "existing homes" energy goal.

2. PATH Activities

Work is underway on several fronts in pursuit of the PATH goals. Extensive technology outreach activities are ongoing, both over the Internet and in field evaluations or demonstrations around the U.S. At the same time, a Technology Roadmapping Working Group has been laying groundwork for the development and introduction of beneficial new products over the life of the program. In addition, four other Working Groups have been organized to focus on the institutional forces that affect technology adoption and utilization, including (1) finance, (2) labor and quality issues, (3) barriers and insurance, and (4) consumer education. Activities of the Working Groups are under the general oversight of an Industry Steering Committee. All of these efforts are described in this section.

PATH Technology Outreach. An extensive Technology Inventory was developed early in the program and placed on the Internet at "http://www.nahbrc.org/toolbase/xtech.html". Visitors will find searchable information about the nature and status of more than 150 emerging technologies for housing. Several of these technologies are being more closely studied and reported on as part of PATH Field Evaluations. Others are being used and documented on a larger scale in PATH Demonstration Projects.

SOME POTENTIAL ENERGY RETROFIT TECHNOLOGIES IN THE PATH TECHNOLOGY INVENTORY

Aerosol Duct Sealing
Drainwater Heat Recovery
Ductless (Mini-Split) Heat Pumps
Energy-Efficient Interior Storm Windows
Foamed Fiber Insulating System
High-Efficiency Refrigerators
Hot Water On-Demand System
Insulative Vinyl Siding
Mini-Duct Air Distribution System
Modulating Furnace
Photovoltaic (PV) Roofing
Radiant Barriers
Spray Foam Insulation
Thermochromic Window Film
Vertical Axis (Top-loading) Energy-Saving Clothes Washers
White LED Lighting
Window Film

A quick scan through the PATH Technology Inventory shows many entries that are relevant to the existing homes goal, some because they are clearly oriented towards retrofit or avoiding the replacement of already-installed products, and others because they concern products or systems that are both installed in new homes and replaced in existing homes. Of course, many of these headings are general so brainstorming possible improvements to these products or systems should properly be part of a longer-term process of technology development.

PATH Technology Roadmapping. PATH has initiated a process of Technology Roadmapping to complement the technology outreach and help accelerate the development and introduction of new technologies that can achieve progress towards the PATH goals. Specific areas for roadmapping will be selected by the Industry Steering Committee, which will review and approve the results.

Roadmapping work began with a two-day brainstorming session in March 2000, where a diverse group of 35 experts reviewed all the PATH goals, then identified and documented a total of 40 "technology options" as candidates for further study. The titles of these options give some idea of their scope and content.

TECHNOLOGY OPTIONS IDENTIFIED DURING MARCH, 2000 PATH BRAINSTORMING

Advanced Roof Coverings
Augmented Reality
Automated Tools
Connected Home
Cooling with Night Air
Distributed Generation - Fuel Cells
Distributed Generation - PV Solar Cells
Electronic Control Technology for HVAC
Enclosed Attic Space
Enterprise Resource Planning for Home Construction
Flexible, Adaptable Space
Foundation Stave System
Frost-Protected Shallow Foundations
Helical (screw) Footings
Homogeneous Wall Panels
Improving Safety in Roof Construction
Indoor Air Quality
Information Technology for the Approval Process
Insulating Concrete Forms
Integrated Wall, Floor and Roof Systems
Interlocking Roof Sections
Less-Finished Interiors
Mechanical System Disentangling
Microtechnology
Modular/Whole House Systems
Non-Commercial Information Portal
Precast Insulated Wall Panels
Precast Panelized Roof Components
Prefabricated Ducts
Radiant Heating
Roof Sandwich Panels with Utilities
Self-Fitting Membrane Interiors
Software Integration/Standards
Sound Isolation
Targeted Heating and Cooling
Virtual Inspections
Water Recycling and Reuse
Whole House Process Redesign
Wireless Communications
Zero Negative Emissions

One-page write-ups of all 40 options in the list can be viewed on-line through the Public Access area at "http://roadmap.nahbrc.org". The brainstorming was followed by an evaluation process in which benefits, risks and other factors were assessed for each technology option. Based on the results of the participant evaluations, three "portfolios" were selected for initial roadmap development. Each portfolio includes several Technology Options that received very high ratings, or were closely related to highly-rated items. Roadmapping task groups being organized under each of these areas will operate concurrently this fall and into the year 2001.

INITIAL PORTOLIOS SELECTED FOR PATH TECHNOLOGY ROADMAPPING

1. *Information Technology to Accelerate and Streamline Home Building*
2. *Advanced Panelized-Type Systems*
3. *Whole-House and Building Process Redesign*

Some of the Technology Options identified in the March, 2000 brainstorming session clearly relate to existing homes. The median participant evaluations indicated that the following six items each offered the potential to reduce energy use in existing homes by 1 percent to 5 percent, and had potential market penetration of 5 to 25 percent of the existing housing stock.

Advanced Roof Coverings
Connected Home
Distributed Generation - Fuel Cells
Distributed Generation - PV Solar Cells
Electronic Control Technology for HVAC
Non-commercial Information Portal

Out of these six topics, only "non-commercial information portal" is included in the three portfolios selected for roadmapping to date. Yet the broad scope of the PATH program meant that the original brainstorming work spent relatively little time on energy retrofit or similar energy issues specific to existing homes, so follow-up work limited to the existing home goal is now being pursued. Therefore, a main purpose of the October 18 brainstorming session is to expand significantly on this list of Technology Options, or elaborate on items already in it. If promising areas of technology are identified through this work, then PATH will create one or more task groups to do roadmapping in this area along with the others previously selected.

Other Roadmapping Work. Participants should be aware of two other recently completed technology roadmaps, sponsored by DOE, that specifically address lighting and windows:

Vision 2020 - The Lighting Technology Roadmap
http://www.eren.doe.gov/buildings/technology_roadmaps/lighting/

Window Industry Technology Roadmap
http://www.eren.doe.gov/buildings/technology_roadmaps/windows/

Both documents address all types of buildings (not just housing), and are focused on energy issues, not all the PATH goals. Neither one specifically addresses existing buildings in any depth. However, they contain ideas about research opportunities and new products that may prove useful to PATH, and the PATH roadmapping work should try to avoid duplicating or re-inventing them.

Other PATH Working Groups. In recognition of the many factors other than simple availability of technology that affect adoption and usage, PATH has created four other working groups responsible for different issue areas. Each group meets periodically and is developing its own strategies, plans and recommendations for pursuing the PATH goals. While new technology development is being pursued as a separate activity in its own right, successful deployment of new technologies often raises issues or problems that should be considered and may be appropriate for another working group, e.g. "who will install it?" "how will it be financed?" "how will it be promoted or marketed to user audiences?", or "are there impediments relating to current codes or standards?" The other PATH Working Groups and their general areas of responsibility are listed below.

Finance Working Group. New technologies cannot succeed unless users have access to affordable financing. The higher the cost of capital, the greater the savings or other benefits must be to justify a voluntary purchase. This group is working to enhance "energy efficient mortgages" and define similar products offering expanded access to financing or reducing the cost of originating mortgages and related loans.

Labor and Quality Working Group. New technologies cannot be used effectively unless labor with the appropriate skills is available to install them, and may not perform as intended unless installers pay close attention to quality issues. This group is working to promote quality improvement methods and provide training that will address persistent labor shortages in the construction market.

Barriers and Insurance Working Group. New technologies may not be introduced if manufacturers or users perceive undue exposure to liability for failures or high probability of "call-backs" and similar corrective needs. In addition, many PATH-related technologies help reduce the risks of property loss while raising the cost of construction and purchase. This group is investigating ways to help control exposure to liability and translate improved building performance into lower insurance premiums that would help cover added up-front cost or higher mortgage payments.

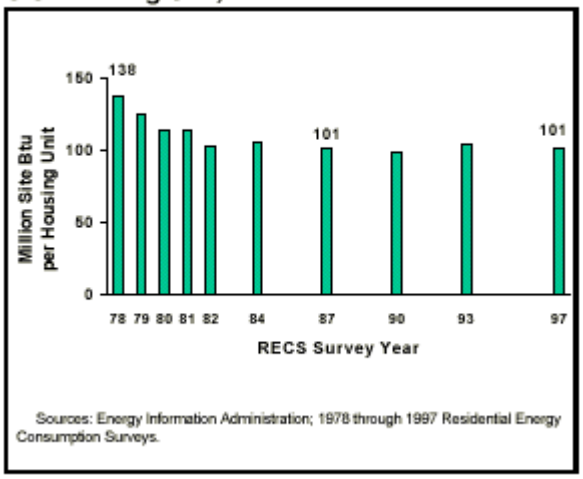
Consumer Education Working Group. New technologies will become standard more quickly if consumers are receptive to them, yet consumers demand "features" rather than products or technologies as such, and the recent environment of low energy prices reduces demand for energy efficiency improvements. This group is looking at ways to stimulate consumer demand and create market "pull" for PATH technologies through mechanisms such as partnering with the "Energy Star Homes" program or providing similar offerings through utilities, lenders, insurers, retailers or other interests.

3. Existing Homes Energy Baseline

The most authoritative information about energy use in the U.S. housing stock comes from the 1997 Residential Energy Consumption Survey (RECS), performed by the Energy Information Administration of the U.S. Department of Energy. Results appear in *A Look at Residential Energy Consumption in 1997* (November 1999), publication DOE/EIA-0632 (97). The full report can be downloaded at "http://www.eia.doe.gov/pub/pdf/consumption/063297.pdf".

According to the RECS, in 1997 there were over 101 million U.S. housing units, with total energy use of 10.25 quadrillion Btus (quads) as measured at the building site (the figures cited here all exclude energy consumed in the generation and transmission processes). This represents dramatic improvement since 1978 when the 77 million housing units in the U.S. used a total of 10.6 quads of site energy. EIA attributes this improvement primarily to reduction of energy required for space heating, which would in turn represent changes such as improved insulation, windows and heating equipment throughout the housing stock.

Figure 2.5. Total Site Energy Consumption per U.S. Housing Unit, 1978-1997



The figure on the right shows this improvement in another way. Average site energy use per housing unit was 101 million Btu in 1997, compared to the 138 million Btu average in 1978 (but unchanged from the 1987 average). By comparison, the PATH energy goal for existing homes calls for slightly larger percentage savings (30 percent vs. 27 percent), but applies only to 15 million housing units rather than the entire stock of existing homes. When averaged across the entire housing stock the PATH goal translates into a drop of 4 to 5 million Btu per house below 1997 usage, assuming no change in performance of other housing units. Of course, the PATH goal of reducing energy use could equally well be interpreted as based on the total cost of purchased energy or, for that matter, on "source" rather than "site" energy use. Similar trends would probably hold in either case.

The EIA report includes a great deal of information that can be used to "ballpark" potential energy savings from different types of technological improvements, and therefore may be helpful in assessing potential energy retrofit technologies for use under PATH. A 2-page graphical summary of key points from the latest RECS is reproduced on the following pages, followed by other relevant information.

AT A GLANCE:

Residential Energy Consumption in Perspective

In-depth information about how energy was used in residential housing units that were occupied year-round is provided by the Energy Information Administration (EIA) in this analysis of the 1997 Residential Energy Consumption Survey results. The uses and costs of residential energy (excluding vehicle fuels, primarily gasoline) were analyzed by using households' energy-related characteristics, such as location, type (for example, single-family), size, number of household members and vehicles, and age.

The average household spent $1,338 on energy in 1997

The average household spent most of their energy dollars on refrigeration, other appliances, and lighting, followed by space heating. Over 45 percent of the average household's energy costs was for energy used in appliances and lighting, while space heating accounted for another 30 percent. Water heating and air conditioning expenditures accounted for the remaining energy expenditures in the average household.

and used 101 million Btu of energy.

This 101 million Btu value reflects the energy content of all energy sources, including electricity, as they are used in the home (so-called "site energy"). However, large amounts of additional energy are used to generate and transmit electricity for residential use. If the energy losses in electricity generation and transmission are added to the energy value of the electricity as it enters the home, then the total energy requirement associated with the average household (so-called "primary energy") becomes 172 million Btu.

About half of the average household's site energy consumption was used for space heating. Another 22 percent was used for appliances. On a per-household basis, site energy consumption was 27 percent lower in 1997 than in 1978. Most of the decrease was in the amount of energy used for space heating and occurred between 1978 and 1987. The 1997 site energy consumption was the same as in 1987.

Households spent more money on electricity than on all other fuels combined,

Households spent a total of $136 billion on energy and almost two-thirds of the total ($88 billion) was used to purchase electricity. The remaining amount was spent on natural gas, $36 billion; fuel oil, $7 billion; LPG, $4 billion; and kerosene, $0.5 billion.

but used more natural gas than all other fuels combined.

Households used a total of 10 quadrillion Btu of site energy in their homes. Natural gas (5.3 quadrillion Btu) and electricity (3.5 quadrillion Btu) predominated. Fuel oil (1.0 quadrillion Btu), LPG (0.4 quadrillion Btu), and kerosene (0.1 quadrillion Btu) accounted for the remainder. The relatively high cost of electricity per Btu accounts for the fact that more was spent on electricity despite the fact that more natural gas was consumed.

Approximately two-thirds of the electricity used in homes was used to operate appliances, refrigerators, and lights;

Appliances, refrigerators, and lights accounted for approximately two-thirds of the electricity consumed in homes; no single appliance was clearly dominant. The remaining one-third was approximately equally divided among air-conditioning, space heating, and water heating.

the greater shares of most other fuels were used for space heating.

Sixty-eight percent of natural gas consumption was devoted to space heating, as was 72 percent of LPG and 84 percent of fuel oil. Kerosene was used almost exclusively for space heating.

Natural gas remained the predominant fuel for space heating.

Natural gas was used as the main space-heating fuel in over half of all homes in 1978 and in 1997. In 1978, fuel oil was the second most prevalent space-heating fuel, while only 16 percent of homes had electric heat. By 1997, the situation was reversed; close to one-third of homes had electric heat, while only 9 percent were heated with fuel oil.

Refrigerators, color televisions, ranges, and ovens all were found in typical U.S. homes in 1997;

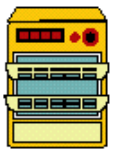
The market penetration of refrigerators and color televisions was almost universal. More precisely, 99.9 percent of the homes had at least one refrigerator and 98.7 percent had at least one color television. (In fact, nearly two-thirds of the households had two or more color televisions.) Similarly, 99.2 percent of the households had ranges and 98.8 percent had ovens.

however, the presence of central air-conditioning depended on the location of the home;

Nationally, on average, 47 percent of the homes had central air-conditioning. In the South, the warmest region, 70 percent of the homes had central air-conditioning. In the Northeast, in contrast, only 22 percent of homes had central air-conditioning.

the presence of a clothes washer and dryer depended on the type of home;

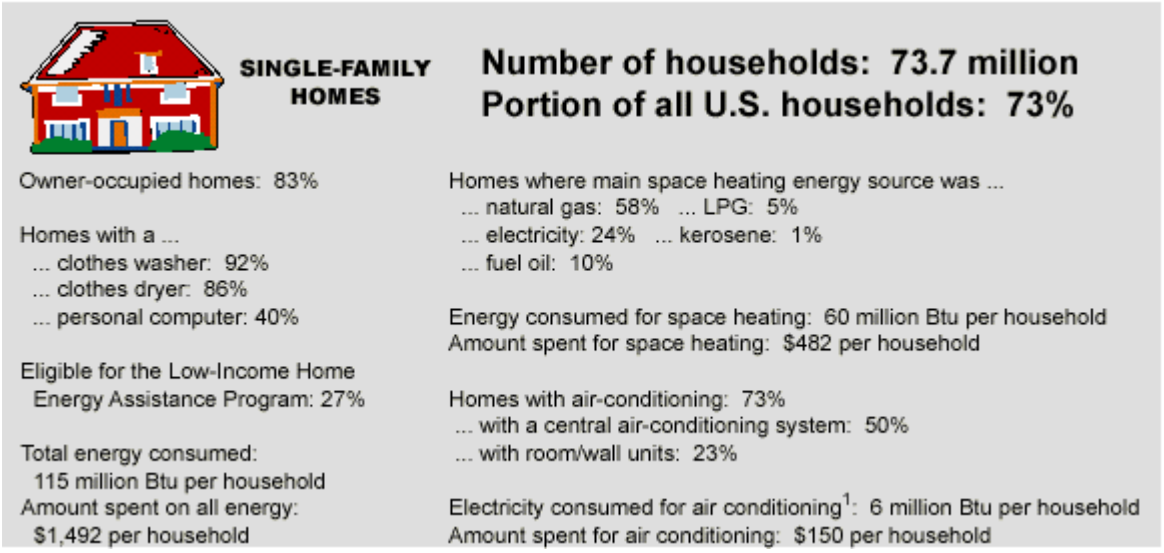
The share of households with clothes washers and dryers varied substantially by type of home. Among single-family homes, 92 percent contained a clothes washer and 86 percent contained a clothes dryer. By contrast, among units in apartment buildings with five or more units, 21 percent contained a clothes washer and 18 percent contained a clothes dryer.



and the presence of a dishwasher depended on the age of the home.

Not surprisingly, the share of households with dishwashers was higher among new homes than among old homes. The percent of homes with dishwashers was 30 percent for old homes (built in 1949 or before) and 77 percent for new homes (built from 1990 through 1997).

The preceding summary data covers all types of housing units (single family, multifamily and mobile homes). An overview of national results limited to existing single-family homes is as follows:



The graphic shows that average site energy consumption in 1997 for the 74 million existing single-family homes was 115 million Btus, with average expenditures for the year of $1,492, including $482 for space heating and an average of $150 for those homes (73%) with air conditioning. The remainder (actually the majority of energy expenditures) went to operate water heaters, refrigerators, other appliances and lighting. Thus, applying the PATH 30 percent savings goal to total expenditures for an average single-family home in 1997 equates to almost $450 per year at 1997 prices, or 35 million Btus at the building site. When multiplied by 15 million homes the savings would total $6.7 billion per year, corresponding to around 0.46 quads of site energy each year on a national scale. Obviously these figures are just rough estimates; the details would depend on characteristics of homes being improved to meet the PATH goal such as size, location, style of construction and fuel types.

When evaluating the potential of different retrofit products or approaches to contribute to achieving the PATH goal, it is helpful to have basic information about the proportion of homes with different types of equipment or appliances, as well as the average amount of energy used by those appliances in houses where they are present. For example, total electricity usage per household for all purposes averaged 10,215 kWh for the year 1997, or 35 percent of total site energy usage in Btus. This actually corresponded to 65 percent of total expenditures on energy (since electric Btus at the site are far more costly than other forms of energy). Household electric consumption is broken down by end use in the following table. Note that more than 50 percent of electricity goes for lighting and appliances other than refrigerators, water heaters and air conditioners (including over 15 percent unallocated residual use).

Table 3.1. End-Use Consumption of Electricity by End Use and Appliance, 1997

End Use/Appliance	Households (millions)	Units (million)	Electricity Consumption for 1997: Annual Consumption kWh per unit	Annual Consumption kWh per household	Total (billion kWh)	Percent
Total Households	101.5			10,215	1,036.7	100.0
Refrigerators	101.3	117.5	1,141	1,323	134.1	12.9
Air-Conditioning					121.8	11.8
Central Air-Conditioners	47.8			2,109	100.8	9.7
Room Air-Conditioners	25.8	40.6	519	817	21.1	2.0
Space Heating					117.9	11.4
Main Space-Heating Systems	29.6			3,760	111.2	10.7
Secondary Space-Heating Equipment	12.4			536	6.7	0.6
Water Heating	40.2			2,835	113.9	11.0
Lighting Appliances (indoor and outdoor)	101.5			[a]940	95.4	9.2
Other Appliances (total of list below)	101.5			4,470	453.6	43.8
Clothes Dryer	55.9			1,090	60.9	5.9
Freezer	33.7	36.9	1,013	1,110	37.4	3.6
Color TV	100.2	213.0		[b]307	30.8	3.0
Cooking [c]	65.0			451	29.4	2.8
Furnace Fan	67.1			[d]398	26.7	2.6
Dishwasher	50.9			[c]410	20.9	2.0
Microwave Oven	84.2			[d]135	11.4	1.1
Personal Computer	35.6	43.0	[d]262	317	11.3	1.1
Waterbed Heater	8.4	10.1	[d]1,070	1,286	10.8	1.0
VCR	88.9	132.2	[b]70	104	9.3	0.9
Clothes Washer	78.5			[d,f]108	8.5	0.8
Ceiling Fan	61.7	155.6	[e]50	126	7.8	0.8
Pool/Hot Tub/Spa Heater	2.7			[e]2,300	6.3	0.6
Stereo	69.8			[d]71	4.9	0.5
Swimming Pool Pump	5.5			[d]792	4.3	0.4
Laser printer	12.6			[e]250	3.2	0.3
Large, Heated Aquarium	3.9			[e]548	2.1	0.2
Answering Machine	59.3			[e]35	2.1	0.2
Battery Charger	44.4			[e]44	2.0	0.2
Cordless Telephone	62.3			[e]26	1.6	0.2
Fax machine	6.3			[e]216	1.4	0.1
Well Pump	14.3			[d]83	1.2	0.1
Copier	3.8			[e]25	0.1	0.0
Residual	101.5				159.4	15.4

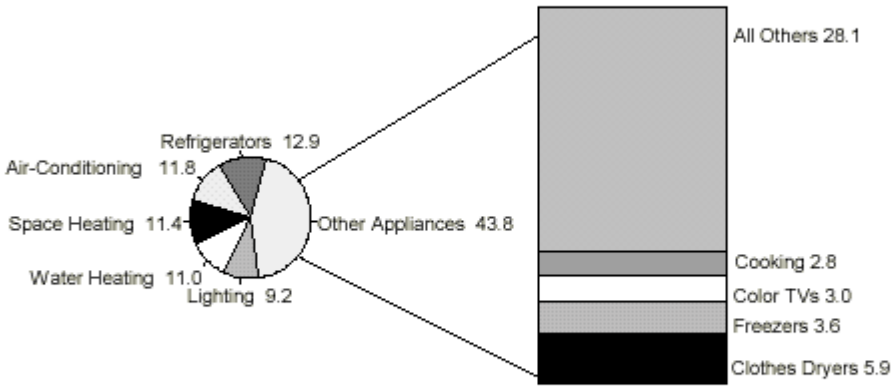
[a]1993 Residential Energy Consumption Survey.
[b]*Energy Use of Televisions and Videocassette Recorders in the U.S., Lawrence Berkeley National Laboratory, 1999.*
[c]See Appendix C, "End-Use Estimation Methodology" for a definition of the households using electricity for cooking.
[d]Electricity Consumption by Small End Uses in Residential Buildings, Arthur D. Little, Inc, 1998.
[e]*Energy Data Sourcebook for the U.S. Residential Sector*, Lawrence Berkeley National Laboratory, 1997.
[f]Does not include energy used to heat water coming into the washer.

Notes: ! "Residual" includes appliances not listed, such as dehumidifiers, evaporative coolers, crankcase heaters, automatic drip coffee makers, irons, air cleaners, and a myriad of other small electrical appliances. "Residual" also includes errors that may be present in estimates of annual consumption. ! Totals may not equal sum of components due to independent rounding. ! This table does not reflect the interactive effects of appliance usage, especially when mixing the estimates from RECS with those from outside sources. For example, for a home with an electric oven, range, and a microwave, the use of the microwave may not add 132 kWh to the cooking consumption. For more discussion of this problem, see Appendix C, "End-Use Estimation Methodology."

Sources: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-457A-C, E, and H of the 1997 Residential Energy Consumption Survey (RECS), RECS Public-Use Data Files; American Electric Power Service Corporation, and Southern California Edison.

A graphical breakdown of average electricity consumption by appliance type is below, showing relative usages for refrigerators, air conditioning, lighting, water heating and other purposes. Of course the amounts of electricity used for space heating and water heating in effect are averages that do not reflect the use of gas or oil systems.

Figure 3.1. Percent of Total Electricity Consumption in U.S. Housing Units, 1997



Source: Energy Information Administration, Forms EIA-457A, B, C, E, and H of the 1997 Residential Energy Consumption Survey.

Finally, a table from the 1993 RECS disaggregating residential natural gas consumption by end use (space heating, water heating, etc.) is below.

Table 3.2. U.S. Residential End-Use Consumption of Natural Gas, 1993

Appliance/End Use	Million Households	Annual Therms* Consumed per Household for End Use Indicated	Natural Gas Consumption for 1993	
			Trillion Btu	Percent
Total Households Using Natural Gas	58.7	899	5,274	100
Main Space-Heating	51.4	709	3,644	69
Secondary Space-Heating	1.2	215	26	(")
Water Heating	51.4	255	1,312	25
Air-Conditioning	0.1	238	2	(")
Appliances	37.8	77	290	5

*A therm is 100,000 Btu.
"Less than 0.5 percent.
Note: Appliances include ranges, ovens, clothes dryers, outdoor gas lights and gas grills, hot tubs, and swimming pool heaters.
Sources: Energy Information Administration, Office of Energy Markets and End Use, Forms EIA-457 A-C and F of the 1993 Residential Energy Consumption Survey (RECS) and RECS Public Use Data Files.

This type of information can be very useful in developing rough estimates of the potential contribution of any given technology to achieving the PATH energy saving goal in existing homes.

4. Examples of Technologies and Sample Write-Up

The technologies of greatest interest under the PATH Existing Homes energy goal should save energy in existing homes, whether or not they would be economical to use (or even appropriate) for new homes. They will need to offer attractive paybacks or return on investment in order to be successful in the market. New technologies could be installed as existing products or systems are replaced, they could be used for special purposes or problems, or they could be variations of existing products that address specific constraints in existing homes (e.g., limited space or need to use without disrupting existing wall or ceiling finishes). Multiple ideas should be considered, since combinations of energy-saving technologies will almost certainly be the most efficient way to reach 30 percent savings any given home.

A few (historical) examples that fit these criteria are listed here to help illustrate the concept. If they had not already been invented and brought to market they might be promising outputs of a PATH brainstorming session.

SOME HISTORICAL ENERGY RETROFIT TECHNOLOGIES

- flame retention head oil burner for retrofit into existing oil furnaces
- interior shrink wrap or exterior insulating films for windows
- water heater blankets
- compact fluorescent lights
- foam gaskets to cut air infiltration at light switches and electrical outlets
- programmable thermostats

The next page has a one-page form that can be used to summarize basic information about specific retrofit technologies that can assist in the evaluation process. In addition to a description of the particular technology, other factors that ultimately need to be considered are the conditions where use would be appropriate or beneficial (i.e., what proportion of the housing stock), the potential energy savings when the product is used, and the anticipated time horizon and cost for development and commercialization. This is followed by a completed sample form for a hypothetical new technology, "Low-E in a Can."

PATH TECHNOLOGY OPTION

Description - *short description of the technology envisioned*

_____

_____

Benefits - *what is the expected impact on energy use in homes where this technology is used?*

_____

_____

Applicability - *what types of homes could use this technology (e.g. what type of construction, fuel, equipment or system type, geographic location)? Is there information about the proportion of the stock of existing homes this represents?*

_____

_____

_____

Current Status - *is the technology brand new? What existing technologies does it relate to or build on?*

_____

_____

Technological and Other Risks and Barriers - *how likely is it that the technology can be successfully developed? What impediments must be overcome as part of development? Once developed, how likely is it the technology can be successfully introduced to the market or used for the intended purposes?*

_____

_____

_____

Estimated Time to Develop and Deploy the Technology (select one)

<> Near-term (1-3 years)
<> Intermediate term (4-7 years)
<> Long-term (8-10 years)
<> Unknown

Estimated Cost to Develop the Technology (select one)

<> Low
<> Medium
<> High
<> Unknown

HYPOTHETICAL PATH TECHNOLOGY OPTION

"Low-E in a Can"

Description - *short description of the technology envisioned*

Aerosol non-opaque low-e spray coating for field application to existing single pane windows with storms. The coating is applied to the outside pane of a prime window and/or the inside of a storm window pane.

Benefits - *what is the expected impact on energy use in homes where this technology is used?*

Factory-applied transparent low-e coatings can reduce U-factor of a double-glazed window by 0.10 to 0.15 Btu/hr·ft^2·ºF. In a 4,000 HDD location this would reduce winter heat loss by approximately 12,500 btu per square foot of glass. After adjusting for equipment and distribution losses this represents about 22,500 input btus, so application to 250 square feet of windows could yield total savings of about $50 over a heating season with gas at $0.80 per therm. Additional savings (typically less) would be realized in cooling seasons.

Applicability - *what types of homes could use this technology (e.g. what type of construction, fuel, equipment or system type, geographic location)? Is there information about the proportion of the stock of existing homes this represents?*

Any homes with single-pane windows and fixed or removable storms, all geographic locations. This included perhaps 30-40 percent of existing homes according to the 1993 RECS (presumably less today), primarily older homes with original windows. Even homes with double pane windows could use it if storms are also installed.

Current Status - *is the technology brand new? What existing technologies does it relate to or build on?*

Factory-applied low-E coatings are standard on many new windows. Both "soft-coat" and "hard-coat" varieties exist, typically applied to the outside surface of the inner glass (heating climates) or the inside surface of the outer glass (cooling climates). Different emissivities and spectral performance properties are available.

Technological and Other Risks and Barriers - *how likely is it that the technology can be successfully developed? What impediments must be overcome as part of development? Once developed, how likely is it the technology can be successfully introduced to the market or used for the intended purposes?*

The likelihood of successful development is good. Low-E coatings are widely available in opaque and transparent forms. Issues include installer skill requirements to ensure proper application thickness and coverage, ensuring good visible light transmittance, and protecting the coating from scratching, discoloring, deteriorating over time, or washing away when windows are cleaned or at other times when storms are not in place.

Estimated Time to Develop and Deploy the Technology

Near-term (1-3 years)

Estimated Cost to Develop the Technology

Low