clasp

Efficient Appliances for People & the Planet

Mepsy Methodology FAQ

What's the sales project methodology of the current MEPSY projection to 2030? Are all the products follow the same projection methodology? When there is no available data for the future, such as from 2022 to 2030. What's the projection methodology in such conditions?

Firstly, CLASP collected market research company's annual sales data from the year 2005 to the year 2024 for different appliances. Data for countries are based on market research (e.g., reviews of official statistics, secondary reports, interviews with manufacturers and associations), and for countries data are not available, Mepsy "modeled" or extrapolated based on the findings in a similar nearby country. Based on the market sales data, CLASP calculated the compound annual growth rate (CARG), and then applied it to linear extrapolation to forecast past 2024 to 2030.

How does CLASP calculate long-term projections?

Appliance stock and national end-use consumption are driven by population growth and trends in appliance ownership rates. Especially for developing countries, ownership rates of home electric appliances depend critically on household income level, degree of urbanization, and the ratio of access to electricity. Therefore, Mepsy bases stock projections through 2050 on multivariate regression modeling, relating the latest year of ownership response to macroeconomic parameters (including Household Monthly Income, Electrification rate, Urbanization rate, Household Rooms Number, and Cooling Capacity). Then CLASP utilizes population forecasts combined with an income model and econometric parameterization to estimate the national ownership rate for each year in the forecast model. The last step of estimating the national appliance stock from 2020 to 2050 is using the forecasted ownership rate to multiply by the Number of national households to calculate total stock. [This is still in progress]

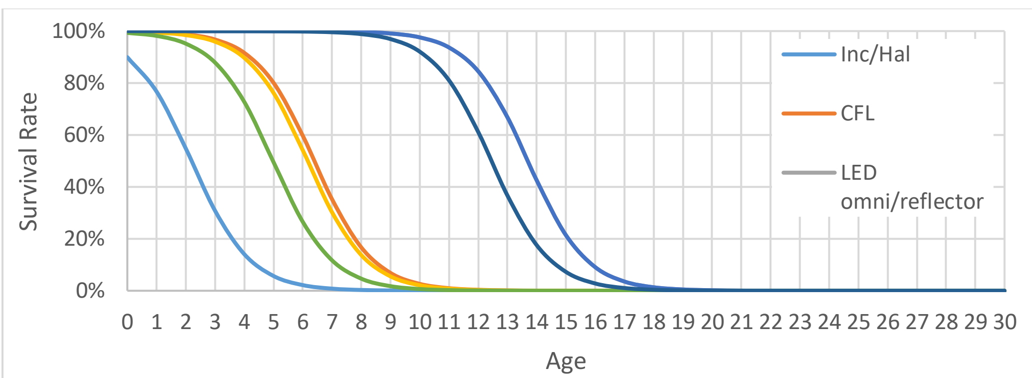
What is MEPSY's methodology of accumulated sales over a lifetime. Do all the products use the same lifetime retirement model?

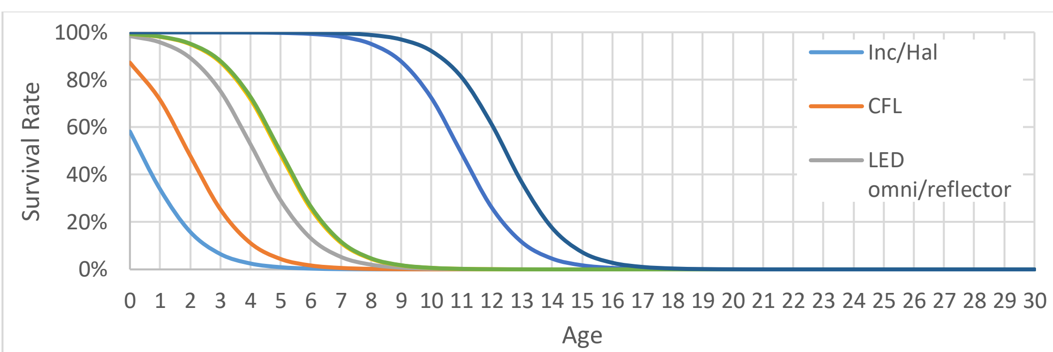
For the lighting, S-curve survival function rates applied in stock accounting for domestic and professional lighting defined based on operating hours and rated lifetime

TABLE 1: MEPSY LIFETIME ASSUMPTION FOR LIGHTING

TECHNOLOGY	LIFETIME (YEARS)	
	Domestic	*Profess.*
Incandescent/Halogen	2.2	0.3
Compact Fluorescent Lamp	6.4	1.9
LED General Service Lamp	13.7	4.1
Linear Fluorescent Lamp	6.2	4.9
LED Tubular Lamp	13.7	11.0
High Intensity Discharge Lamp	5.0	5.0
LED Outdoor Lamp	12.5	12.5

Two figures below show S-curve survival function rates applied in stock accounting for domestic and professional lighting, defined based on operating hours and rated lifetime





For ACs and refrigerators, lifetime survival function is based on Weibull distribution.

The replacement of an appliance in terms of an annual retirement probability that varies as a function of the appliance age, given by:

$$P(x) = e^{-\left(\frac{x-\theta}{\alpha}\right)^{\beta}}$$

Where
P(x) is the probability that the appliance is still in use at age *x*;
x is the appliance age; *α* is the scale parameter, which corresponds to the decay length in an exponential distribution;
β is the shape parameter, which determines the way in which the failure rate changes through time;
and *θ* is the delay parameter, which provides for a delay before any failures occur.

- Air Conditioning
  - Ranging between 9 to 13 years, calculated for each country based on the estimated residential and commercial share; reference, US Weibull distribution for residential ACs at 8.36 years median lifetime, and 18.04 years for commercial ACs. (LBNL, US)
- Refrigerator-Freezers
  - All countries, 17.68 years (LBNL, US)

- For Fans and TVs, lifetime assumptions are assigned for countries
  - Ceiling and Portable Fans: 11 years for ceiling and 10 years for portable for most countries, with some differences in certain regions

REGION	CEILING FANS	PORTABLE FANS
South Asia	10 (BEE, India)	
Southeast Asia	7 (CLASP, Indonesia)	5 (CLASP, Indonesia)
North America	13.8 (DOE, US)	

  - Televisions: 5 - 14 years based on national studies in the US, India, South Africa and the EU

REGION	TV LIFETIME
China	5 (Energy Foundation, China)
India	7 (Park, et al.)
European Union	10 (Top 10, EU)

- For other appliances
  - Electric Motors
    - All countries, 7.72 years (OECD)
  - Space Heating
    - All countries, 25.4 years (Pezutto et al.)

When the function "BAU efficiency improvement rate" is developed. How is the BAU efficiency improvement rate going to affect the results?

For appliances, CLASP assumes a **2% annual improvement rate**, on average, across all appliances. This is consistent with historical rates of efficiency gains for refrigerators, clothes washers, and dishwashers—all of which have improved at annual rates ranging from 2.3 to nearly 6 percent (televisions have seen even higher efficiency gains).

The 2 % annual improvement rate reduces new appliance energy use by 50% by 2050, which is consistent with the results from the ACEEE study.[1] [2]

Mepsy's energy consumption calculation methods and formulas for each product:

The National Perspective: projects the total national costs and benefits including both financial benefits, energy savings and carbon emission reductions. The national perspective calculations are called **National Energy Savings (NES)** and the **Net Present Value (NPV)** calculations. The National Energy Savings (NES) is the total primary (input) fossil fuel energy saved in the MEPS or BAT scenarios verses the base case, which accounts for the stock and shipments of different appliances.

$$NES = NEC_{Base} - NEC_{MEPS\ or\ BAT}$$

NEC(y) is the total energy consumption of the national stock of products in year y, the calculation of *NEC(y)* is given by:

$$NEC(y) = \sum_{age} Stock(y, age) \times UEC(y, age)$$

Where the Unit Energy Consumption (*UEC*, kWh/year) of each cohort is determined based on the year of purchase *(y, age) UEC* would differ among the Baseline, MEPS and BAT scenarios for years after the implementation date of policies. The relationship between the base case UEC and MEPS/BAT UEC is:

$$UEC_{MEPS\ OR\ BAT} = UEC_{Base} \times Eff_{Base} / Eff_{MEPS\ or\ BAT}$$

Apart from calculating National Energy Savings, the New Modeling System also estimates the Primary Energy Consumption (total fossil fuel energy inputs),

[1] Anthony Fryer, "Why Recent Progress in Television Efficiency Should Make You Feel Better About Binge Watching Your Favorite Shows," Appliance Standards Awareness Project, 2017, https://appliance-standards.org/blog/why-recent-progress-television-efficiency-should-make-you-feel-betterabout-binge-watching.

2 NRDC calculations based on Joanna Mauer et al., Better Appliances: An Analysis of Performance, Features, and Price as Efficiency Has Improved, ACEEE, May 2013, https://appliance-standards.org/sites/default/files/Better_Appliances_Report.pdf.

which is the key indicator of national utility and environmental impacts. Primary Energy Savings (PES) is calculated from the national energy savings by factoring in the electricity generation fuel mix and transmission and distribution losses. The formula for PES is:

$$PES = \frac{NES}{1 - TD} \times HR$$

Where *TD* is the percentage of energy lost in transmission and distribution, and *HR* is the heat rate.
Finally, Carbon Dioxide Emission Reductions (CER) are calculated from energy savings by applying carbon factors (CF in Mt CO_2 /TWh = $kgCO_2$/kWh) to the national energy savings according to:

$$CER = \frac{NES}{1 - TD} \times CF$$

UEC formulas for different appliances are listed below:

- Fans:

$UEC_{Baseline}$ was calculated for a key country in each region based on either the service value and flow rate of the typical-sized fan on the market or by dividing a reported UEC by the average usage hours.

- $UEC_{Baseline\ OR\ MEPS\ or\ BAT} = \frac{Service\ Value\ (m3/min/W)}{Flow\ Rate\ (m3/min)} / 60 \times$ *Annual hours of use*

Or

= *Reported UEC ÷ Average usage hours*

For example, for China, CLASP did not have any data apart from MEPS requirements that had not been recently updated, so CLASP estimated the business-as-usual service value. The fan size and flow rate were assumed equal to those in nearby regions (typically 48 or 52 in/1200 or 1300 mm for ceiling fans and 16 in/400 mm blade sweep for portable fans).

TABLE 2: CHINA'S SERVICE VALUE (M3/MIN/W) AND FLOW RATE (M3/MIN) OF THE CEILING AND NON-CEILING FANS UNDER BAU, MEPS, AND BAT SCENARIOS

		Ceiling Fan (48-52 in)	Non-ceiling fan (16 in)
Flow Rate (*m^3/min*)		150	56.21
Service Value (m3/min/W)	BAU	3.0	1.0
	MEPS	4	1.08
	BAT	6	1.7

- TVs
  - $UEC_{Baseline}$
    To better estimate the efficiency of products currently in the market, CLASP uses shipment-weighted $UEC_{Baseline}$. Market databases were used to develop energy consumption trends and were applied to the other countries in each region. In cases where there were multiple key countries in one region, CLASP calculated a shipment-weighted average on the assumption that the shipments to the country with the highest shipments would tend to be most representative of the other countries in each region.

  - $UEC_{MEPS\ or\ BAT}$
    CLASP applied the recent EU Ecodesign MEPS requirements for on-mode of electronic displays, which is given in the equation and table below. CLASP also assumed that the standby power was 0.5 W in all countries.
    $$On\ Mode\ Power\ = EEI \times (3\ \times\ [90 \times\ tanh(0.02\ +\ 0.004\ \times\ (Area\ -\ 11)) +\ 4] +\ 3) - 1$$
    Where $Area$ is the screen area measured in square decimeters (dm^2)

TABLE 3: TV ENERGY EFFICIENCY INDEX IN MEPS AND BAT SCENARIOS

Scenarios	High Definition (HD) EEI (Energy Efficiency Index)	Ultra-High Definition (UHD) EEI	Standby Power Limit (Watts)
MEPS	0.9	1.1	0.5
BAT	0.65	0.8	0.5

Calculated the shipment-weighted average area and proportion of High Definition (HD) and Ultra High Definition UHD for each area and weighted it by the expected number of hours in On Mode to calculate the final MEPS and BAT UECs

- Domestic Refrigerators

$UEC_{Baseline}$, UEC_{MEPS} , and UEC_{BAT} for are harmonized with United for Efficiency's estimates[3], reproduced below. For example, for China, BAU is 228 kWh/yr, MEPS is 177 kWh/yr, and BAU is 127 kWh/yr.

[3] UN Environment, "United for Efficiency Country Savings Assessments Methodology and Assumptions", 2019, p. 3.

Region	Volume			UEC (kWh/y)		
	Volume of refrigerator compartment	Volume of freezer compartment	Adjusted volume	Business As Usual	Minimum Ambition UEC (kWh/y)	High Ambition UEC (kWh/y)
ASEAN	165	85	357	342	259	129
China	157	78	333	228	177	127
LAC	188	82	373	471	263	131
MENA	245	85	437	485	278	139
Oceania	210	90	413	398	273	136
Other Regions Income* <$10,000	188	82	373	607	263	131
Other Regions Income* >$10,000	188	82	373	437	263	131
South Asia	165	85	357	342	259	129
Sub-Saharan Africa	134	76	305	340	247	123
Turkey	200	100	426	347	276	138
Ukraine	188	82	373	363	263	131

** Annual income based on 2019 GDP per capita*

*** Countries with existing MEPS in place assume that new sales meet those MEPS. Where those MEPS are in line with or exceed the MEPS in the Minimum Ambition Scenario, the Minimum Ambition Scenario is assumed to be halfway between the local MEPS and High Ambition Scenario.*

- Air Conditioning

Similarly, $UEC_{Baseline}$, UEC_{MEPS} , and UEC_{BAT} are harmonized with United for Efficiency's estimates, where available. U4E's Methodology and Assumptions document provides a table of BAU, MEPS, and BAT UECs for different climate zones, capacities (3.5 kW and 7 kW) and type (fixed-speed versus variable-speed).[4] U4E combined these climatic assumptions with a table of primary cities by climate zone[5] as well as information about the mix of ACs on the market to develop the UECs for each country. For example, China's are listed below,[6] and these were also used in Mepsy:

TABLE 4: CHINA'S AC ENERGY EFFICIENCY INDEX IN THREE SCENARIOS

Unit Energy Consumption (kWh/year) or Efficiency Level for RACs			
Business As Usual	Minimum Ambition Scenario	High Ambition Scenario	Type of Product
703	615	528	A mix of 3.5 kW and 7 kW split units with a weighted-average cooling capacity of 3.9 kW

Note: The minimum ambition scenario MEPS are set at a higher level than the model regulations for the product because China has existing MEPS at that level.

For countries not analyzed by U4E (subset of OECD countries), CLASP used information about the predominant climate zone in each country as well as the product mix to calculate the UEC from the U4E climate zone assumptions

[4] UN Environment, "United for Efficiency Country Savings Assessments Methodology and Assumptions", p. 4.
[5] UN Environment, "Model Regulation Guidelines: Energy-efficient and Climate-friendly Air Conditioners", September 2019, pp. 21—22. For countries that span multiple climate zones, both CLASP and United for Efficiency used the class with the asterisk (*) which represents the primary city.
[6] UN Environment, "United for Efficiency Country Assessment: China: Cooling", October 2020, p. 3.

- Motors

For motors, CLASP used the following assumptions for the major industrial motor loads[7]. Average fan power obtained directly from Omdia (source of shipments data).

TABLE 5: MEPSY MOTOR MAJOR ASSUMPTIONS

Average Compressor Nameplate Power (kW)	Average Centrifugal Pump Nameplate Power (kW)	Average Industrial Fan Nameplate Power (kW)	Average Compressor Load Factor	Average Centrifugal Pump Load Factor	Average Industrial Fan Load Factor	Average Compress or Usage (hr/yr)	Average Centrifugal Pump Usage (hr/yr)	Average Industrial Fan Usage (hr/yr)	Average Compressor Lifetime (hr)	Average Centrifugal Pump Lifetime (hr)	Average Industrial Fan Lifetime (hr)
11.4	11.4	7.1	62%	62%	62%	3280	3280	3280	25323	25323	25323

The energy consumption of the different loads was divided by motor efficiency to obtain energy consumption of the entire system. Country MEPS levels were calculated assuming an 8-pole motor. Information on MEPS was consistent with U4E. For countries without MEPS, the baseline was assumed at 1 percentage point below IE1 efficiency leve

- Space Heating

CLASP assigned average capacity, equivalent full load hours, and operating efficiency for each space heating equipment to calculate UECs.

- $UEC_{Baseline} = \frac{Capacity \times Equivalent\ full\ load\ hour}{Operating\ efficiency}$

  Where capacity is in the unit of kW, equivalent full load hour in the unit of the hour, and operating efficiency as a dimensionless factor.

- UEC_{MEPS} estimating impacts under policy intervention, replacing the lowest efficiency equipment to the next more efficient
  - All stock of non-condensing boilers and furnaces (NCB) to be converted to condensing boiler and furnaces (CB)
- UEC_{BAT} estimating impacts under halfway achievement of the assumptions stated as significant but reasonable in realizing national space heating electrification.[8]
  - 25% of electric resistance units (ER) to be converted into ASHP
  - 50% of existing ASHP to have 15% higher operating efficiency
  - 40% of boilers and furnaces (CB and NCB) to be converted into ASHP

TABLE 6: TOP 10 COUNTRIES WITH THE HIGHEST SPACE HEATING ENERGY CONSUMPTION

COUNTRY	$UEC_{Baseline}$	UEC_{MEPS}	UEC_{BAT}
United States	20,083	18,391	12,897
China	8,598	8,062	5,787
Russian Federation	43,565	39,777	27,009
Canada	36,293	33,263	23,457
Germany	28,306	26,086	17,560
United Kingdom	30,655	27,644	19,208
France	22,254	20,598	14,404
Japan	14,487	13,248	9,064
Italy	25,757	23,469	15,589
Spain	17,890	16,411	11,497

[8] Shipley, J., Lazar, J., Farnsworth, D., and Kadoch, C. (2018, November). Beneficial electrification of space heating. Montpelier, VT: Regulatory Assistance Project. Page 34. https://www.raponline.org/wp-content/uploads/2018/11/rap-shipley-lazar-arnsworth-kadoch-beneficial-electrification-space-heating-2018-november.pdf

- Lighting

CLASP developed average efficacy, wattage, operating hours, and lifetime assumptions for single global values. To integrate trends in technological development for lighting technology groups considered for this model, annual index values were assigned for efficacy and wattage from 2005 to 2050 for each technology group referencing the year of 2020 as the base year. In this way, the efficacy and wattage could be adjusted up or down to mirror observed or expected trends in the market.

Individual calculations were conducted for the technologies used in domestic and professional lighting sectors to obtain annual lighting energy use for 162 countries. Data processing was done in the R-software, based on LBNL's PAMS stock accounting methodology. To allocate stock distribution based on age, S-shape survival functions were assigned for each technology type.

- $UEC_{Baseline}$ for each technology is calculated based on the adjusted wattage for the respective year and the assigned operating hour for the sector. These values were then assigned to each corresponding shipment data, along with the assigned lifetime for each technology, to obtain country-level annual energy consumption

- UEC_{MEPS} MEPS Scenario assumes the implementation of lighting policy that forces the market to LED technologies only, such as the EU's ban on halogen and CFL lamps. Under the MEPS Scenario, all non-LED lighting shipments are reallocated as LED, thereby creating an LED market. To account for the expected gradual reduction in shipments due to the significant shift in lifetime, dynamic annual adjustment factors are assigned for each sector for each non-LED technology, applied from the policy year onwards. All stock of non-condensing boilers and furnaces (NCB) to be converted to condensing boiler and furnaces (CB)

- UEC_{BAT} assumes the implementation of a lighting policy that creates an all-LED market. Under the BAT Scenario, all non-LED are reallocated as LED shipments. The efficacy and wattage of the four types of LED technology (omnidirectional, reflector, tube, and outdoor) are assumed to match the highest efficacy and lowest wattage in the 2020 market. Gradual shipment reduction for non-LED technology is also simulated based on annual adjustment factors, at a slightly higher rate than the values applied in the MEPS scenario, similarly from the policy year onwards.

What are Mepsy's sources for given variables?

DATA	MEPSY RESOURCES
Stock	• CLASP primary research in countries • Industry and market research reports or surveys/interviews (e.g., Euromonitor, Omdia, etc.) • Customs data (UN Comtrade, national customs authorities, etc.), for import-only markets to approximate market size
UEC	• CLAP primary research and proxy data • Industry and market research reports or surveys/interviews • (e.g., Euromonitor, Omdia, etc.)
Transmission and Distribution Losses	US Energy Information Administration (EIA), "International," Data for Electricity Consumption and Distribution losses, 2018 data or earlier.
Heat Rate	Various sources including ADB, World Efficiency Council, GE, Lazard, BP, World Bank, and EIA 2010-2019
Grid Emission Factor	• National statistics from CLASP primary research • International Financial Institutions Technical Working Group (IFI TWG) "Harmonized Grid Emission Factor Data," 2019.
Lifetime	• Detailed surveys and interviews with manufacturers and consumers • Academic and industry research
Macroeconomic (households/ population/GDP)	• The World Bank

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Mepsy Term List

TABLE 7: MEPSY TERM LIST

PARAMETER	HOVER TEXT TIP
Optional Parameters	Click each of the options below to check analysis inputs or provide your own. Data sources and assumptions are detailed in the methodology.
Shipment Data	Enter/review annual shipments for the region under analysis (in individual units, not thousands or millions).
Equipment Data	Enter/review data regarding the equipment under analysis, such as energy consumption, cost, and changes over time.
Average Equipment Lifetime	The number of years when 50% of equipment are expected to be removed from service under typical usage for the region.
Business-as-Usual Eff. Improvement Rate	Annual rate of decrease in the unit energy consumption (due to business-as-usual technology improvement, as a decimal).
Business-as-Usual Price Decrease Rate	Annual rate of decrease in the unit price (due to business-as-usual technology improvement, as a decimal).
Scenario	The price (in desired currency) and unit energy consumption (in kWh/year) in the region under analysis for three scenarios: 1. Business as usual (current prices and performance) 2. Recommended efficiency policy (CLASP's recommended standards) 3. Best available technology (target for next-generation standards)
Currency Name/Code	Specify the currency name or code in which price and cost data are provided.
Economic Data	Enter/review data regarding the used equipment market, which are not regulated.
Consumer Discount Rate	Median consumer discount rate, as a decimal, intended to assess consumer paybacks in the region under analysis

Used Equipment Market	Enter/review data regarding the used equipment market, which are not regulated (as a decimal).
Energy Sector Data	Enter/review data regarding the energy sector, such as consumer costs and generation mix.
Electricity Price (kWh):	Median electricity price per kWh in the same currency as specified in the equipment data tab.
Heat Rate:	Ratio of primary energy (power plant inputs) to generated electricity. Depends on the region's generation mix.
T&D Loss Factor:	The proportion of generated electricity lost due in transmission and distribution (T&D).
Electricity Emissions per kWh(kg):	The amount of emitted by power plants for each kWh of electricity generated. Excludes T&D losses.
Heating Fuel Price (per kWh):	Median price for the other dominant heating fuel in the region under analysis, per kWh and in the same currency as specified in the equipment data tab (only applies to analysis of space and water heating).
Heating Fuel Emissions Factor (kg/kWh):	The amount of CO_2 emitted for each kWh of space or water heating.