Technical Appendix

Lighting

1. Introduction

This appendix offers a detailed explanation of the specific assumptions used in the lighting module of Mepsy. For information on outputs and data sources for the parameters, please refer to the comprehensive Mepsy Methodology document.

The CLASP lighting model looks at general purpose lighting equipment across all sectors: residential, commercial, industrial, and outdoor. The model covers the full range of lighting technologies, including incandescent, halogen, compact fluorescent (CFL), linear fluorescent (LFL), light emitting diode (LED), and high intensity discharge (HID) lamps. The model does not incorporate lighting technologies typically excluded from mandatory regulations such as portable lighting, lighting on automobiles and aircrafts, or specialty lighting installations such as runways, tanning beds, or UV industrial process lighting.

The most common lighting technologies vary by sector and region, however, to create a global lighting model, CLASP simplified the market to a matrix of seven technologies across two sectors. The residential sector was considered as one sector, called "domestic" and the other sectors – commercial, industrial, and outdoor – were combined into another sector called "professional". This market simplification mirrors how global lighting companies such as Signify/Philips and Osram/LEDvance organize their product catalogues. There is a domestic sector catalogue for homeowners, which tends to have products that are less expensive and of a lower quality specification; and there is a professional sector catalogue, which includes products that have a higher specification, including a longer service life, and therefore are more expensive.

On the technology side, we simplified the categories of products by combining ones that had similar efficacy and lifetime and are used in similar applications. Table 1**Error! Reference source not found.** lists the seven technologies and two sectors tracked in the global lighting model and provides a brief description of these light sources.

TABLE 1: LIGHTING TECHNOLOGIES TRACKED IN THE MODEL AND A BRIEF DESCRIPTION OF THEIR SCOPE

Domestic	Professional	Description
D1. Incandescent/Halogen	P1. Incandescent/Halogen	Non-directional and directional tungsten-filament lamps

D2. Compact Fluorescent Lamp	P2. Compact Fluorescent Lamp	Non-directional and directional CFLs, integrally and non-integrally ballasted
D3. LED General Service Lamp	P3. LED General Service Lamp	LED lamps designed to replace (retrofit) incandescent, halogen & CFL
D4. Linear Fluorescent Lamp	P4. Linear Fluorescent Lamp	Linear and non-linear fluorescent lamps, all phosphors, T5, T8, T12 diameter
D5. LED Tubular Lamp	P5. LED Tubular Lamp	Tubular LED lamps designed to replace (retrofit) linear and non-linear fluorescent lamps
D6. High Intensity Discharge Lamp	P6. High Intensity Discharge. Lamp	HID lamps, including high pressure sodium, metal halide, mercury vapor
D7. LED Outdoor Lamp	P7. LED Outdoor Lamp	LED lamps and fixtures designed to replace HID installations

To model lighting energy consumption, we identified four key product attributes to estimate for each technology: **efficacy**, **wattage**, **operating hours**, and **lifetime**. The seven product categories listed in Table 1 were defined because they share similar characteristics, allowing for the development of representative average values. These values, shown in Table 2, are applied consistently across the 162 countries included in the model.

For LED retrofit products, both efficacy and wattage change over the analysis period as LED technology continues to improve. The wattage of LED retrofit products is determined based on providing an equivalent level of illumination to the conventional light source being replaced. This means the wattage of LED retrofits varies over time.

For example, an LED retrofit lamp replacing a 70-watt incandescent lamp (840 lumens) when LEDs are operating at 100 lumens/watts would consume 8.4 Watts to provide the same level of illumination.

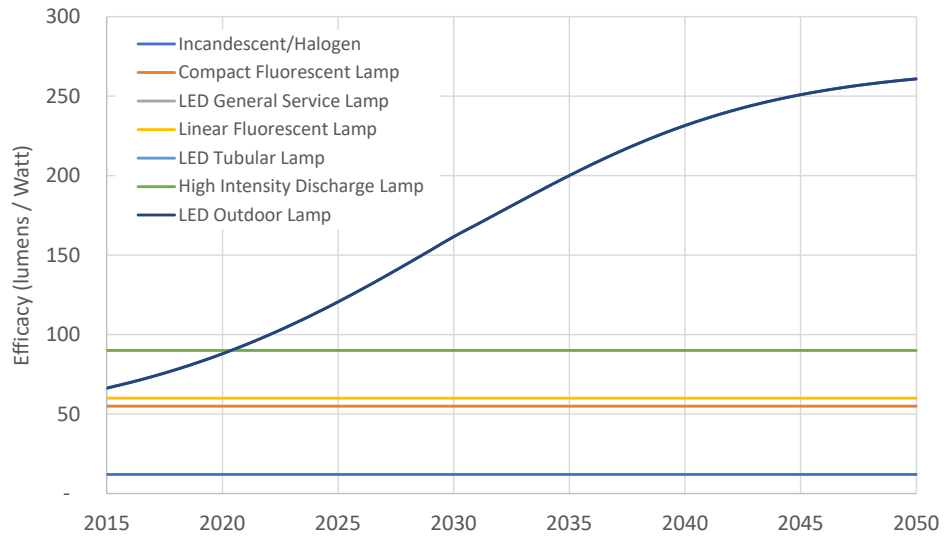
TABLE 2: ESTIMATES OF EFFICACY, WATTAGE, OPERATING HOURS, AND LIFETIME USED IN THE MODEL

Technology	Efficacy	Wattage	Operating Hours		Lifetime	
			Domestic	Profess.	Domestic	Profess.
Units	*Lumens/Watt*	*Watts*	*Hours*	*Hours*	*Years*	*Years*
Incandescent/Halogen	12	70	1.5	10	2.2	0.3
Compact Fluorescent Lamp	55	15	3	10	6.4	1.9
LED General Service Lamp	*varies*	*varies*	3	10	13.7	4.1
Linear Fluorescent Lamp	60	40	8	10	6.2	4.9
LED Tubular Lamp	*varies*	*varies*	8	10	13.7	11.0
High Intensity Discharge Lamp	90	135	11	11	5.0	5.0
LED Outdoor Lamp	*varies*	*varies*	11	11	12.5	12.5

Figure 1 presents the efficacy values of the seven lighting technologies over the analysis period. The conventional technologies, which are no longer being researched for improvement, remain static. All three LED light sources are assumed to increase from approximately 65 lm/W in 2015 to over 250 lm/W in 2050. Since all three sources rely on LED technology, all three trend lines

are super-imposed in the figure. However, these sources are tracked separately in the model to calculate the necessary wattages for each when establishing equivalent light output.

FIGURE 1. EFFICACY VALUES USED FOR EACH OF THE LIGHT SOURCE TECHNOLOGIES OVER THE ANALYSIS PERIOD



2. Shipments and Stock

To develop an estimate of the global lighting stock, CLASP obtained a database of lamp shipments from Guidehouse Insights, a market research group with substantial experience in lighting markets around the world. Guidehouse prepared a master database for CLASP of the different technology categories across sectors by drawing from and aggregating market data from four recent Guidehouse global market research reports:

- Market Data: Energy Efficient Lighting for Commercial Markets, published 1Q 2019
- Market Data: Industrial and High Bay Lighting, published 4Q 2019
- Market Data: Outdoor Lighting Systems, published 3Q 2020
- Market Data: Residential Energy Efficiency Lighting and Lighting Controls, published 1Q 2021

Using the regional shipment and revenue data aggregated from existing reports, Guidehouse created disaggregated shipment estimates at the country-level for the different light sources and sectors through interpolation of relevant indicators. These indicators were primarily based on country-level building type and stock data, derived from the Guidehouse Building Stock Database, as well as country-level road networks, which were used to estimate outdoor street lighting.

Guidehouse's lighting shipments database covers the year 2019 to 2028, a critical period for developing lighting policy measures in the next few years. However, to develop an inventory stock model, CLASP needed to backcast shipments to 2005 and forecast shipments to 2030. To backcast the market size for 2005-2018, CLASP calculated the compound annual growth rates (CAGRs) from 2019-2022 for each country, sector, and lamp category. These CAGRs were then used to extend the shipment estimates to 2005. To extend the forecast to 2030, CLASP calculated the CAGR for the years 2026-2028, and extended that to 2030 for each country, sector and lamp category.

$$Shipments_{i,t} = Shipments_{i,t0} \times (1 + CAGR_i)^{(t-t0)}$$

Where:

$Shipments_{i,t}$ represents shipment value for country i in year t;

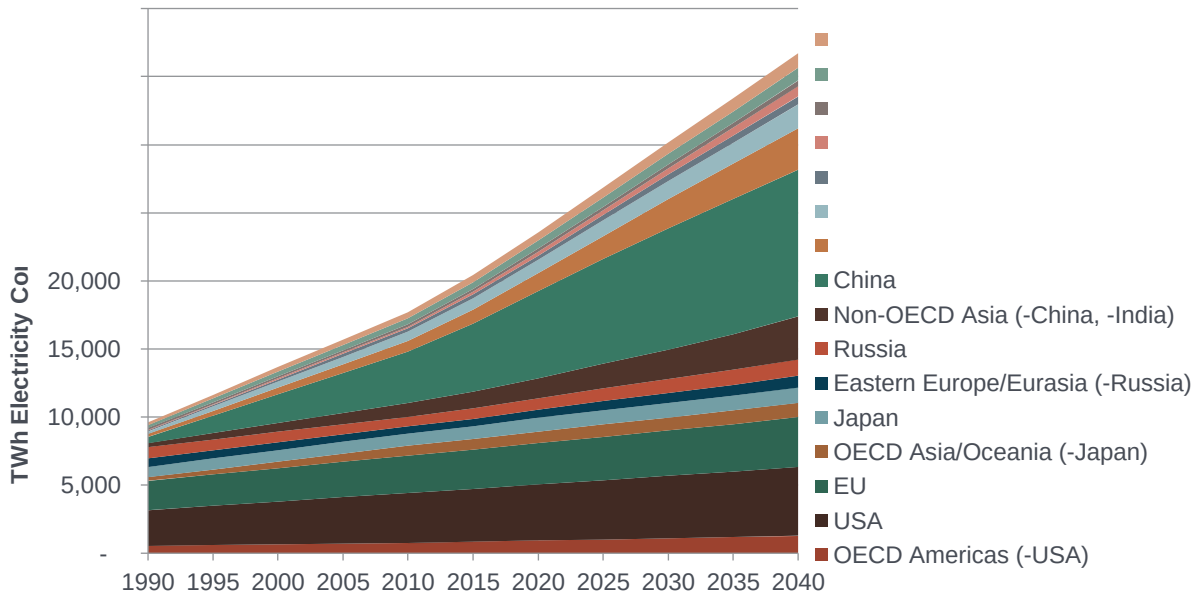
$Shipments_{i,t0}$ represents known shipment value for country i in base year t_0;

$CAGR_i$ represents country-specific compound annual growth rate from a specific year range. In the analysis, CAGR was calculated from 2006 to 2028 for forecasting purposes and from 2019 to 2022 for back casting.

To forecast the market size through 2050, country-specific CAGR values were assigned for the 162 countries, the 7 lighting technologies, and the 2 sectors, using an equation similar to the above. In the equation, $CAGR_i$ represents country-specific compound annual growth rate, derived from electricity consumption trends, based on the International Energy Agency World Energy Outlook (IEA WEO) 2014.[1] The global electricity consumption trend is illustrated in Figure 2.

[1] "World Energy Outlook 2014 – Analysis - IEA," accessed January 14, 2025, https://www.iea.org/reports/world-energy-outlook-2014.

FIGURE 2. GLOBAL ELECTRICITY CONSUMPTION TREND (IEA WORLD ENERGY OUTLOOK 2014)



The applied back- and forecasting CAGR values for each technology are visualized in Figure 3 and Table 5 respectively.

FIGURE 3 . BACK - CAST CAGR FOR DOMESTI C AND PROFESSI ONAL L I GHT I NG I N 162 COUNTRI ES (I N RED, AVERAGE GLOBAL)

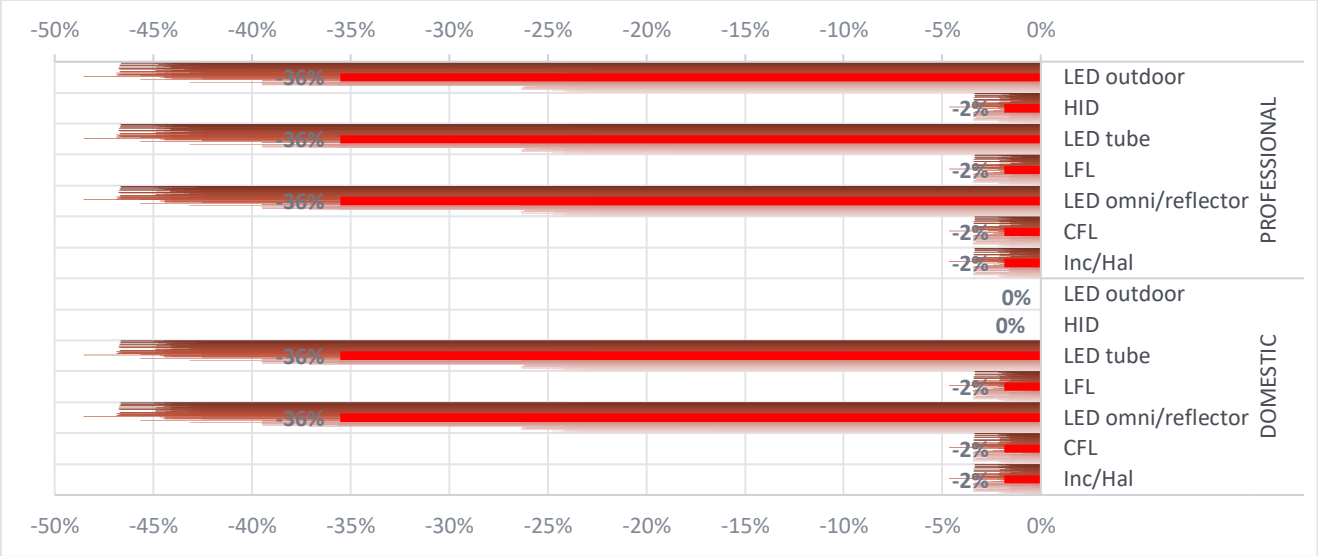
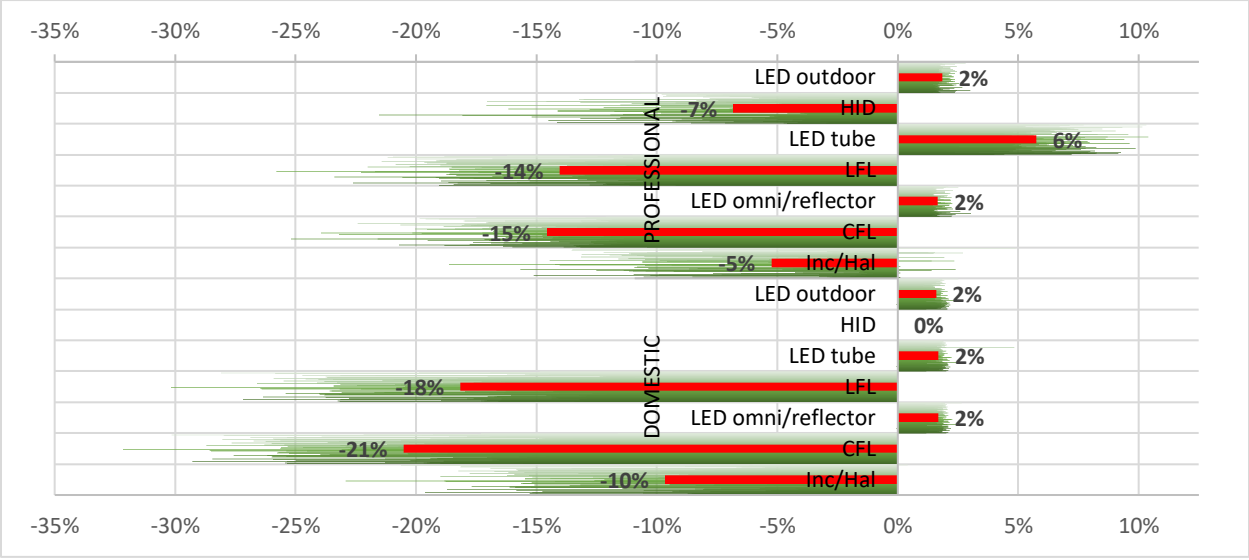


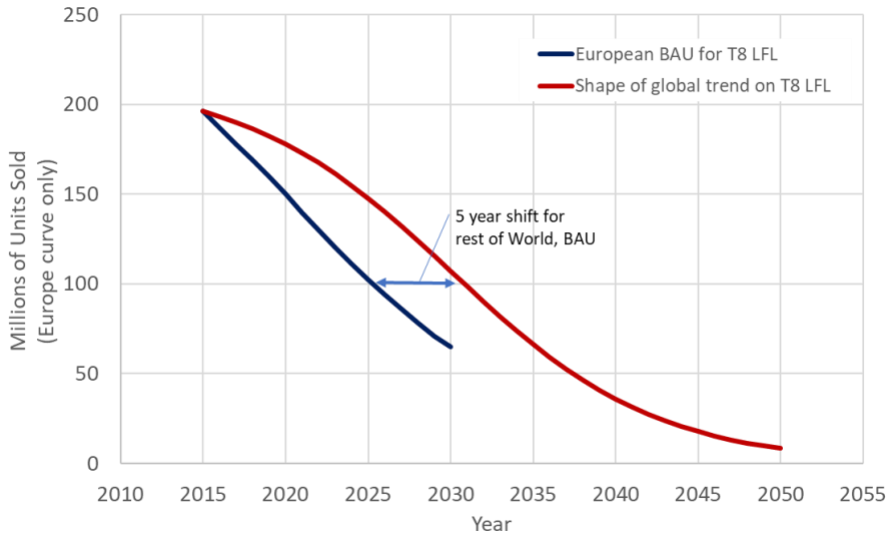
FIGURE 4. FORECAST CAGR FOR DOMESTIC AND PROFESSIONAL LIGHTING IN 162 COUNTRIES (IN RED, AVERAGE GLOBAL)



In addition to these adjustments, we also made a cross-cutting adjustment to the shipments of compact fluorescent (D2, P2) and linear fluorescent (D4, P4) lamps to ensure that they reflected the expected global shipment trends that were developed in Europe and scaled up to the world through the Clean Lighting Coalition (CLiC) lighting market model. These curves were adapted

from the "MELiSA model" (Model for European Light Sources Analysis), which is a European lighting market model developed by VHK, a Dutch consultancy that supports the European Commission on Ecodesign.[2] VHK developed the MELiSA model in consultation with LightingEurope, a lighting industry association. MELiSA was accepted by all stakeholders involved in the EU regulatory processes and was used in the European lighting market analysis for both the Ecodesign and RoHS Directives. CLASP used their data projections from 2015 through 2035 and applied a curve-fit function (Fischer-Pry equation) to extend those projections to 2050. We then shifted the curves out by five years, assuming that Europe's market is about five years ahead of the rest of the world. Thus, the BAU global fluorescent shipments of CFL and LFL are simply the European BAU scenario delayed by five years.

FIGURE 5. SCALING THE GLOBAL TREND OF T8 FLUORESCENT LAMP SALES AS EUROPE BAU + 5 YEARS

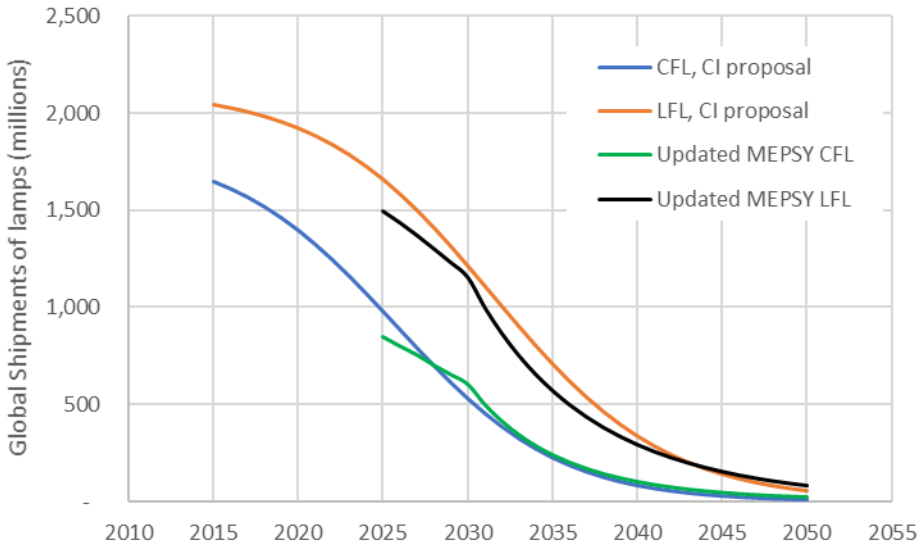


We then applied these shipment curves (like the one shown in Figure 6) to our global sales estimate to create a unit forecast for all lamp types, resulting in the sales projections for this time period. These adjustments ensured that the projected persistence

[2] "Model MELISA - Model for European LIght Sources Analysis | Modelling Inventory and Knowledge Management System of the European Commission (MIDAS)," accessed January 14, 2025, https://web.jrc.ec.europa.eu/policy-model-inventory/explore/models/model-melisa/.

of fluorescent lighting technology in the global market was tracking the expected trends that were originally published in the MELiSA model. Figure 6 shows how the projected shipments of CFLs and LFLs in the Mepsy model compare to the projected shipments for these two lamp categories in CLASP's Climate Imperative CLiC project model forecast, which aimed at phasing out fluorescent lighting through the Minamata Convention on Mercury.

FIGURE 6. COMPARISON OF CFL AND LFL SHIPMENTS BETWEEN THE CLIC GLOBAL MARKET MODEL AND MEPSY



The shipments from Guidehouse were segmented according to the scope of their research. Where data was not disaggregated into the distinct product categories identified in Table 1, CLASP relied on a 2015 United Nations Environment Programme (UNEP) global lighting market model, which was developed in consultation with the two largest lighting companies globally to estimate the market share of the various technologies in 16 different regions/countries used in the model. Table 3, Table 4, Table 5, and Table 6 present the relative shares of each of the technologies within the major categories.

TABLE 3: REGIONAL TECHNOLOGY SHARES USED TO DISAGGREGATE RESIDENTIAL LIGHTING SHIPMENTS DATA (SHARE OF GUIDEHOUSE MARKET CATEGORY %)

Region/Country	Non-LED					LED			
	Incandesc.	Halogen	CFL	LFL - T5 & T8	LFL - T12	General Service	Directional	Tube	Outdoor
OECD Americas (-USA)	82%	9%	8%	1%	1%	61%	31%	6%	2%
United States of America	87%	7%	4%	1%	1%	61%	30%	6%	3%
European Union	64%	26%	7%	2%	0%	53%	32%	9%	5%
OECD Asia / Oceania (-Japan)	46%	11%	36%	5%	2%	43%	45%	7%	5%

Japan	27%	20%	22%	11%	21%	48%	20%	20%	12%
East Europe / Eurasia (-Russia)	77%	10%	10%	2%	1%	35%	50%	5%	10%
Russia	78%	9%	9%	2%	2%	33%	47%	1%	19%
Non-OECD Asia (-China, -India)	54%	9%	32%	4%	2%	44%	46%	6%	4%
China	70%	14%	14%	2%	0%	57%	27%	15%	1%
India	84%	3%	12%	1%	1%	40%	55%	5%	0%
Middle East	65%	17%	14%	4%	1%	31%	44%	19%	6%
North Africa	83%	4%	10%	2%	1%	23%	58%	17%	2%
Sub-Sahara (-South Africa)	81%	7%	11%	2%	1%	24%	61%	13%	2%
South Africa	83%	4%	11%	2%	1%	22%	58%	18%	2%
Latin America (-Brazil)	69%	12%	17%	1%	1%	53%	34%	10%	2%
Brazil	69%	12%	17%	1%	1%	56%	31%	11%	2%

TABLE 4: REGIONAL TECHNOLOGY SHARES USED TO DISAGGREGATE COMMERCIAL PORTION OF PROFESSIONAL LIGHTING SHIPMENTS DATA

Region / Country	Incand. / Halogen	Fluor-escent	HID			LED			
			HP Sodium	Metal Halide	Mercury Vapor	General Service	Direct-ional	Tube	Outdoor
OECD Americas (- USA)	Shipments already fully disaggregated	Shipments already fully disaggregated	55%	13%	33%	62%	31%	4%	2%
United States of America			50%	14%	36%	63%	31%	3%	2%
European Union			16%	69%	15%	56%	34%	6%	4%
OECD Asia / Oceania (- Japan)			30%	36%	34%	44%	45%	5%	6%
Japan			24%	31%	45%	54%	23%	13%	10%
East Europe / Eurasia (-Russia)			12%	21%	67%	33%	47%	4%	15%
Russia			7%	12%	80%	34%	48%	0%	18%
Non-OECD Asia (-China, -India)			21%	27%	52%	43%	45%	5%	7%
China			18%	59%	23%	58%	27%	13%	2%
India			46%	17%	38%	41%	55%	4%	0%
Middle East			29%	49%	22%	33%	46%	14%	7%
North Africa			51%	7%	41%	24%	61%	13%	3%
Sub-Sahara (-South Africa)			51%	7%	41%	24%	61%	13%	3%
South Africa			57%	16%	27%	54%	34%	8%	3%
Latin America (-Brazil)			57%	16%	27%	54%	34%	8%	3%
Brazil			61%	11%	28%	58%	32%	7%	3%

TABLE 5: REGIONAL TECHNOLOGY SHARES USED TO DISAGGREGATE INDUSTRIAL PORTION OF PROFESSIONAL LIGHTING SHIPMENTS DATA

Region / Country	Incand. / Halogen	Fluorescent			HID			LED			
		CFL	LFL – T5 & T8	LFL – T12	HP Sodium	Metal Halide	Mercury Vapor	General Service	Direct-ional	Tube	Outdoor
OECD Americas (- USA)	Shipments already fully disaggregated	53%	27%	20%	55%	13%	33%	62%	31%	4%	2%

United States of America		43%	33%	23%	50%	14%	36%	63%	31%	3%	2%
European Union		45%	47%	7%	16%	69%	15%	56%	34%	6%	4%
OECD Asia / Oceania (- Japan)		59%	29%	12%	30%	36%	34%	44%	45%	5%	6%
Japan		20%	27%	53%	24%	31%	45%	54%	23%	13%	10%
East Europe / Eurasia (-Russia)		39%	37%	24%	12%	21%	67%	33%	47%	4%	15%
Russia		40%	30%	30%	7%	12%	80%	34%	48%	0%	18%
Non-OECD Asia (-China, -India)		57%	29%	13%	21%	27%	52%	43%	45%	5%	7%
China		55%	41%	4%	18%	59%	23%	58%	27%	13%	2%
India		61%	21%	19%	46%	17%	38%	41%	55%	4%	0%
Middle East		42%	43%	14%	29%	49%	22%	33%	46%	14%	7%
North Africa		50%	37%	12%	51%	7%	41%	24%	61%	13%	3%
Sub-Sahara (-South Africa)		50%	38%	13%	51%	7%	41%	24%	61%	13%	3%
South Africa		50%	38%	13%	51%	7%	41%	24%	61%	13%	3%
Latin America (-Brazil)		59%	24%	16%	57%	16%	27%	54%	34%	8%	3%
Brazil		61%	22%	17%	61%	11%	28%	58%	32%	7%	3%

TABLE 6: REGIONAL TECHNOLOGY SHARES USED TO DISAGGREGATE OUTDOOR LIGHTING SHIPMENTS DATA

Region / Country	Fluorescent			HID			LED			
	CFL	LFL – T5 & T8	LFL – T12	HP Sodium	Metal Halide	Mercury Vapor	General Service	Direct-ional	Tube	Outdoor
OECD Americas (- USA)	57%	25%	18%	Shipments already fully disaggregated	Shipments already fully disaggregated	Shipments already fully disaggregated	63%	32%	3%	2%
United States of America	47%	31%	22%				64%	32%	2%	2%
European Union	50%	43%	7%				57%	35%	4%	4%
OECD Asia / Oceania (- Japan)	63%	27%	11%				45%	46%	4%	6%
Japan	23%	26%	51%				57%	24%	9%	11%
East Europe / Eurasia (-Russia)	43%	34%	23%				34%	48%	3%	16%
Russia	44%	28%	28%				34%	48%	0%	18%
Non-OECD Asia (-China, -India)	61%	27%	12%				43%	46%	3%	7%
China	60%	36%	4%				61%	28%	9%	2%
India	65%	18%	17%				41%	56%	3%	0%
Middle East	47%	40%	13%				34%	48%	10%	8%
North Africa	54%	34%	11%				25%	64%	9%	3%
Sub-Sahara (-South Africa)	54%	35%	12%				25%	64%	9%	3%
South Africa	54%	35%	12%				25%	64%	9%	3%
Latin America (-Brazil)	63%	22%	15%				55%	35%	6%	4%
Brazil	65%	20%	15%				59%	33%	5%	3%

SHIPMENT ADJUSTMENT BASED ON FLOORSPACE LIGHTING DENSITY

The shipments from Guidehouse were backcast and forecast to create estimates of the shipments over several decades. These shipments were fed into a lighting stock model, along with the average wattages, efficacies, lifetime, and operating hours. From these values, total lighting service–measures in lumen-hours of light were calculated for each country and

compared to the Guidehouse total building floorspace (square meters) over a decade (2020-2030).

The total lighting service is calculated as:

$$Lighting\ Service_{i,t} = \sum_{j=1}^{N} \left(\text{Shipments}_{i,j,t} \times Wattage_j \times Efficacy_j \times Operating\ Hours_j \times Lifetime_j \right)$$

Where:

$Lighting\ Service_{i,t}$ = Total lighting service for country i in year t (measured in lumen-hours);

$\text{Shipments}_{i,j,t}$ = Number of shipments for each lighting type j in country i for year t,

$Wattage_j$ = Average wattage for lighting type j;

$Efficacy_j$ = Efficacy (lumens per watt) for lighting type j;

$Operating\ Hours_j$ = = Annual operating hours for lighting type j;

$Lifetime_j$ = Average lifetime of lighting type j.

To calculate the illumination level per square meter:

$$Illumination\ Level\ _{i,t} = \frac{Lighting\ Sercice_{i,t}}{Building\ Floorspace_{i,t}}$$

Where:

$Building\ Floorspace_{i,t}$ = Total building floorspace in country i in year t (measured in square meters).

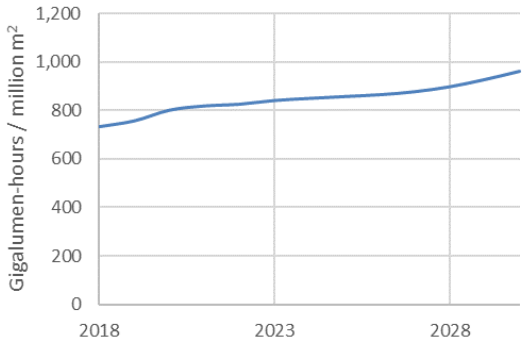
If the level of lighting service per square meter (lumens/m2) was found to be increasing over that period, the shipments may have been adjusted downward slightly to have even or slightly increasing illumination (take back effect) per unit floorspace over the analysis period. Similarly, if the level of lighting service was decreasing over this period, the shipments were adjusted up to increase the stock of lighting and increase the lighting service, so it kept pace with the increasing building floorspace stock estimates. These adjustments were made at a country level for all 162 countries.

Furthermore, the total energy consumed by all light sources in stock (considering average operating hours and rated wattages) was calculated to determine the fraction of total national electricity consumption due to lighting. In general, research has shown that lighting is

responsible for 9% to 17% of national electricity consumption. Thus, if the stock model predicted lighting consumption fell outside of this range, it was investigated, and shipments were adjusted to bring the consumption into alignment with expectations. The percentage of annual electricity consumption attributable to lighting was reviewed for all 162 countries, but minor adjustments were made only to those countries with a consumption outside of the expected range.

The following provides an illustration of this estimate for the country of Hungary as an example. The graph shows the level of illumination (presented in gigalumen-hours per million square meters of building floor space), which is found to be gradually increasing over the analysis period by about 10%. This level seems reasonable since lighting consumption may increase as it becomes less expensive to operate (i.e., the "take back effect"). In addition, the total electricity consumption for lighting was calculated to be 12.5% of national consumption, thus no further adjustments were necessary to the shipment estimates used in the model for Hungary.

FIGURE 7. LIGHTING SERVICE PER UNIT FLOORSPACE FOR HUNGARY, 2018 – 2030



3. Unit Energy Consumption, Usage, and Standards Scenarios

To estimate the energy consumption from lighting, CLASP developed average efficacy, wattage, operating hours, and lifetime assumptions for single global values. To integrate trends in technological development for the seven 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 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.

Unit Energy Consumption (UEC) for each technology is calculated based on the adjusted wattage for the respective year, and the assigned operating hours for the sector.

$$UEC_{i,t} = W_{i,t} \times H_{i,t}$$

Where:

$UEC_{i,t}$ = Unit Energy Consumption for technology i in year t (in kWh or other relevant units);

$W_{i,t}$ = Adjusted wattage for technology i in year t (in watts);

$H_{i,t}$ = Assigned operating hours for the sector in year t.

These values were then assigned to corresponding shipment data, along with the assigned lifetime for each technology, to obtain country-level annual energy consumption.

$$Energy\ Consumption_{i,t} = UEC_{i,t} \times Stock_{i,t}$$

Where:

$Stock_{i,t}$ = Stock of technology i in year t (the total number of units in use in that year).

Figure 8 and Figure 9 illustrate the trends for the assigned efficacy and wattage values.

FIGURE 8. WATTAGE VALUES DEFINED FOR 2005-2050 FOR THE TECHNOLOGIES

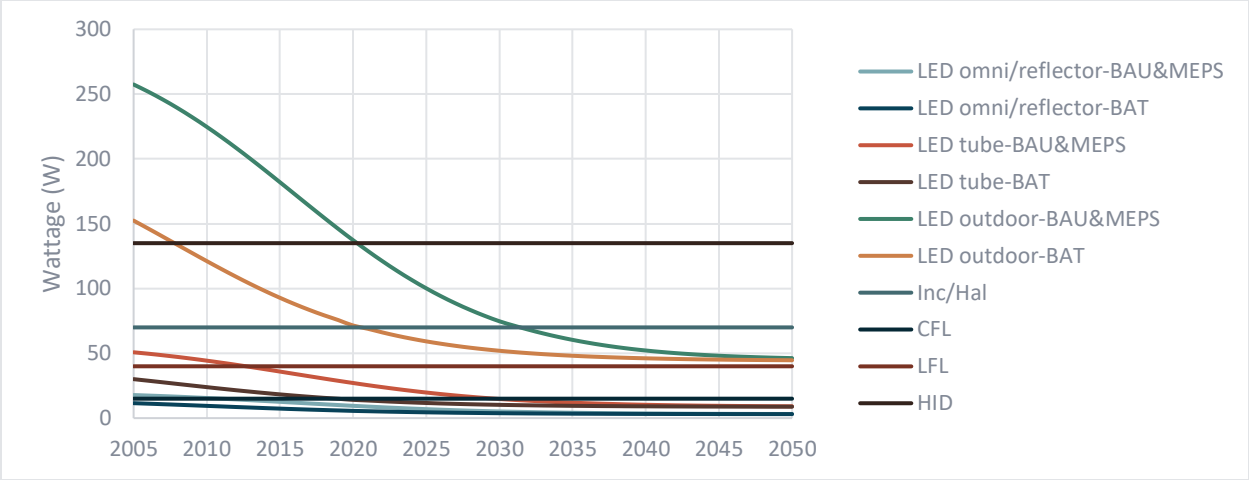
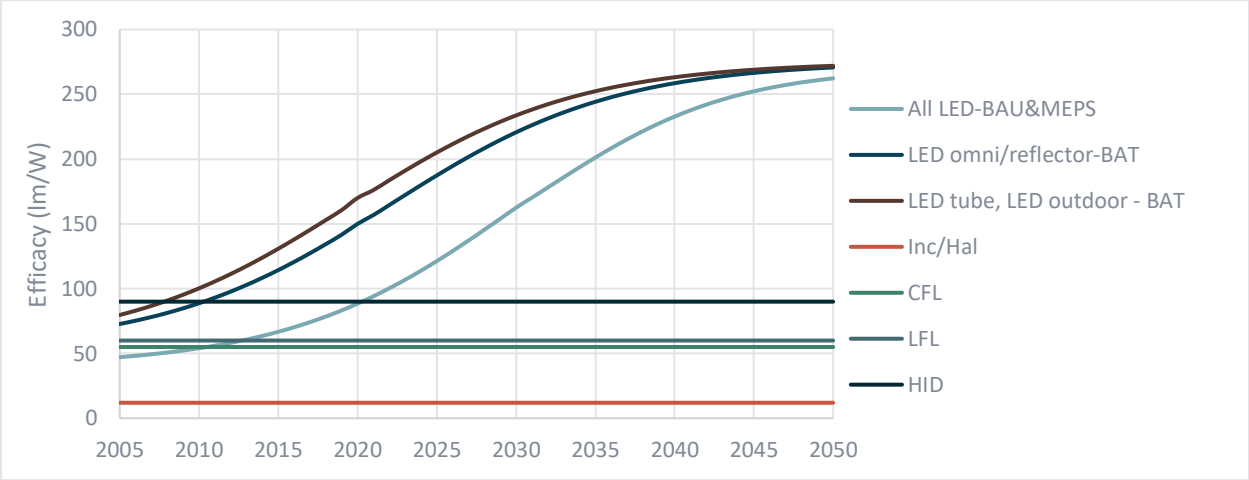


FIGURE 9. EFFICACY VALUES DEFINED FOR 2005-2050 FOR THE TECHNOLOGIES



We conducted individual calculations for the technologies used in the domestic and professional lighting sector to obtain annual lighting energy use for 162 countries. Data processing was done in r-software, based on LBNL's PAMS stock accounting methodology.3 to allocate stock distribution based on age, s -shape survival functions were assigned for each technology type, as illustrated in figure 10 and figure 11 .

[3] "User Instructions for the Policy Analysis Modeling System (PAMS) | LBL ETA Publications," accessed January 14, 2025, https://eta-publications.lbl.gov/publications/user-instructions-policy-analysis.

FIGURE 10. S-SHAPE SURVIVAL FUNCTION RATES APPLIED IN STOCK ACCOUNTING FOR DOMESTIC LIGHTING, DEFINED BASED ON OPERATING HOURS AND RATED LIFETIME

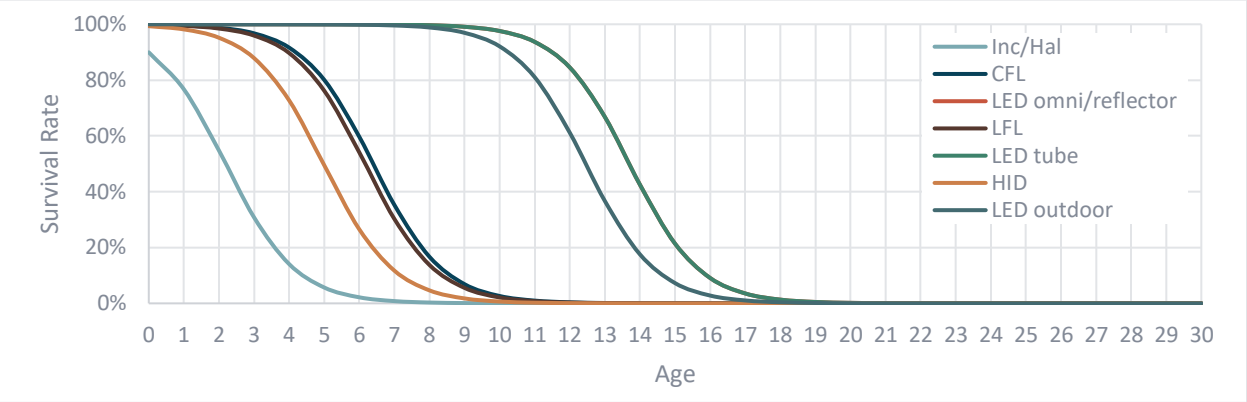
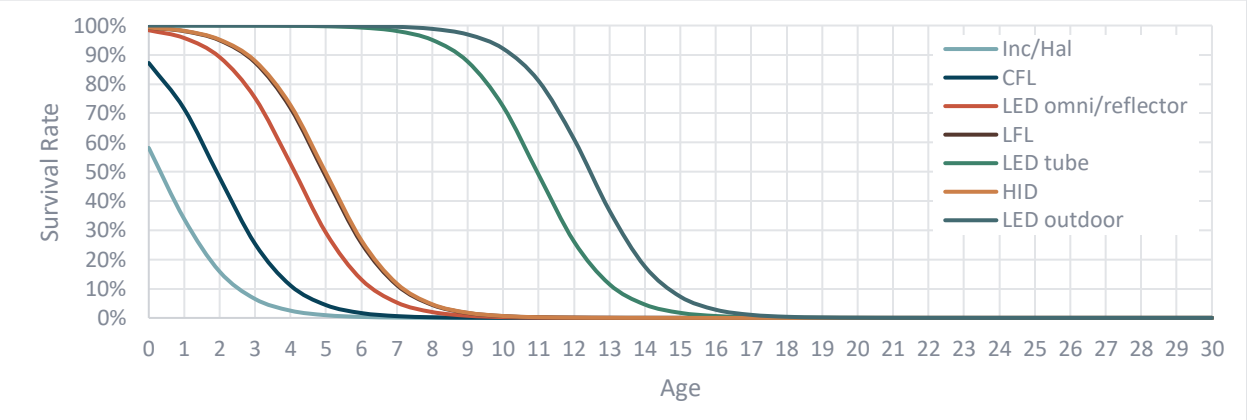


FIGURE 11. S-SHAPE SURVIVAL FUNCTION RATES APPLIED IN STOCK ACCOUNTING FOR PROFESSIONAL LIGHTING, DEFINED BASED ON OPERATING HOURS AND RATED LIFETIME



The assumptions used in the business-as-usual (BAU), Global Benchmark (GB), and Net Zero Hero (NZH) scenarios are summarized in

Table 7. These three scenarios are defined as follows:

- **Business-as-usual (BAU) Scenario:** assumes no changes implementation of lighting policy between 2020 and 2030.
- **Global Benchmark (GB) Scenario:** assumes the implementation of a lighting policy that forces the market to LED technologies only, such as the EU ban on halogen and CFL lamps.

Under the GB Scenario, all non-LED lighting shipments are reallocated as LED, thereby creating an all-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.

- **Net Zero Hero (NZH) Scenario:** assumes the implementation of a lighting policy that not only creates an all-LED market but pushes the market to best currently available LED technologies.

  Under the NZH Scenario, all non-LED shipments are reallocated as LED shipments, and 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 reductions for non-LED technology are simulated based on annual adjustment factors at a slightly higher rate compared to the values applied in the MEPS scenario, similarly from the policy year onwards.

TABLE 7: EFFICACY, WATTAGE, OPERATING HOURS, AND LIFETIME ASSUMPTIONS

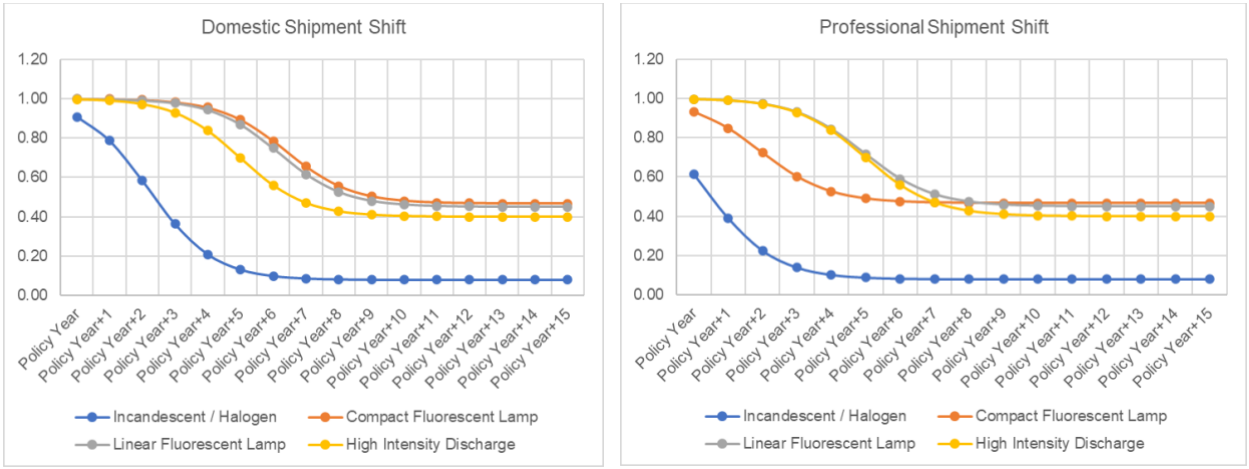
TECHNOLOGY	BAU & MEPS		BAT		OPERATING HOURS		LIFETIME	
	EFFICACY	WATTAGE	EFFICACY	WATTAGE	DOMESTIC	PROFESS.	DOMESTIC	PROFESS.
UNITS	*(LM/W)*	*(W)*	*(LM/W)*	*(W)*	*(HOURS)*	*(HOURS)*	*(YEAR)*	*(YEAR)*
INCANDESCENT/HALOGEN	12	70	12	70	1.5	10	2.2	0.3
COMPACT FLUORESCENT LAMP	55	15	55	15	3	10	6.4	1.9
LED GENERAL SERVICE LAMP	88	9.5	150 (varies)	6 (varies)	3	10	13.7	4.1
LINEAR FLUORESCENT LAMP	60	40	60	40	8	10	6.2	4.9

LED TUBULAR LAMP	88	27.1	170 (varies)	14 (varies)	8	10	13.7	11.0
HIGH INTENSITY DISCHARGE LAMP	90	135	90	135	11	11	5.0	5.0
LED OUTDOOR LAMP	88	137.3	170 (varies)	71 (varies)	11	11	12.5	12.5

Gradual shipment shifts from non-LED to LED technologies are allocated by the assignment of shipment adjustment factors. Starting from the policy year, shipments of all non-LEDs become zero, and the demand for the respective non-LED technology will shift to the replacement LED technology.

Figure 12 shows plotted trends of shipment adjustment factors assigned from the policy year onwards for domestic and professional lighting sectors in both MEPS and BAT scenarios.

FIGURE 12. SHIPMENT ADJUSTMENT FACTORS ASSIGNED TO DOMESTIC AND PROFESSIONAL LIGHTING SECTOR FOR MEPS AND BAT SCENARIOS



4. Model Outputs and Validation

This section includes visual graphs and tables for further evaluation, organized by global aggregate, as well as specific data for the United States, China, India, the EU-28, and Brazil. The information covers the following:

- The number of lighting units in-use, along with the respective shipments used to generate the stock estimates by technology
- The generated shift in shipment and respectively stock due to the implementation of non-LED phase-out
- Energy consumption, by technology and aggregated
- Energy savings under the defined scenario, aggregated

SHIPMENT AND STOCK BY TECHNOLOGY

FIGURE 13. GLOBAL LIGHTING SHIPMENTS AND STOCK UNDER BAU SCENARIO

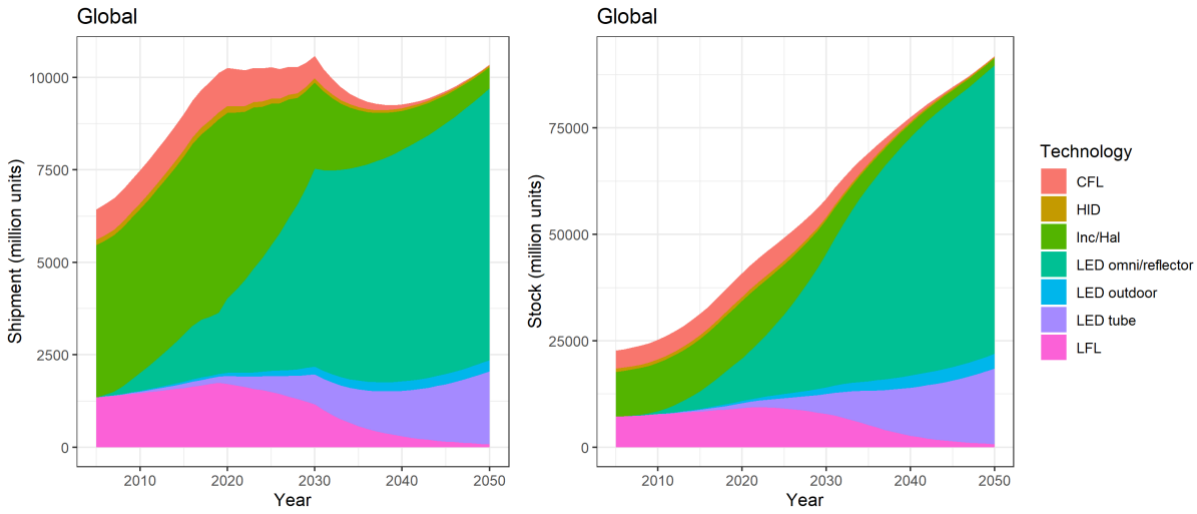


FIGURE 14. GLOBAL SHIPMENTS AND STOCK UNDER THE NON-LED PHASE-OUT SCENARIO IN 2025

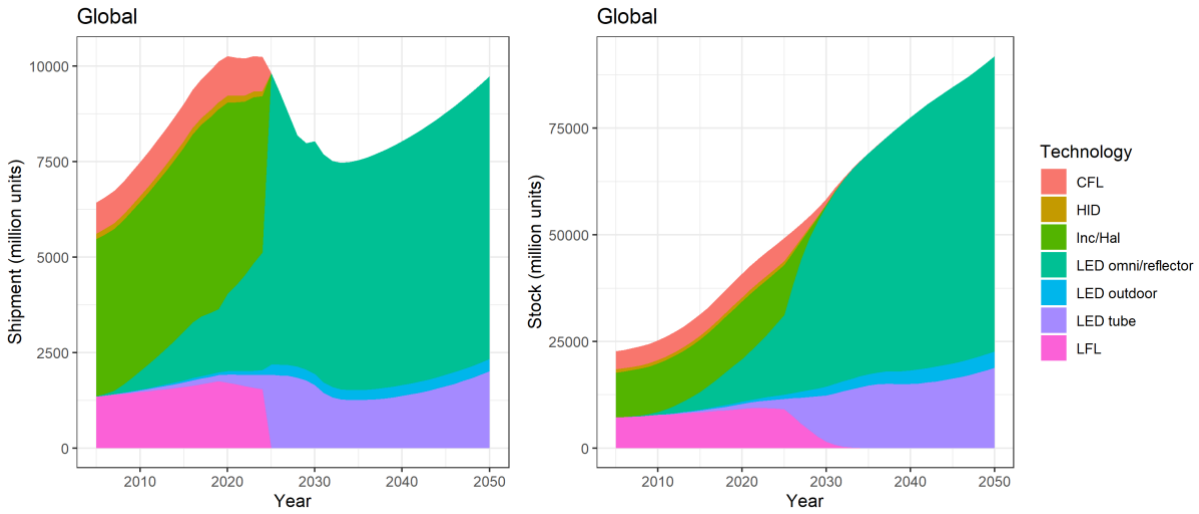


FIGURE 15. LIGHTING SHIPMENTS AND STOCK IN THE UNITED STATES UNDER THE BAU SCENARIO

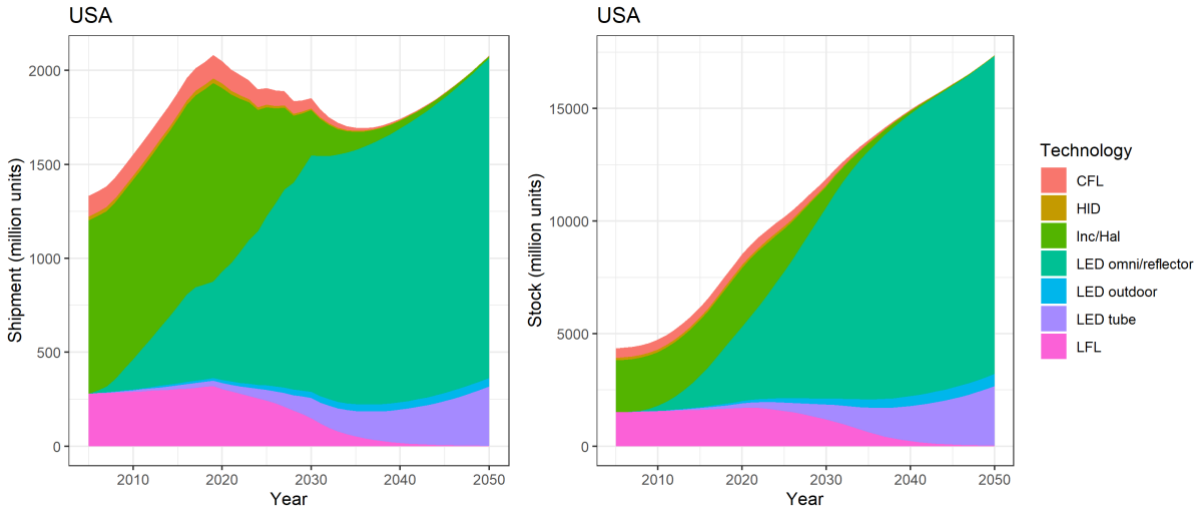


FIGURE 16. LIGHTING SHIPMENTS AND STOCK IN THE UNITED STATES UNDER THE NON-LED PHAE-OUT SCENARIO IN 2025

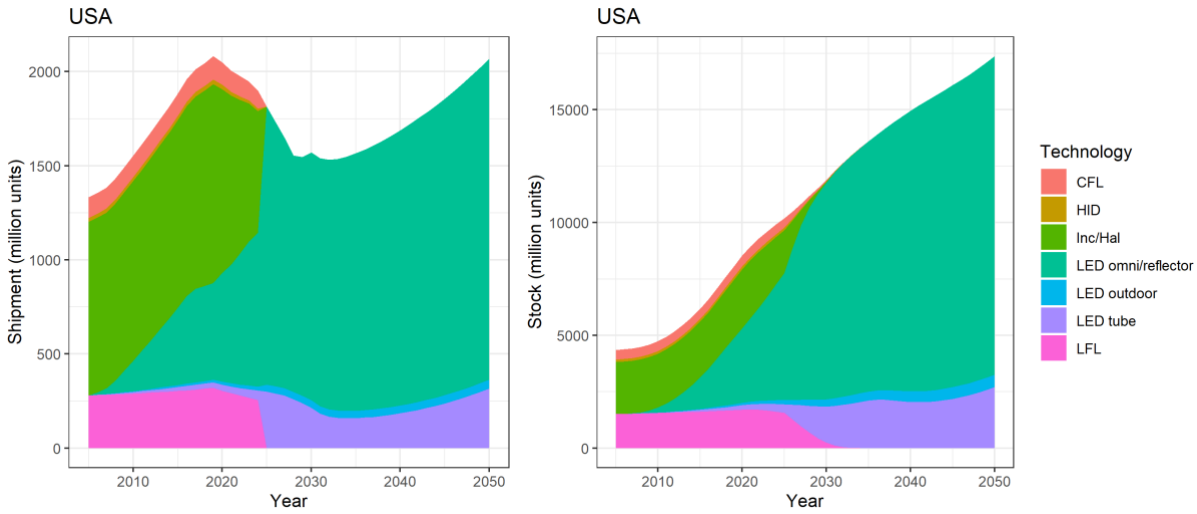


FIGURE 17. LIGHTING SHIPMENTS AND STOCK IN CHINA UNDER THE BAU SCENARIO

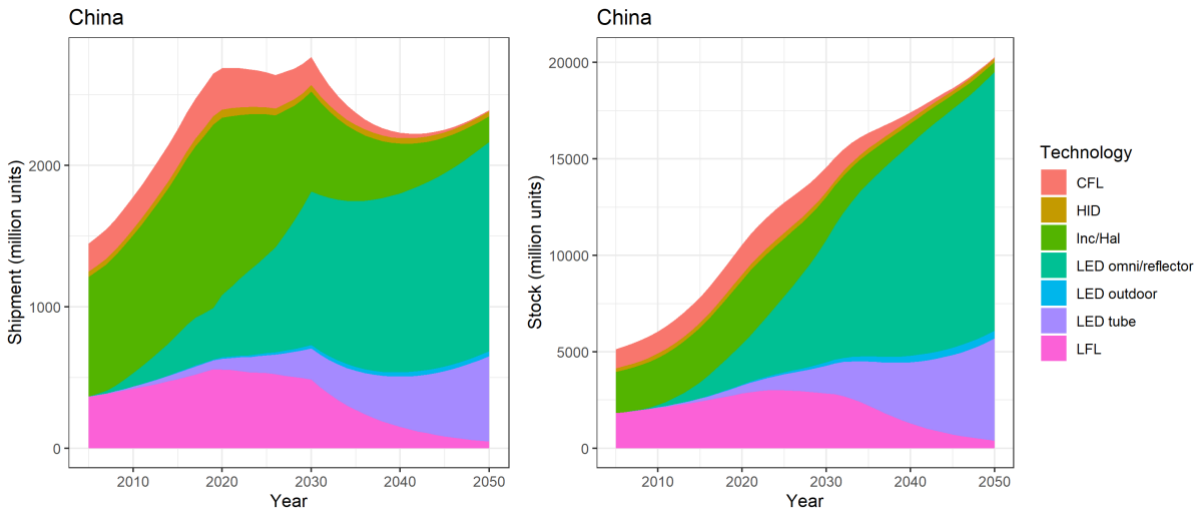


FIGURE 18. LIGHTING SHIPMENTS AND STOCK IN CHINA UNDER NON-LEC PHASE-OUT SCENARIO IN 2025

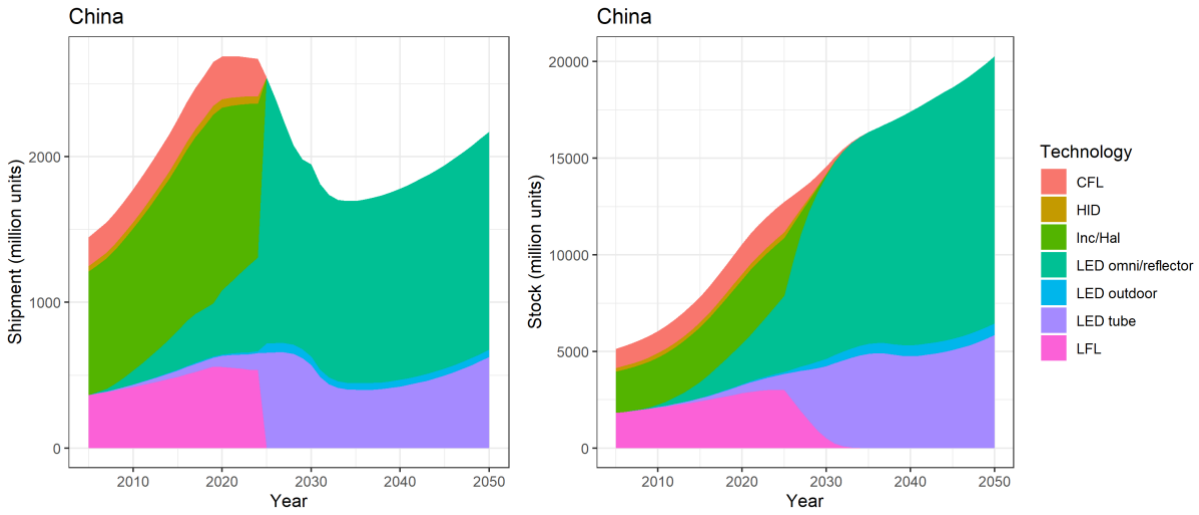


FIGURE 19. LIGHTING SHIPMENTS AND STOCK IN INDIA UNDER BAU SCENARIO

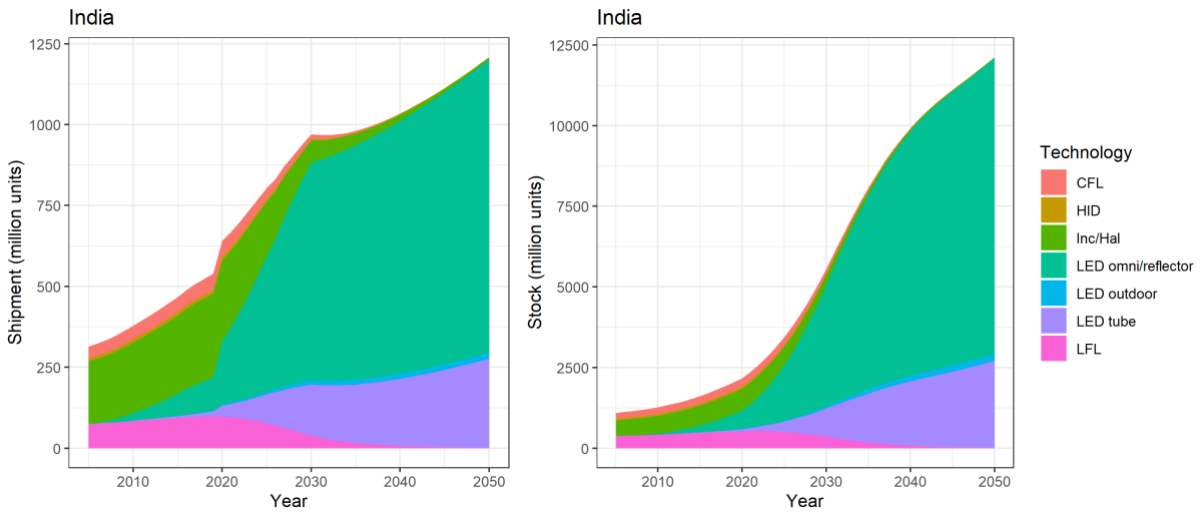


FIGURE 20. LIGHTING SHIPMENTS AND STOCK IN INDIA UNDER NON-LEC PHASE-OUT SCENARIO IN 2025

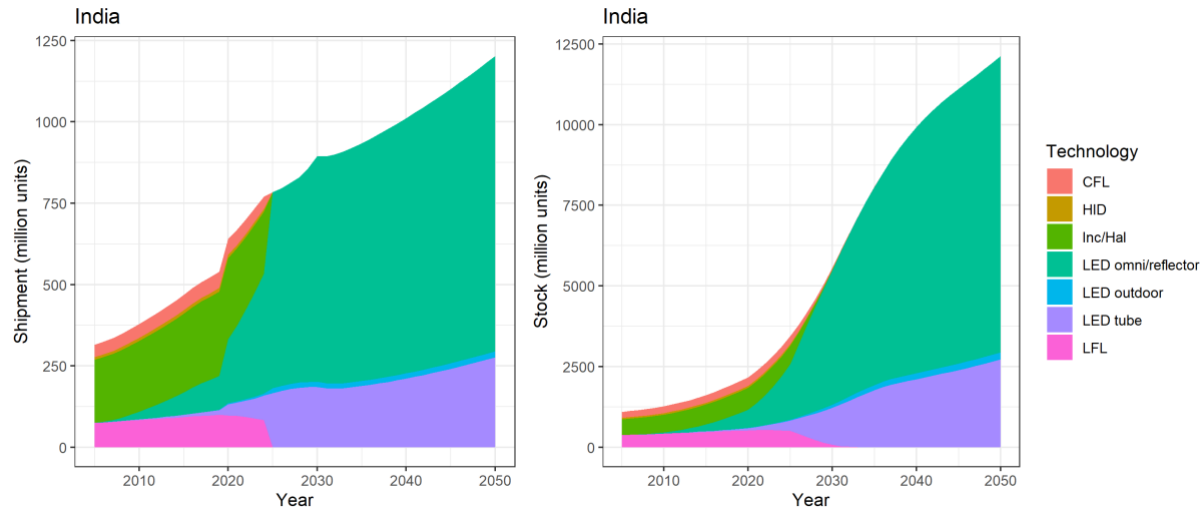


FIGURE 21. LIGHTING SHIPMENTS AND STOCK IN EU-28 UNDER BAU SCENARIO

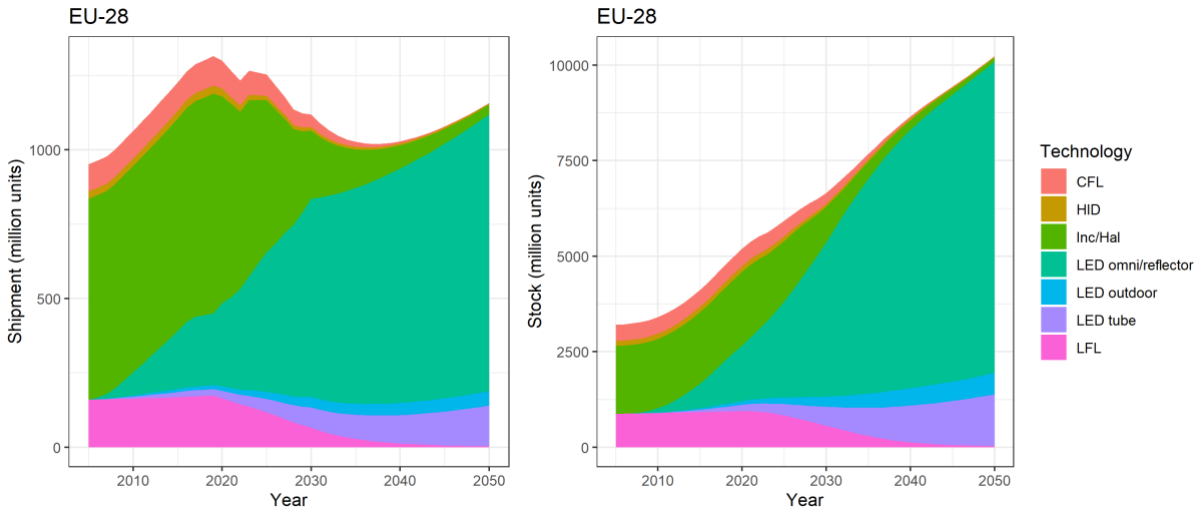


FIGURE 22. LIGHTING SHIPMENTS AND STOCK IN EU-28 UNDER NON-LEC PHASE-OUT SCENARIO IN 2025

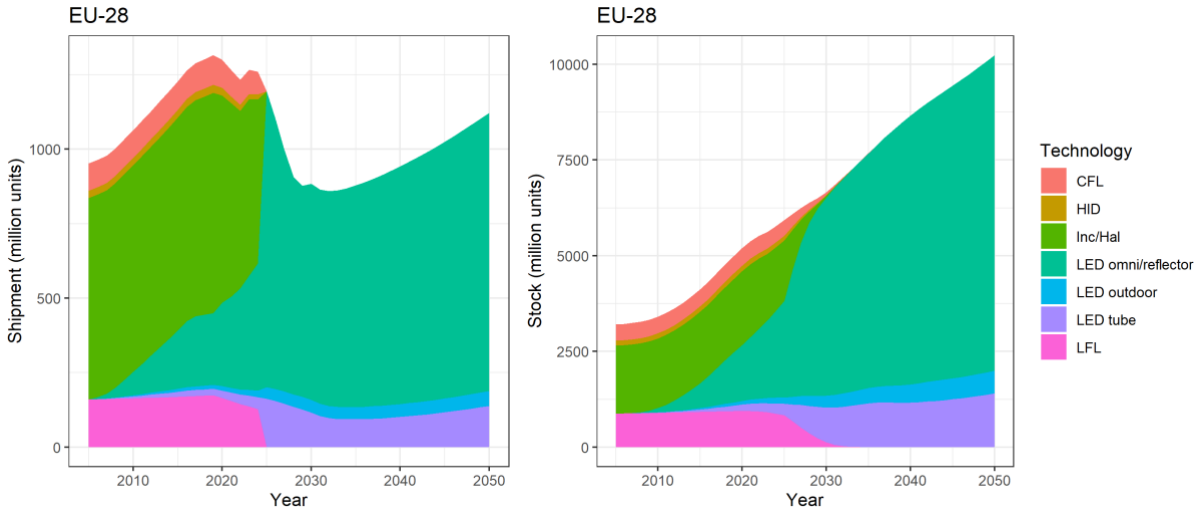


FIGURE 23. LIGHTING SHIPMENTS AND STOCK IN BRAZIL UNDER BAU SCENARIO

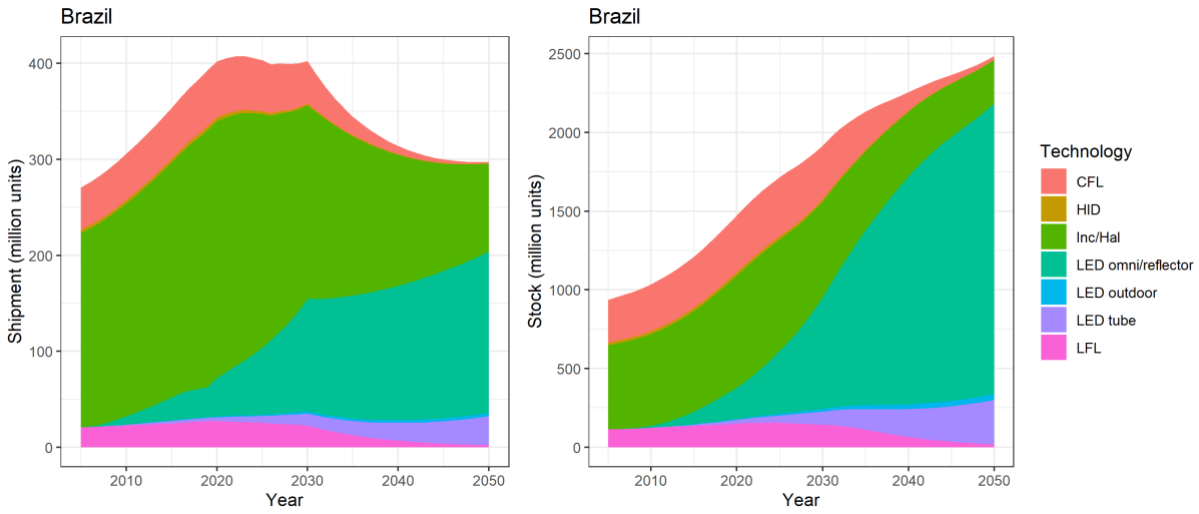
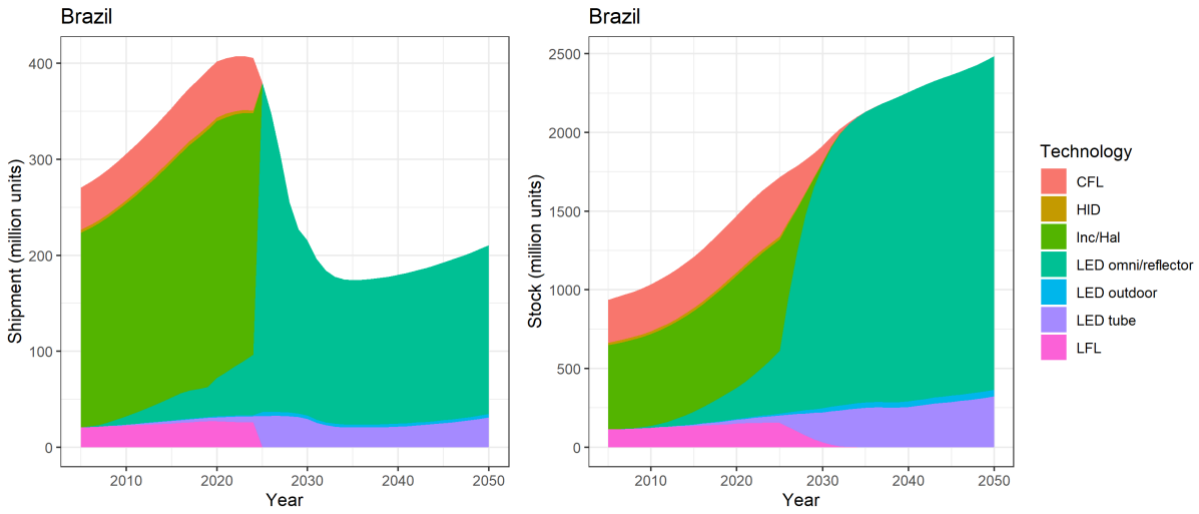


FIGURE 24. LIGHTING SHIPMENTS AND STOCK IN BRAZIL UNDER NON LED PHASE-OUT SCENARIO IN 2025



ENERGY CONSUMPTION RESULTS IN DIFFERENT COUNTRIES

FIGURE 25. GLOBAL ENERGY CONSUMPTION OF LIGHTING UNDER THE BAU SCENARIO

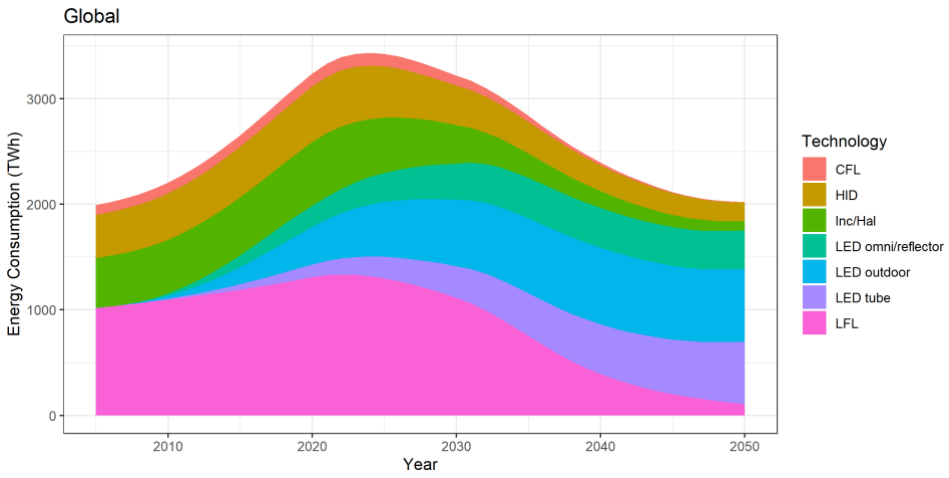


FIGURE 26. GLOBAL ENERGY CONSUMPTION OF LIGHTING UNDER NON-LED PHASE-OUT SCENARIO IN 2025

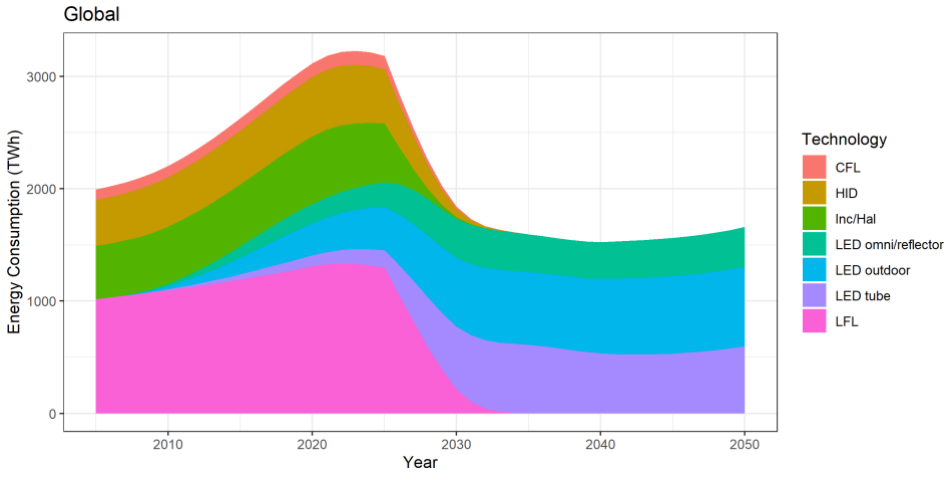


FIGURE 27. LIGHTING ENERGY CONSUMPTION IN THE UNITED STATES UNDER THE BAU SCENARIO

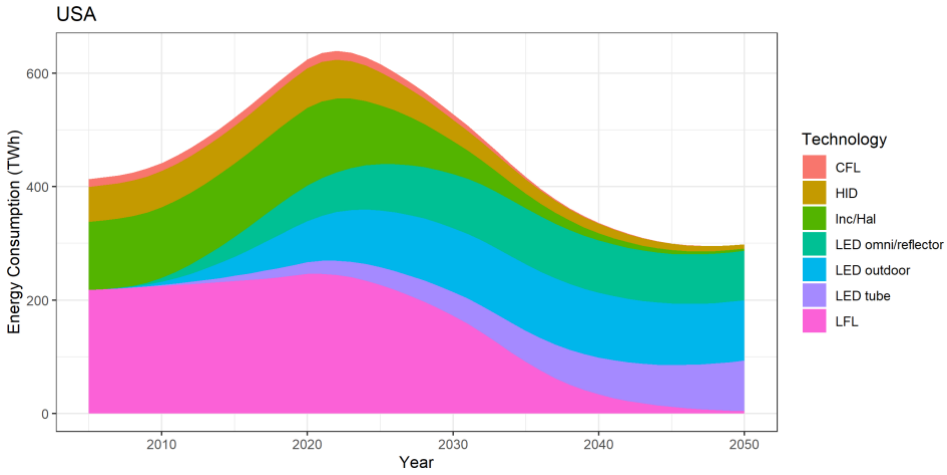


FIGURE 28. LIGHTING ENERGY CONSUMPTION IN THE UNITED STATES UNDER THE NON-LED PHASE-OUT SCENARIO IN 2025

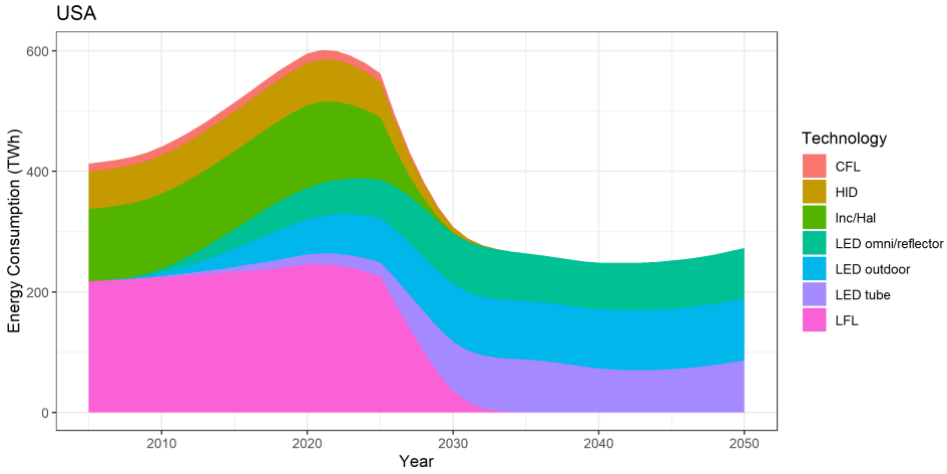


FIGURE 29. LIGHTING ENERGY CONSUMPTION IN CHINA UNDER THE BAU SCENARIO

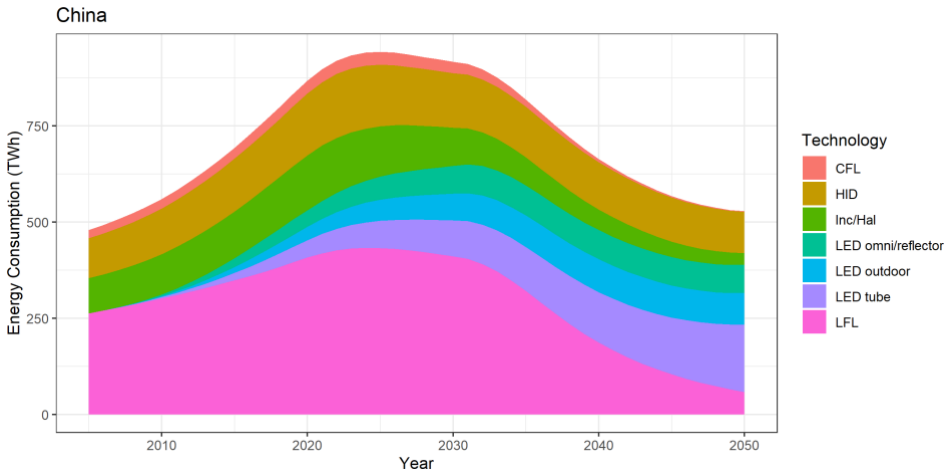


FIGURE 30. LIGHTING ENERGY CONSUMPTION IN CHINA UNDER THE NON-LED PHASE-OUT SCENARIO IN 2025

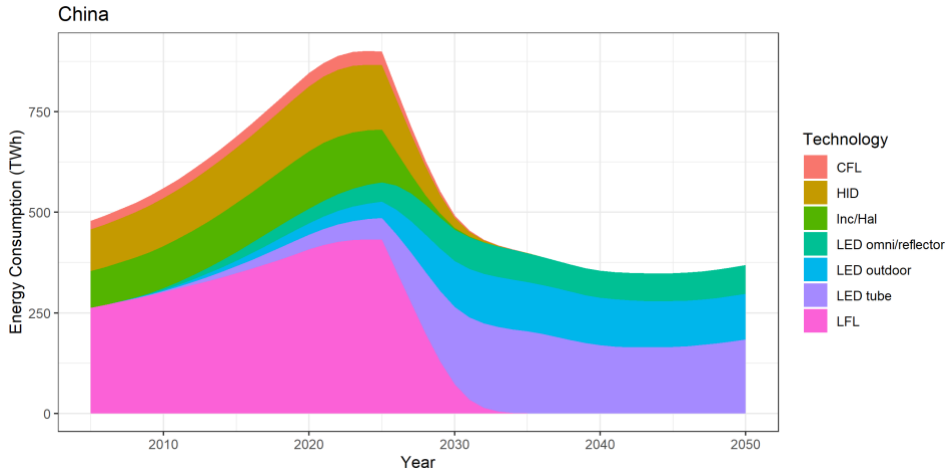


FIGURE 31. LIGHTING ENERGY CONSUMPTION IN INDIA UNDER THE BAU SCENARIO

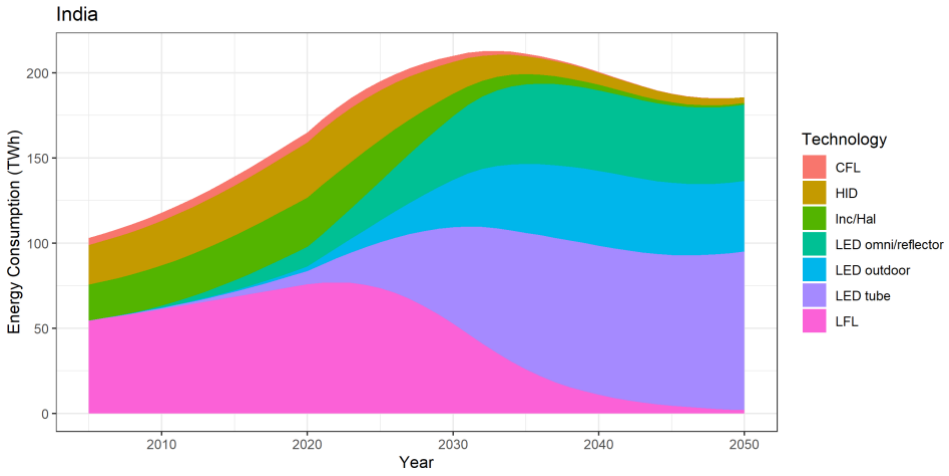


FIGURE 32. LIGHTING ENERGY CONSUMPTION IN INDIA UNDER THE NON-LED PHASE-OUT SCENARIO IN 2025

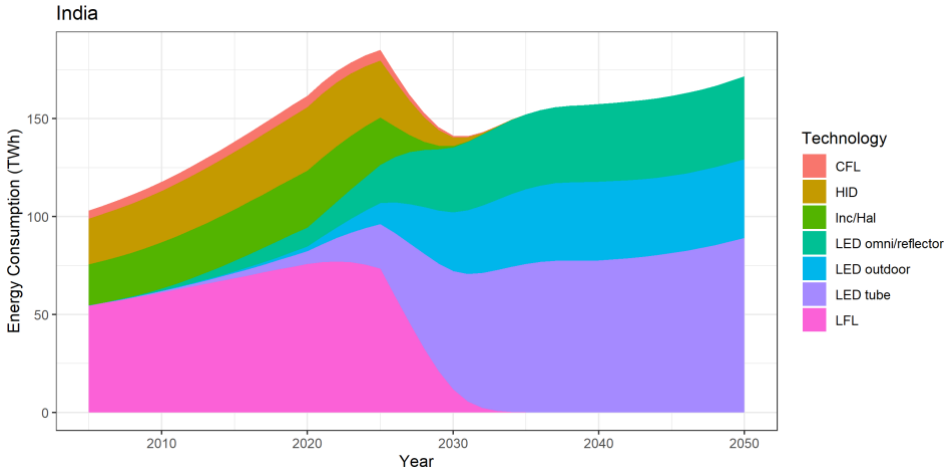


FIGURE 33. LIGHTING ENERGY CONSUMPTION IN EU-28 UNDER THE BAU SCENARIO

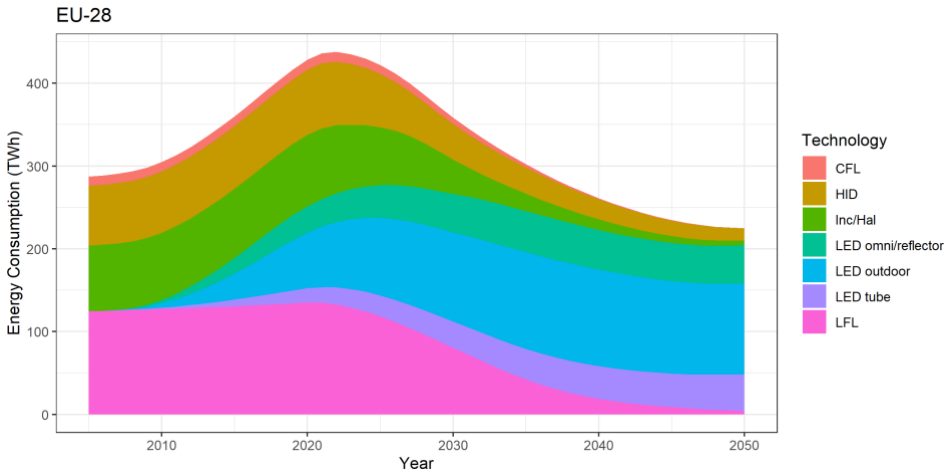


FIGURE 34. LIGHTING ENERGY CONSUMPTION IN EU-28 UNDER THE NON-LED PHASE-OUT SCENARIO

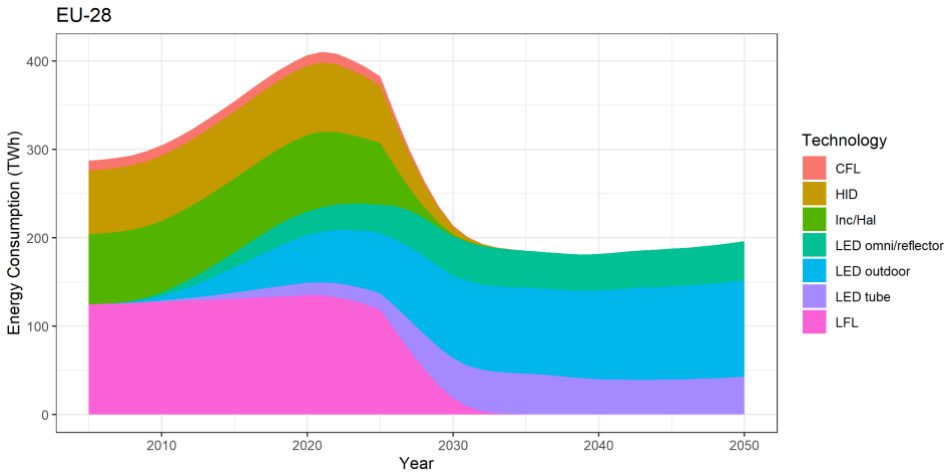


FIGURE 35. LIGHTING ENERGY CONSUMPTION IN BRAZIL UNDER THE BAU SCENARIO

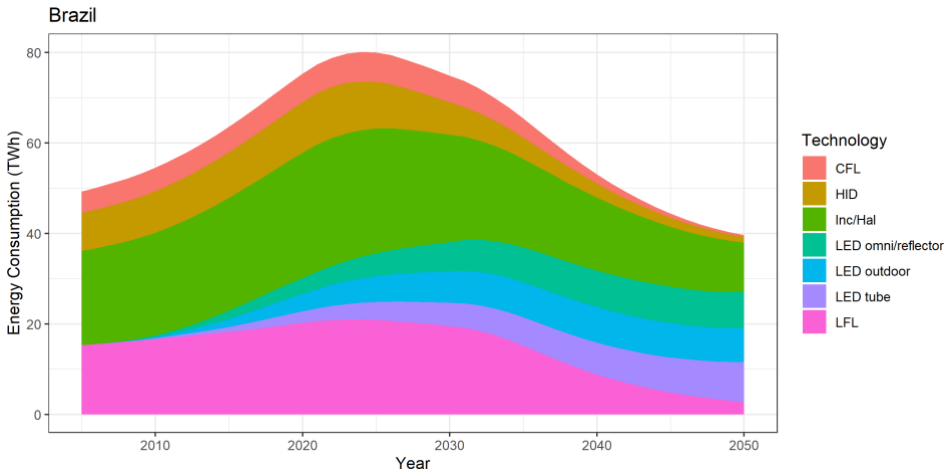


FIGURE 36. LIGHTING ENERGY CONSUMPTION IN BRAZIL UNDER THE NON-LED PHASE-OUT SCENARIO IN 2025

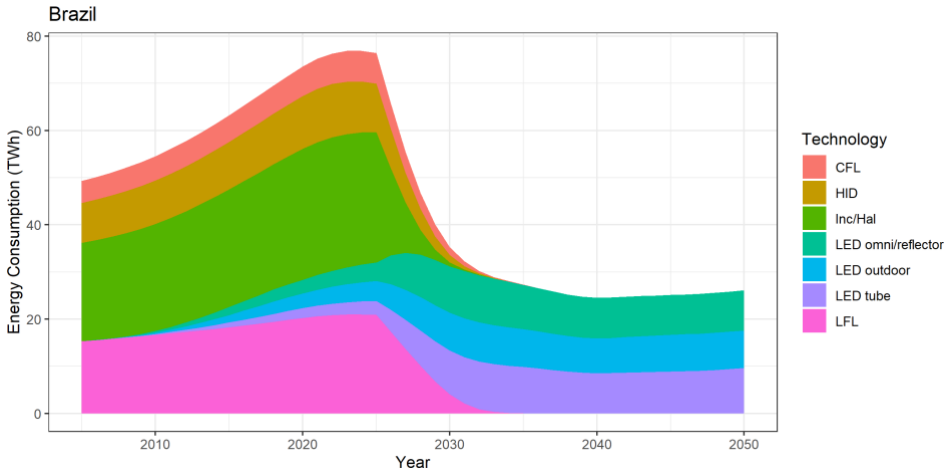


TABLE 8. COMPILATION OF NATIONAL SAVINGS (TWH) – GLOBAL BENCHMARK SCENARIO

YEAR	GLOBAL	UNITED STATES OF AMERICA	CHINA	EU-28	INDIA	BRAZIL	SCENARIO
2026	130.9	16.4	47.9	9.1	11.7	2.5	Global Benchmark
2027	248.3	29.4	92.7	16.5	21.7	4.7	
2028	347.0	38.8	132.7	22.1	29.5	6.4	

2029	423.2	44.8	165.9	25.6	34.7	7.6	
2030	473.5	47.5	190.2	27.4	37.0	8.3	
2031	495.2	46.8	204.0	27.3	36.1	8.6	
2032	488.2	43.3	206.1	25.9	32.9	8.6	
2033	462.9	38.2	200.1	23.7	28.6	8.4	
2034	428.5	32.6	189.6	21.4	24.2	7.9	
2035	391.1	27.2	177.0	19.1	20.2	7.5	
2036	354.2	22.5	163.5	17.0	16.9	7.0	
2037	320.8	18.6	150.7	15.2	14.4	6.5	
2038	291.7	15.7	139.3	13.7	12.6	6.0	
2039	265.3	13.3	128.8	12.3	11.2	5.6	
2040	239.9	11.3	118.8	10.8	9.9	5.1	
2041	215.5	9.5	109.2	9.4	8.7	4.7	
2042	193.2	8.0	100.4	8.1	7.6	4.2	
2043	173.8	6.8	92.4	7.1	6.7	3.8	
2044	157.1	5.8	85.3	6.3	5.8	3.5	
2045	142.7	5.0	78.9	5.6	5.1	3.2	
2046	130.3	4.3	73.3	5.1	4.5	3.0	
2047	119.3	3.7	68.1	4.6	3.9	2.7	
2048	109.7	3.2	63.4	4.2	3.5	2.5	
2049	101.1	2.8	59.2	3.8	3.0	2.3	
2050	93.4	2.4	55.3	3.5	2.7	2.2	
CUMULATIVE	6796.8	497.6	3092.9	344.9	393.3	132.9	

TABLE 9. COMPILATION OF NATIONAL SAVINGS (TWH)– NET ZERO HERO SCENARIO

YEAR	GLOBAL	UNITED STATES OF AMERICA	CHINA	EU-28	INDIA	BRAZIL	SCENARIO
2026	173.0	20.0	57.4	13.1	17.0	2.8	Net Zero Hero
2027	296.8	33.3	105.1	20.9	28.0	5.0	
2028	399.4	42.9	146.9	26.6	36.5	6.8	
2029	477.1	48.9	181.0	30.1	42.1	8.0	
2030	526.7	51.6	205.4	31.7	44.5	8.7	
2031	547.2	50.8	219.0	31.5	43.6	9.0	
2032	537.4	47.1	220.2	29.8	40.2	8.9	
2033	508.4	41.7	213.1	27.3	35.5	8.6	
2034	469.9	35.8	201.3	24.6	30.6	8.2	
2035	428.4	30.2	187.4	22.0	26.1	7.7	
2036	387.5	25.1	172.7	19.6	22.3	7.2	
2037	350.4	21.0	158.9	17.6	19.3	6.6	
2038	317.7	17.8	146.3	15.7	16.9	6.2	
2039	288.1	15.1	134.9	14.1	15.0	5.7	
2040	259.8	12.9	124.1	12.4	13.3	5.2	
2041	232.8	10.9	113.7	10.8	11.6	4.7	
2042	208.2	9.3	104.2	9.3	10.1	4.3	
2043	186.8	7.9	95.7	8.1	8.8	3.9	
2044	168.4	6.7	88.1	7.2	7.7	3.6	
2045	152.5	5.8	81.3	6.4	6.7	3.3	
2046	138.9	5.0	75.3	5.8	5.9	3.0	
2047	126.9	4.3	69.9	5.2	5.2	2.8	
2048	116.3	3.8	65.0	4.7	4.6	2.6	
2049	107.0	3.3	60.6	4.3	4.0	2.4	

2050	98.7	2.9	56.6	4.0	3.6	2.2	
CUMULATIVE	7504.5	554.1	3284.2	403.0	499.3	137.2	

GLOSSARY

BAU (Business-as-usual) Scenario: A scenario that assumes no changes in lighting policies between 2020 and 2030, reflecting current trends without additional interventions.

CAGR (Compound Annual Growth Rate): The rate of growth of a variable over a specific time period, compounded annually. For this model, it is applied to estimate country-specific growth rates for shipments of different lighting technologies.

CFL (Compact Fluorescent Lamp): A type of fluorescent light that is more energy-efficient than incandescent bulbs, used primarily in residential and commercial lighting.

Efficacy: A measure of how efficiently a light source produces visible light, expressed in lumens per watt (lm/W).

Floor Space: The total square meters of floor area in buildings, used in the model to assess lighting service per unit of space.

GB (Global Benchmark) Scenario: A scenario that assumes the implementation of a lighting policy that forces the market to transition to LED technologies only, similar to the EU ban on halogen and CFL lamps.

Guidehouse: A market research group that provides shipment data and forecasts on global lighting markets, which CLASP uses for their analysis.

HID (High-Intensity Discharge) Lamp: A type of gas-discharge lamp that produces light by passing an electric current through a gas. It is commonly used for street lighting and industrial applications.

Illumination Level: A measure of the amount of light (lumens) provided per unit of area (square meter). In the model, it is tracked over time to ensure adequate lighting levels are maintained relative to building floorspace.

LED (Light Emitting Diode): A highly energy-efficient lighting technology that has rapidly evolved in efficacy and wattage, replacing traditional incandescent and fluorescent lighting.

LFL (Linear Fluorescent Lamp): A type of long fluorescent light, often used in commercial and industrial settings. It is more energy-efficient than incandescent bulbs.

MEPS (Minimum Energy Performance Standards) Scenario: A scenario that assumes lighting policies enforce a transition to higher-efficiency lighting, including the phase-out of non-LED technologies in favor of LEDs.

MELiSA Model: The Model for European Light Sources Analysis, developed by VHK to support the European Commission in Ecodesign regulations, used for projecting European lighting market trends.

Non-LED Technology: Lighting technologies that are not based on LED technology, such as incandescent, halogen, and fluorescent lighting.

Operating Hours: The annual number of hours a lighting technology is expected to operate. This value helps determine the total energy consumed by a light source.

Professional Sector: A sector that includes lighting technologies used in commercial, industrial, and outdoor applications, as opposed to the residential or "domestic" sector.

Shipment Backcasting: A method of estimating historical shipments of lighting technology, starting from available data and using growth rates (CAGRs) to backtrack the shipment values.

Shipment Forecasting: A method of predicting future shipments of lighting technology by extrapolating historical data and growth trends.

Take-back Effect: A phenomenon in which the lighting service (illuminance level) per square meter increases over time, leading to a slight reduction in the total shipments of lighting to maintain consistent illumination levels.

Total Lighting Service: A measure of the total amount of light provided over a period, usually expressed in lumen-hours, taking into account the wattage, efficacy, operating hours, and lifetime of the lighting technologies in use.

Total Electricity Consumption: The total amount of electricity consumed in a country, used as a basis to estimate the share of electricity consumption attributable to lighting.

UEC (Unit Energy Consumption): The amount of energy consumed by a specific lighting technology, typically measured in kilowatt-hours, based on wattage and operating hours.

Wattage: The power consumption of a light source, typically measured in watts (W). Wattage varies depending on the technology used (e.g., LED, CFL, incandescent).

Wattage Adjustment: Changes in the power consumption (wattage) of lighting technologies, such as LEDs, over time as technological advancements lead to more efficient lighting solutions.

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