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User Instructions for the Policy Analysis Modeling System (PAMS)

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Policy Analysis Modeling System (PAMS)

PAMS uses country-specific and product-specific data to calculate estimates of impacts of a Minimum Efficiency Performance Standard (MEPS) program. The analysis tool is self-contained in a Microsoft Excel spreadsheet, and requires no links to external data, or special code additions to run. The analysis can be customized to a particular program without additional user input, through the use of the pull-down menus located on the **Summary** page. In addition, the spreadsheet contains many areas into which user-generated input data can be entered for increased accuracy of projection. The following is a step-by-step guide for using and customizing the tool.

Part I – Step-by-Step Instructions

Step 1 – Open Spreadsheet Tool

Open the spreadsheet file.

Step 2 – Country Selection

Navigate to the **Summary** worksheet. Use the *Country* pull-down menu to select the country. The country selection is used to reference appropriate data for the following:

· Per Capita Income (Gross National Income, corrected for Purchase Power Parity)
· Population and Projected Growth (from World Bank)
· Household Size and Projections (from the United Nations)
· Consumer Discount Rates (according to Human Development Index)
· Urbanization – Percent of Urban Population (according to the World Bank)
· Electrification Rate
· Energy Sector Data (Site to Source Conversion Factor and CO_2 Emissions Coefficient)
· Climate Variable (used to Predict Air Conditioner Ownership)

Step 3 – Appliance, Design Option and Economic Growth Selection

There are four other pull down menus located on the **Summary** page to customize the model.

Appliance – The PAMS models minimum efficiency performance standards for Refrigerators, Air Conditioners or Washing Machines. The appliance type to be modeled is chosen according to the *Appliance* pull-down menu. The spreadsheet includes multiple proxy engineering datasets for some appliances. For example, in order to model refrigerator costs as a function of efficiency, the user must choose between engineering data from India, China, Brazil, or one of several classes of European refrigerator-freezers. The user should choose the dataset with the *Appliance Country* pull-down menu that is most similar to products common in the country being modeled.

Design Option – Each set of engineering data gives several technology options for improving efficiency. The cost-effectiveness of these options will vary from country to country according to local energy costs, and retail prices of baseline appliances. The user may use the *Design Option* pull-down menu to choose a target efficiency level, according to consumption reduction goals, cost-effectiveness to consumers, etc.

Economic Scenarios – Using the *Economic Growth* pull-down menu, the user can choose between the low, intermediate or high economic growth forecasts, each of which corresponds to a regional growth projection given by one of the scenarios in the International Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES). Alternatively, the user may choose the current growth rate based on the GNI per capita between 1990 and 2003. The growth rate of electrification is calculated according to the economic growth scenario chosen.

Step 4 (Optional) –User Inputs

In this step, any data obtained by the user specific to the country being analyzed, or the products being considered is entered. The spreadsheet allows data input for several parameters. All areas for user input are located on the **User Inputs** sheet. These cells are highlighted in green. The user has the option of only entering data in some of these areas. Areas for which no data are available should be left blank. The model will ignore these.

Shipments Data

By default, the spreadsheet models product shipments (unit sales) according to an econometric model that takes into account growth in ownership, and replacements. Often, however, actual sales data and projections are available. Sales data or other estimates are entered in the *Shipments Data* table in the *Base Case* column. In adding user data to the *Base Case* column it is important that data be entered in *all* cells, that is, through 2030. This requires the user to estimate future sales to that date. Once the base case forecast is input, the model calculates shipments under the Policy Case, according to the expected reduction in sales arising from higher retail prices.

Appliance Data

Local Baseline Price – The retail price of the most common appliances sold (usually among the least expensive models of the most popular product class and size). This parameter is used to scale design costs to reflect the local market. This parameter may be entered in the *Local Baseline Price* cell.

Local Baseline UEC - The per unit energy consumption of the most common appliances sold. This parameter is used to scale design efficiency to reflect the local market. This parameter may be entered in the *Local Baseline UEC* cell.

Appliance Lifetime – The average number of years consumers keep the product before replacing it, whether due to failure or other reason. This parameter may be entered in the *Appliance Lifetime* cell.

Baseline Efficiency Improvement Rate – In general, even in the absence of standards, the efficiency of appliances improves somewhat, due to the availability

and cost-effectiveness of new technologies. The annual rate of improvement can be entered, if known in the *Base Case Eff. Improvement Rate* cell.

Baseline Price Decrease Rate – Historical trends of appliance prices indicate that real prices of major appliances are falling over time, that is, prices are increasing at less than the rate of inflation. This is due to improved manufacturing processes, or economies of scale in growing or consolidating markets. The annual rate of improvement can be input, if known in the *Base Case Price Decrease Rate* cell.

Engineering Data

By default, the model relies on proxy engineering data gathered in particular products in specific countries. The key parameters utilized by the model are the relationship between cost increases and efficiency improvements for specific technology options. If these data are available for local products, they may be input in the *Engineering Data* table. The model is formulated to reference these data in terms of factors relative to the baseline, that is, the most common model sold. These factors are then scaled according to the proxy baseline price and baseline UEC, or the local baseline price and UEC if available. The baseline relative price and efficiency factors are each defined as 1.00. For each subsequent design option, efficiency and price factors parameterize the cumulative impacts of adding successive technologies. For example, if the first technology option increases efficiency by 10% while raising the cost 5%, the user would input 1.1 and 1.05 into the row labeled *Design #1*. If a second option would further increase efficiency by 10% and add an additional 10% to the cost, the user would input 1.2 and 1.15 into the row labeled *Design #2,* etc.

Economic Data

Discount Rates – Two different discount rates are used for assessing the value of future costs and benefits. These are the *consumer* discount rate, and the *national* discount rate. The consumer discount rate describes consumer preference for short- versus long-term costs and benefits. This is generally related to prevailing interest rates. The consumer discount rate is used in the Life Cycle Cost calculation. By default, consumer discount rates are parameterized according to the World Bank's Human Development Index. On the other hand, the *national* discount rate is used in evaluating national investments and may be taken from rates used in evaluating other programs, such as infrastructure improvement, etc. The default national discount rate is 10%. Both discount rates may be modified via the *Discount Rate* cells on the **User Input** sheet.

Income Growth Rate – By default, the user can choose between different scenarios of economic growths throughout the summary sheet. Often, however, more accurate forecasts of growth are available from local finance ministries, or other sources. This data can be input in the *Income Growth Rate* cell.

Energy Sector Data

Electricity Price - This is the price paid by consumers for electricity in dollars per kilowatt-hour. The correct price to use is the Marginal Price, that is, the price paid for the last kilowatt-hour used, according to prevailing tariff structures. If

this data is not available, however, average electricity rates may be substituted. Electricity price should be estimated in U.S. dollars per kilowatt-hour, and entered in the *Electricity Price* cell.

Generation Factor – This is the factor to be applied to power plant generated energy in order to arrive at plant input energy (heat rate) This parameter is dependent on the percentage of thermal and nuclear vs. renewable (including hydroelectric) generation. For example, if the thermal heat rate of thermal power plants in the country is known to be 3.0, and half of the generation is renewable, a generation factor of *50% x 3.0 + 50% x 0 = 1.5* should be entered in the *Generation Factor* cell.

T&D Loss Factor – This is the fraction of electricity lost in transmission and distribution. For example, if losses are known to amount to 10% of generated electricity, the value 0.1 should be entered in the *T&D Loss Factor* cell.

CO_2 emissions Factor – This is the conversion factor between electricity generated by power plants (in kWh), and the amount of carbon dioxide released (in kg). This value should be entered in the cell labeled *CO_2 Emissions per KWh*.

Step 5 – Other Adjustable Model Parameters

Finally, there are three adjustable parameters to be input by the user on the summary sheet.

Standard Year – This is the date of policy implementation. All products shipped after this date will be effected by the standard.

Policy End Year – This the date the policy ends, impacts are calculated trough this year.

Analysis Year – This is the date to which future impacts are discounted.

Part II – Step-by-Step Instructions

Example – Guatemalan Refrigerator Standards

Guatemala is chosen as an example. A refrigerator standard is modeled, since this appliance is far more prevalent than washing machines or air conditioners. Brazilian engineering data is chosen as a proxy for Guatemala, as Guatemalan models are expected to be more similar than products produced in Brazil, than in India, China, or the European Union.

Default economic parameters are shown in Table 1

Table 1 – Economic Parameters for Guatemala

Economic Parameters	
Consumer Discount Rate	11.1%
National Discount Rate	10%
Income Growth	3.0%

The discount rate for Guatemalan consumers is interpolated between known country discount rates according to the UN Development Programme's Human Development Index. The national discount rate is assumed to be 10%. Income growth is set to 3.0%, which corresponds to a moderate growth scenario for Latin America in the IPCCs scenario definitions[1].

Table 2 – Energy Sector Parameters for Guatemala

Energy Sector Parameters	
Electricity Cost	$0.070
Heat Rate	1.7
T&D Loss Factor	15.5%
CO_2 per kWh (kg)	0.484
Electrification	66.7%

Energy Sector Parameters are shown in Table 2. The marginal price of residential electricity is assumed to be 7 US cents per kWh. The heat rate, defined as the ratio of input to output energy for electricity production is found to be 1.7, indicating a significant fraction of hydroelectric or other renewable generation. The amount of renewable electricity production also has a direct influence on the carbon emission factor of 0.484 kg of CO_2 per kWh produced. Transmission and distribution losses are 15.5% of production. Currently, 66.7% of Guatemalan households use commercial electricity.

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[1] The IPCC's Special Report on Emissions Scenarios only defines a High and Low growth case. PAMS defines a Moderate growth case as the average of these.

Per Unit Results

There are 5 possible efficiency design options for the Brazilian type single door (manual defrost) refrigerators. For this example, we have chosen Design Option 2, because this option maximizes savings to the consumer over the lifetime of the appliance[2].

Table 3 – Per Unit Model Resorts for Brazilian-type refrigerators in Guatemala

Unit Level Results		
	Base Case	Standard Case
Purchase Price	$212	$235
UEC in kWh/year	493	396
Electric Bill	$34.51	$27.72
Life Cycle Cost	$459	$434
Efficiency Improvement	25%	
Payback Time (years)	3.43	
Lifetime (Years)	15	
LCC Savings	$25	

Table shows the per-unit results of the standard. The baseline model refrigerator is estimated to cost $212 and use 493 kWh per year. The standard would raise the efficiency of the baseline model by 25%. According to the Brazilian data, the most cost-effective way to achieve this improvement is to increase the efficiency of the compressor moderately, and add insulation to the door panel[3].

Implementation of these high-efficiency options increases the price of the refrigerator by 11%, or $23. On the other hand, annual consumption goes down to 396 kWh per year, a decrease of nearly 100 kWh per year. Correspondingly, the customer's annual electric bill contribution from the refrigerator decreases by about $7. Simple payback in this case is about three and a half years. Over the 15 year appliance lifetime, each household that purchases a refrigerator after standards are implemented would save about 1450 kWh.

Life Cycle Cost savings takes into account that operating cost savings in the second year are valued 10% less than those in the first year, etc. For this example, LCC savings is $25 over the life of the refrigerator.

National Level Results

Energy, financial and environmental impacts are calculated on the national level in a similar way to unit level results. In the standards scenario, every appliance that is purchased after the standards implementation date (2010 by default) saves energy relative to the base case. National impacts therefore depend on the expected number of sales over the forecast period. Figure 1 shows the shipments forecast for refrigerators in Guatemala.

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[2] Maximum lifetime savings is a common criterion for optimizing minimum efficiency standards. Another common strategy is to choose the option which affords maximum energy savings while still providing positive (though not necessarily maximized) savings.
[3] Details of design options for each engineering dataset are given in a separate Methodology document.

Figure 1 – Guatemala Refrigerator Shipments
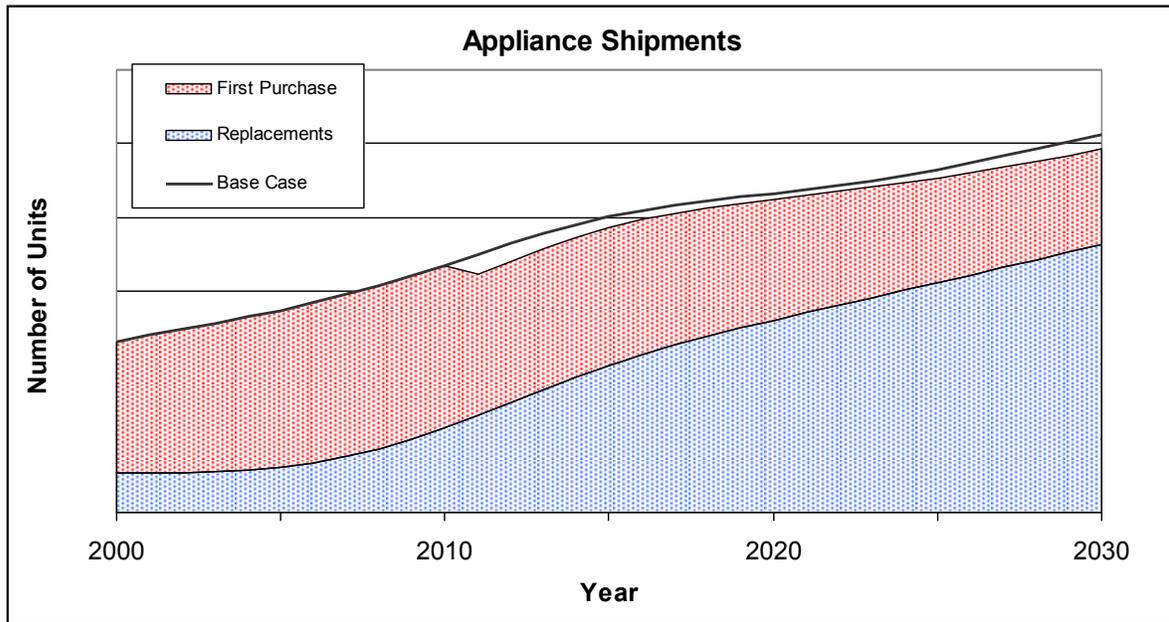
The model forecasts product sales arising from first purchases and from replacements. In the Guatemalan example, first purchases dominate in the early years of the forecast because overall ownership remains quite low, but households are rapidly entering the market as incomes rise[4]. In later years, fewer first purchase sales are made as the market approaches full ownership. On the other hand, replacement sales continue to rise as the stock grows and ages. Total sales are on the rise, but flattening as time goes by, approaching the scenario common in industrialized countries.

For each year in the forecast, the appliance stock is calculated from previous sales and the appliance survival probability. Total electricity savings is given by the stock times the annual savings of each unit, equal to about 100 kWh in the above example. National operating cost savings are then calculated by multiplying the total electricity savings by the electricity price per kWh. Likewise, national equipment costs are the incremental per unit cost ($23) multiplied by unit sales.

Future savings and costs are discounted by the National Discount Rate, which is 10% by default. A summary of costs and savings is given in Table 4, taken from the **Summary** page of the spreadsheet. All monetary values are given in millions of $US. In this example, total discounted electricity cost savings through 2030 are 22.7 million $US, while discounted incremental equipment costs for the same period are 9.8 million $US implying a net present benefit of 12.9 million $US from the program. A positive net savings is to be expected, since the cost benefit was shown to be favorable in the per unit case.

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[4] Details on the ownership model and contribution to sales can be found in the methodology document.

Table 4 – National Level Results for Guatemalan Refrigerator Standards

National Level Results		
Discounted at 10% to year 2005 (millions $US)		
Total Electricity Cost Savings through 2030		**22.7**
Total Incremental Equipment Cost through 2030		**9.8**
Net Present Benefit		**12.9**
Benefit/Cost Ratio		**2.32**
Site Energy Savings in	**2010 (GWh)**	**0**
	2020 (GWh)	**72**
	2030 (GWh)	**128**
Site Energy Savings through	**2010 (GWh)**	**0**
	2020 (GWh)	**380**
	2030 (GWh)	**1454**
Source Energy Savings through	**2010 (Mtoe)**	**0.000**
	2020 (Mtoe)	**0.065**
	2030 (Mtoe)	**0.247**
CO2 Emissions Mitigation through	**2010 (MT)**	**0.00**
	2020 (MT)	**0.22**
	2030 (MT)	**0.83**

In addition to net financial savings, results are summarized for site energy, source energy and carbon dioxide emissions mitigation. Annual site energy savings is given in three different years. This savings number can be compared to forecast annual residential sector electricity consumption, for example. Cumulative savings values are also given. For example, a total of 380 GWh will be saved by the Guatemalan refrigerator program through 2020. Cumulative energy savings and carbon dioxide mitigation are zero in 2010, as this is the year chosen as the start of the program (this can be modified). Impacts in 2030 are several times larger than those in 2020, due to the accumulation of stock in the intervening time.