Comment Received From: California Investor Owned Utilities
Submitted On: 11/10/2020
Docket Number: 17-AAER-12

Small Network Equipment White Paper

Additional submitted attachment is included below.

Small Network Equipment:
Energy Savings Opportunities and Test Procedure Needs for the LPM Roadmap

November 10, 2020

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY

SOUTHERN CALIFORNIA EDISON

SAN DIEGO GAS AND ELECTRIC

Prepared by:
Katherine Dayem, XERGY CONSULTING
Chris Granda, ENERGY SOLUTIONS

This report was prepared by the California Statewide Investor-Owned Utilities Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

Acknowledgements

The Statewide CASE Team would like to acknowledge Jay Yang of 2050 Partners, Noah Horowitz of the Natural Resources Defense Council, and Hans-Paul Siderius of the Netherlands Enterprise Agency for their contributions to this report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Executive Summary

The Statewide Codes and Standards Enhancement (CASE) initiative presents research findings in support of the California Energy Commission's (Energy Commission) efforts to update California's Appliance Efficiency Regulations (Title 20) and, more broadly, to increase appliance energy efficiency in California. The California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE) (herein referred to as the Statewide CASE Team) – sponsored this white paper as part of ongoing efforts to support the Energy Commission's Low Power Mode (LPM) Roadmap and the related Data Collection Procedure (DCP).

The United States (U.S.) Voluntary Agreement (VA) for Ongoing Improvement in the Energy Efficiency of Small Network Equipment (SNE)[1] has been in effect for four years as an industry-led alternative to mandatory minimum energy efficiency standards for SNE. The VA has been in existence long enough that it is now possible to assess the effectiveness of the VA in reaching its stated goals. The SNE industry has claimed that the VA adequately addresses their products' energy consumption and recommends that SNE should therefore be left out of the Energy Commission's LPM Roadmap. This document assesses the SNE industry's claims and presents the results of the Statewide CASE Team investigation into VA test procedures and SNE energy consumption.

The Statewide CASE Team wrote this white paper to (1) evaluate whether the LPM Roadmap could achieve additional SNE energy savings beyond those gained through the VA and (2) review and recommend changes to test procedures for measuring SNE power consumption for the purpose of the LPM DCP. This white paper also presents the findings of the Statewide CASE Team review of available information on the VA, an analysis of the SNE market in the U.S., and a review of international efforts to improve the energy efficiency of SNE.

With no regulatory authority, the VA is a voluntary program that applies only to the businesses that choose to sign it. Even if many of the SNE products available on the market were to comply with the VA energy efficiency targets, broad compliance with the VA's requirements by non-signatories to the VA might only demonstrate that the VA's targets are not difficult to achieve. Therefore, the effectiveness of the VA should be measured both by breadth, in terms of the market share of complying SNE products, and by stringency in terms of its energy efficiency targets.

Regarding the breadth of coverage, the Statewide CASE Team assessment shows that the VA is more successful for one kind of sub-category of SNE than the other. A review of available market data indicates that VA signatories accounted for more than 80 percent of U.S. shipments of wide area network (WAN) SNE products in 2018. However, VA signatories were only responsible for about half of local network equipment (LNE) SNE products shipped in that year. **Including LNE in the LPM Roadmap would broaden the coverage of energy efficiency requirements and could yield additional energy savings.**

Regarding stringency, the Statewide CASE Team analysis also suggests that the VA energy efficiency targets may be too lenient for some covered products. In 2018 and 2019, 85 and 93 percent of models reported to the VA already met Tier 2 efficiency levels, respectively, which did not come into effect until 2020. Some SNE products exceeded VA efficiency levels by wide

[1] The VA and annual reports can be found online at: https://www.energy-efficiency.us/#:~:text=The%20primary%20objective%20of%20the,and%20timely%20introduction%20of%20new

margins. **If the LPM Roadmap applied more stringent efficiency levels it could yield additional SNE energy savings beyond what the SNE VA has been able to achieve.**

With respect to test procedures, the Statewide CASE Team believes that with select modifications, the American National Standards Institute/Consumer Technology Association® (ANSI/CTA) - 2049 test method could be effectively used for SNE for the purposes of the LPM Roadmap. **The Statewide CASE Team would not recommend developing an entirely new SNE test method to generate data to inform the LPM Roadmap; however, modifications to ANSI/CTA-2049 would make it more realistic and representative for the context of the LPM DCP.**

2. Introduction

With the global proliferation of consumer electronics products there is a large and growing set of devices that consume power when not performing their primary, active-mode energy service. Devices with these idle or "low power mode" functions are responsible for a growing share of total electricity use, and often are not already subject to energy efficiency standards. Consumer electronics products are often designed around new technologies that continue to evolve rapidly, which can make regulating their energy efficiency difficult. SNE products are an example of electronic devices that have become ubiquitous in businesses and homes across the U.S. over the last 20 years as access to the Internet has become a modern necessity; however, SNE is not covered by current federal or state energy efficiency standards.

The Energy Commission initiated the Low Power Mode (LPM) "Roadmap" to meet the twin challenges of encouraging continuous energy efficiency improvement for devices that are able to enter a LPM and the need to avoid constraining the technological evolution of those devices and the services that they provide. An outline of the Roadmap process and how it might evolve into a typical Energy Commission Title 20 Regulation is shown in Figure 1.

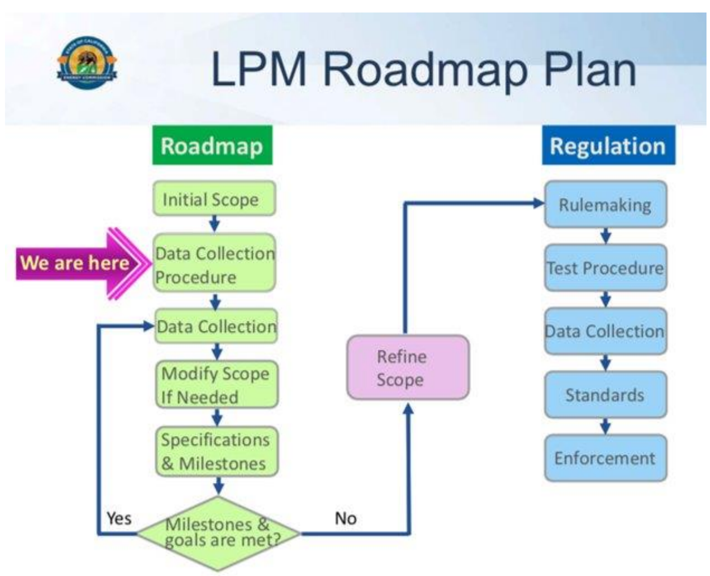

Figure 1: Outline of LPM Roadmap and resulting regulation if milestones are not met.

Source: California Energy Commission (2019).

The LPM Roadmap involves a Data Collection Procedure (DCP), similar to a Test Procedure used in conventional energy efficiency standards, and energy performance requirements based on the cost-effectiveness and technical feasibility of potential energy savings. Also, like conventional regulations, the Roadmap process offers opportunities for public comment during development. However, because the Roadmap is voluntary, it can propose solutions that are more flexible and less burdensome to industry than traditional standards. The Energy Commission has indicated that it will pursue conventional LPM standards if the Roadmap process does not meet targets regarding industry participation and energy efficiency improvements.

The Energy Commission's initial scope for the LPM Roadmap includes SNE. Several SNE vendors and trade organizations have argued that SNE should not be included in the Roadmap, in part because the VA exists and has been effective at improving the energy efficiency of SNE in the U.S.[2,3] In this white paper, the Statewide CASE Team reviews the savings potential of SNE and the degree to which that potential has been realized by the VA. Based on market research data obtained from ABI Research, the Consumer Technology Association (CTA), and Informa Tech, as well as annual reporting for the VA (D+R 2019, 2020), the Statewide CASE Team estimates that about 170 to 260 million SNE units are installed in the U.S. today, of which approximately 31 million units are in California (by proportion of population). Assuming that power consumption reported by VA signatories in the VA annual reporting is representative of this current stock, the Statewide CASE Team estimates that SNE consumes over 2,000 gigawatt-hours (GWh) of electricity per year in California. Because even a small percentage reduction in SNE energy use could yield GWh-scale savings in California, the Statewide CASE Team believes it is valuable to estimate the savings opportunity of SNE if it were to be included in the LPM Roadmap, as opposed to the savings achieved under the SNE VA.

3. Energy Savings Potential Beyond the SNE VA

3.1 U.S. SNE VA Overview

The U.S. VA for SNE was adopted in 2015 and has been effective since 2016. Signatories of the VA include Internet service providers that often provide SNE to their residential and business customers, SNE vendors that offer network equipment for sale through retail channels, and trade associations that organize and advocate for the SNE industry (Table 1). Signatories to the VA commit to sell or install products that meet power targets based on product type and functions. Signatories pledge that at least 90 percent of new SNE installed by Internet service providers[4] and sold by vendors will comply with the target limits. To demonstrate compliance, signatories submit annual sales and product power draw data to the independent administrator responsible for determining overall compliance with the VA. In 2018 VA signatories adopted a second Tier of target levels, which increased stringency for some functional allowances. The Tier II levels became effective at the beginning of 2020. The VA will expire in 2021 unless the signatories renew it.

[2] https://efiling.energy.ca.gov/GetDocument.aspx?tn=219188&DocumentContentId=26803

[3] https://efiling.energy.ca.gov/GetDocument.aspx?tn=221110&DocumentContentId=26809

[4] In this context, service provider is intended to mean an entity that provides broadband Internet access services to residential subscribers with whom it has an ongoing contractual relationship through a cable, satellite, or other managed distribution network provided by that entity, as defined in the SNE VA.

Table 1: U.S. SNE VA Signatories

Service Provider	Vendor	Trade Association
Altice USA	Actiontec Electronics	Consumer Technology Association (CTA)
AT&T Services	ASUSTeK*	NCTA – The Internet & Television Association
Cablevision Systems	Belkin International*	Cable Television Laboratories (CableLabs)
CenturyTel Broadband Services (CenturyLink)	CommScope (formerly ARRIS)	
Charter Communications	Netgear	
Comcast Cable Communications	Technicolor Connected Home USA	
Cox Communications	Ubee Interactive	
Frontier Communications	Actiontec Electronics	
Verizon Communications		

* New signatory in December 2019 (Belkin) and February 2020 (ASUSTeK).
Source: SNE VA Signatories (SNE VA Signatories 2020).

The VA was designed to improve the energy efficiency of SNE without sacrificing product functionality or interfering with technology innovation and avoid government energy efficiency regulations (SNE VA Signatories 2020). Signatories commit to promoting the VA as an alternative to federal or state energy efficiency regulations and agree to terminate the VA if a federal or state authority initiates SNE efficiency regulation proceedings.

Signatories to the VA agree that:

> "It is intended to be a complete and adequate substitute for all Federal and State legislative and regulatory solutions related to the energy efficiency of SNE. The Signatories agree that this agreement is the preferred means for addressing the energy consumption of complex and rapidly changing networked devices that consumers purchase for home use for Internet access" (SNE VA Signatories 2020).

The VA covers both WAN equipment and local network equipment (LNE)[5] (Figure 2). WAN products include modems, integrated access devices (IADs, also referred to as gateways) and optical network terminals (ONTs) that provide the data interface between the building's local area network (LAN) and the Internet service provider's wired or optical network. IADs provide the interface to the WAN and also route data traffic to the LAN of a home, building, or collection of buildings. LNE includes routers, access points, switches, and network extenders including Wi-Fi mesh systems. These devices route and move data traffic through the LAN.

[5] Also referred to as local area network (LAN) equipment.

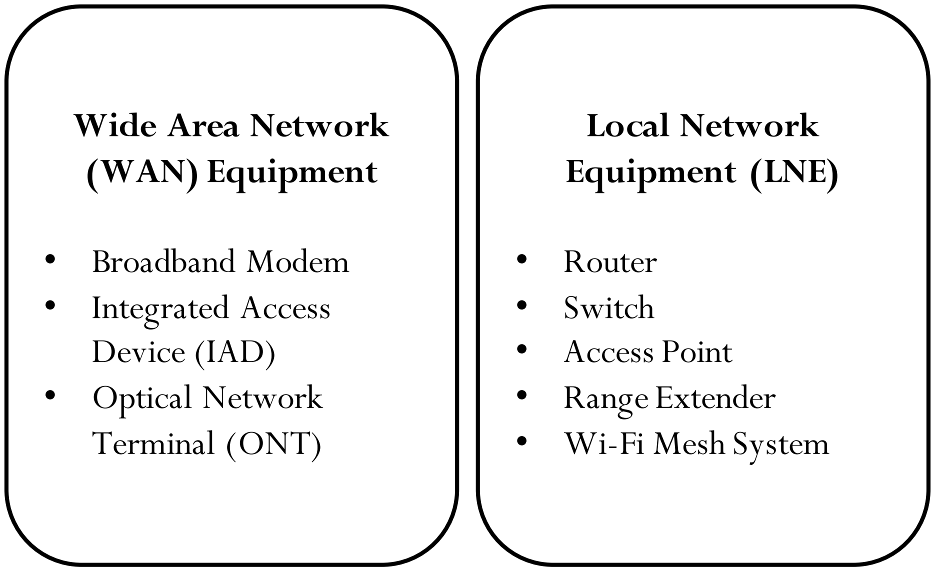

Figure 2: Products covered by the VA by product category.

Source: Statewide CASE Team summary of categories within SNE VA Signatories (2020).

As of this writing, there is no federal or state regulation of the energy efficiency of SNE in the U.S. The U.S. Environmental Protection Agency (EPA) issued the voluntary ENERGY STAR® specification for SNE in 2012 but it has not been embraced by the SNE industry (see further discussion below). SNE energy efficiency has been addressed by regulatory initiatives in Europe,[6] and as noted above the Energy Commission currently includes SNE in its proposed LPM Roadmap.

Because WAN equipment must be configured to communicate correctly with a specific Internet interface, the service provider generally provides WAN equipment with Internet service in the form of a modem, IAD, or ONT. Consumers can also purchase WAN equipment through retail channels, but it must be compatible with their service provider's network. Some service providers also supply consumers with LNE such as range extenders or routers, but as shown below, customers more often purchase these LNE products through retail channels to set up or improve LAN coverage for their homes or businesses.

3.2 Market Coverage

A key measure of the effectiveness of the VA is the share of the U.S. SNE market that it influences. The greater the share of the total SNE market claimed by VA signatories, the more products installed or sold in the U.S. must meet VA targets. Substantial gaps in VA coverage may indicate an opportunity to improve SNE energy efficiency through the LPM Roadmap. In this section, the Statewide CASE Team estimates market coverage of the VA for the two main categories of SNE: WAN equipment and LNE.

Internet service providers who are VA signatories provide broadband to about 89 percent of residential Internet subscribers in the U.S. (D+R 2019, 2020). VA signatories do not report the

[6] (EU) No 801/2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electric and electronic household and office equipment.

proportion of subscribers served by signatories in the commercial and industrial sectors, nor do they estimate the share of the LNE market claimed by VA signatories. In order to examine how much of the SNE market VA Signatories address, the Statewide CASE Team examined data from three market research sources: ABI Research, CTA, and Informa Tech. In addition, the Statewide CASE Team gathered data from SNE retailer websites to better understand how many vendors sell SNE products, particularly in the expanding LNE category. The Statewide CASE Team found that WAN equipment is well-covered by the VA but that coverage of LNE is below 50 percent. It may be challenging for the VA to improve coverage for LNE given rapid changes in brands and technologies, as discussed below in Section 3.2.2.

3.2.1 WAN Equipment

Estimates of WAN shipments in the U.S. derived from the various sources examined do not agree. CTA estimates of WAN shipments for 2017 and 2018 are fairly consistent with VA reporting for each of those years, but are significantly lower than Informa Tech estimates, as shown in Figure 3. Additionally, CTA predicts growing WAN shipments through 2022, while Informa Tech predicts slight growth in the next few years after five years of declining or relatively flat sales.

The Statewide CASE Team therefore estimates that WAN shipments in the U.S. are fairly well covered by the VA. Five vendor signatories of the VA account for approximately 72 percent of 2018 WAN shipments in North America (Informa Tech 2020a) as shown in Figure 4. An additional eight or more percent of WAN shipments were brands that Internet service provider VA signatories installed that year. The Statewide CASE Team estimates that approximately 80 to 89 percent of U.S. WAN shipments are subject to the VA, based on Informa Tech and VA data estimates, respectively.

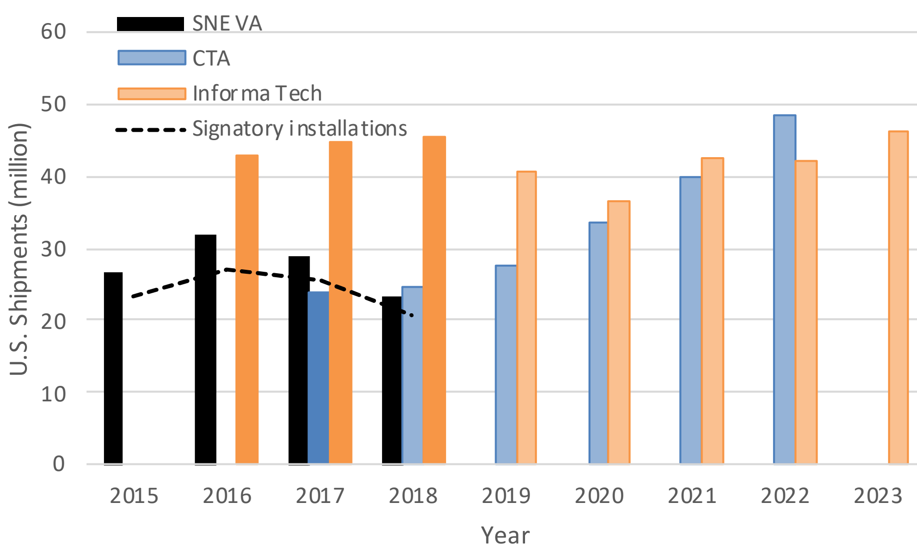

Figure 3: WAN shipments in the U.S.

Note: Shipments based on two market research datasets, CTA (2018) (blue bars) and Informa Tech (2020a) (orange bars) as well as VA data (black bars). Projected (rather than actual) shipments are indicated by faded bars. The number of installations reported by VA signatories is indicated by the dashed black line (D+R 2019).
Source: Statewide CASE Team analysis of CTA and Informa Tech datasets.

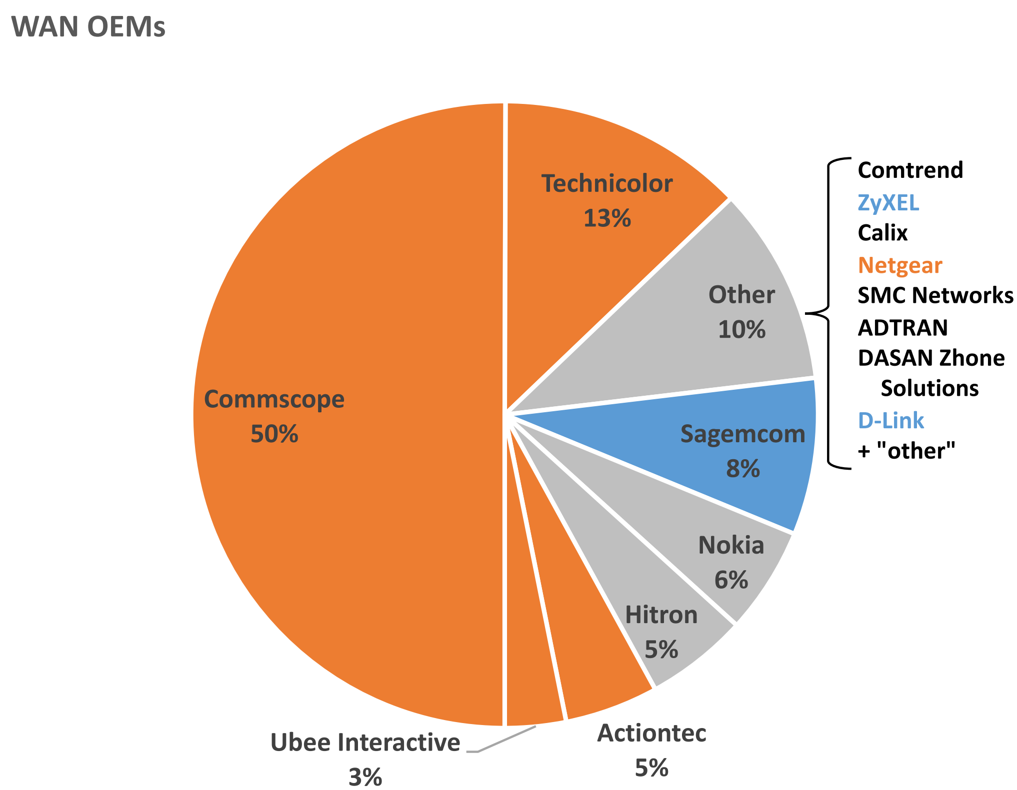

Figure 4: WAN shipments by brand in North America.

Note: Market data for 2018, estimated by Informa Tech (2020a). Orange indicates VA vendor signatories. Blue indicates additional brands installed by Internet service provider signatories. Gray slices indicate brands that are not subject to the VA.
Source: Statewide CASE Team analysis of Informa Tech datasets.

3.2.2 LNE

Estimates of LNE shipments in the U.S. also differ across the market databases accessed; Informa Tech (2020b) estimates of router, Wi-Fi extender, and whole-home Wi-Fi systems are about double the CTA estimates, but both predict continued growth of LNE shipments, as shown in Figure 5. CTA (2018) shipments are less than the sales and installations by VA signatories, and given that the Informa Tech data seems to be a more accurate picture of the market as compared to VA data, the Statewide CASE Team assessment is that CTA (2018) is underestimating LNE shipments.

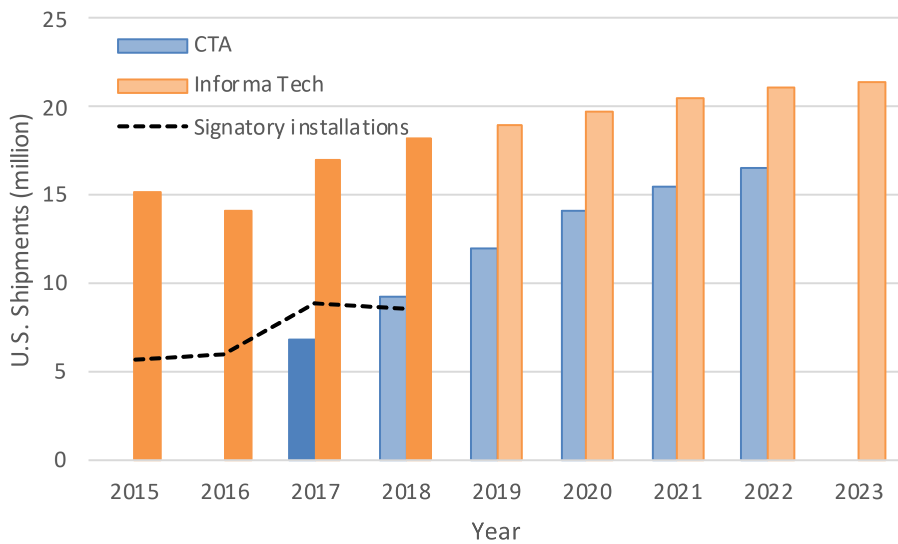

Figure 5: LNE shipments in the U.S.

Note: Shipments based on two market research datasets, CTA (2018) (blue bars) and Informa Tech (2020b) (orange bars). The number of installations reported by VA signatories is indicated by the dashed black line (D+R 2019). Light-colored columns indicate shipment forecasts.
Source: Statewide CASE Team analysis of CTA and Informa Tech datasets.

Much of the predicted growth of the LNE market is due to whole-home Wi-Fi network equipment, as shown in Figure 6. These systems create a mesh Wi-Fi network in the home or building to improve coverage. They are growing in popularity due to their off-the-shelf availability to consumers at retail stores and their ability to improve a home's network coverage, usually without service provider intervention. All three datasets predict these devices will account for almost half or more of LNE shipments by 2022. Aspects related to whole-home Wi-Fi systems, such as test set up and base allowances, are not yet specifically addressed in the SNE VA.

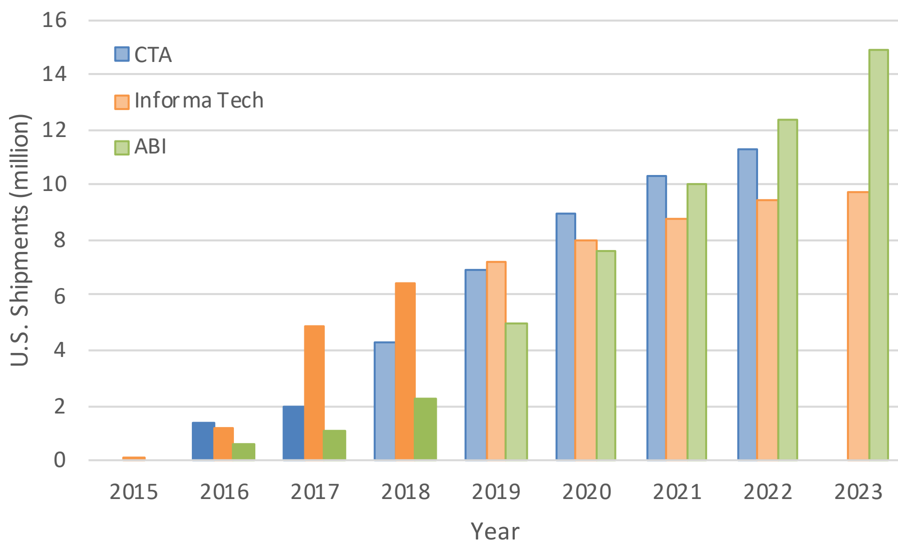

Figure 6: Whole-home Wi-Fi system shipments in the U.S.

Note: Shipments estimates based on three market research datasets: CTA (2018) (blue bars), Informa Tech (2020b) (orange bars), and ABI Research (2018) (green bars).
Source: Statewide CASE Team analysis of CTA, Informa Tech, and ABI Research datasets.

Perhaps in part because of the shift in the LNE market towards newer product types like whole-home Wi-Fi systems, the LNE market includes not only traditional SNE brands (who also tend to offer WAN equipment), but also vendors that are relatively new to SNE, such as Google, Plume, and Eero. About 48 percent of North American LNE shipments in 2018 were from VA vendor signatories, as shown in Figure 7.

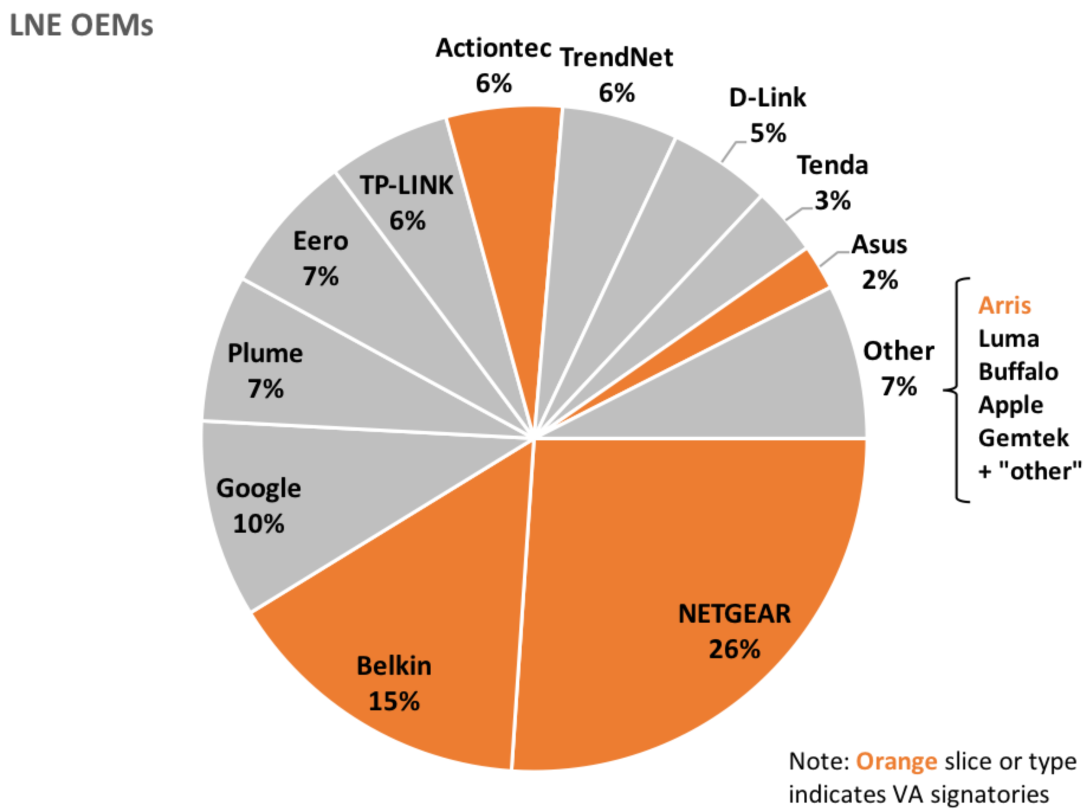

Figure 7: WAN shipments by vendor in North America.

Note: Market data for 2018 estimated by Informa Tech (2020b). Orange indicates VA vendor signatories.
Source: Statewide CASE Team analysis.

To better understand the major players in LNE and the extent of their offerings, the Statewide CASE Team analyzed retail models sold online by two electronics-focused websites (Newegg and B&H Photo) as of June 2020. The Statewide CASE Team finds that about 560 LNE models were available on these sites, whereas only 16 LNE models were reported in the VA annual report of 2019 installations (D+R 2020).

Statewide CASE Team analysis shows that about five brands offer several dozen LNE models, and a long tail of 59 brands offer ten or fewer models (Figure 8). Of the 72 vendors represented on these two retail sites, only Netgear, Asus, and Belkin are VA signatories. Although Newegg and B&H Photo do not carry every LNE brand, the Statewide CASE Team research shows that a large and diverse set of LNE vendors do not participate in the VA.

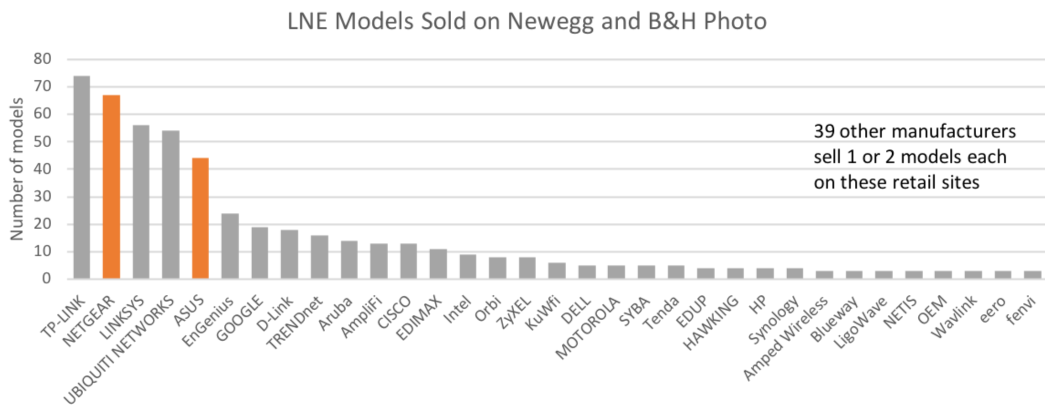

Figure 8: Number of LNE models by brand sold on Newegg and B&H Photo retail websites.

Note: Orange bars indicate VA signatories. Belkin, a new VA signatory, sells one model on these sites.
Source: Statewide CASE Team analysis.

The market information suggests that about half of LNE shipments in the U.S. are not subject to VA targets, and the large number of brands in the LNE space may make it particularly challenging to address LNE with the VA in its current form.

3.3 VA Stringency

The VA sets targets for SNE idle power consumption calculated by starting with a base allowance, depending on product type, and functional adders which increase allowable idle power for SNE models that offer additional features. The structure of the VA requirements is fairly complex, with 18 different base allowances and 30 functional adders.

The Statewide CASE Team analysis of models reported under the VA in 2018 and 2019 suggests that VA targets are somewhat lenient for several reasons. First, the reported power draw of a large number of models is well under Tier 2 targets. Second, SNE models with the same functionality can show a wide margin in power draw, with some models providing the same functions for less power than others. Third, many power allowances and adders set by the SNE VA are significantly higher than comparable targets in the European Union (EU) Code of Conduct (CoC), the voluntary agreement for broadband network equipment in Europe, and may be higher than those of the U.S. VA for set-top boxes (STB). These three lines of reasoning, which are described in the following paragraphs, lead the Statewide CASE Team to conclude that additional savings potential for SNE exists, and may be realized through the LPM roadmap.

3.3.1 Pass Margin Analysis

As noted above, Tier 2 targets became effective at the beginning of 2020. 93 percent of models reported for the VA in 2019 already meet Tier 2 levels, with 35 percent of models passing those targets by more than 25 percent, as shown in Figure 9. This suggests that some models may possess much more efficient designs than others, and raises the question: are the targets stringent enough to yield real energy savings pressure on the market?

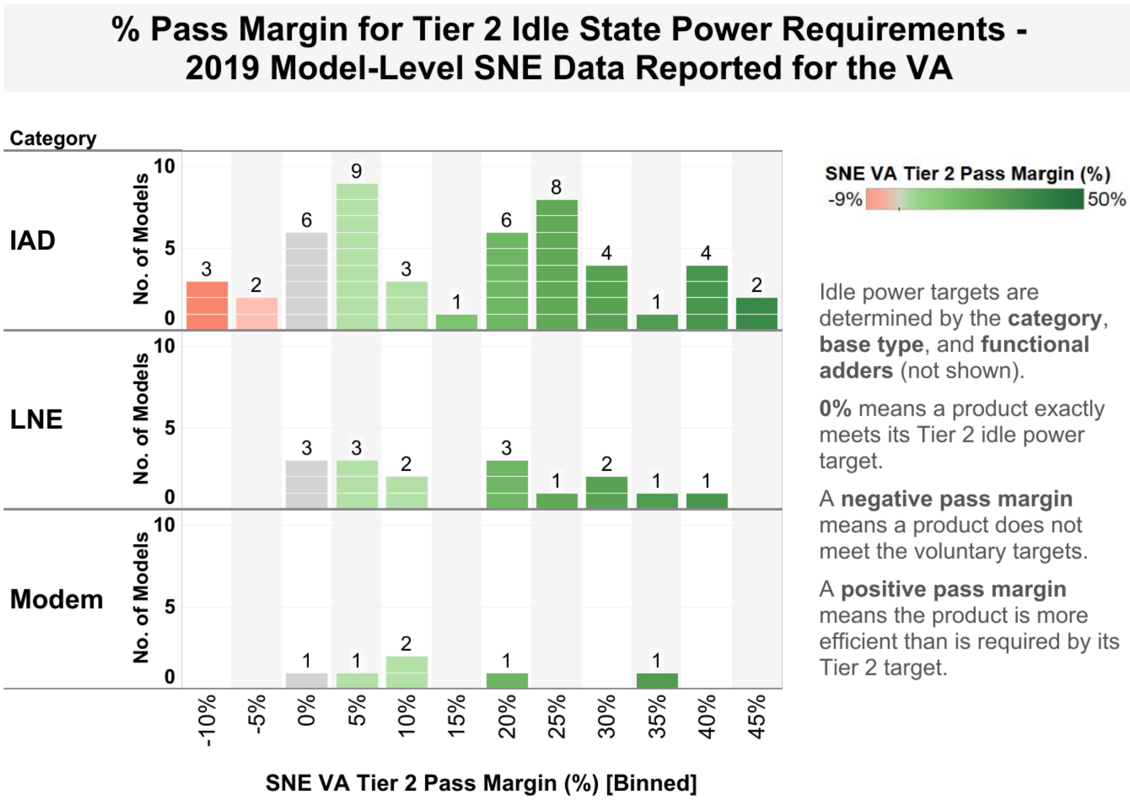

Figure 9: Pass margin of models reported for the VA in 2019 relative to Tier 2 (effective 2020) power requirements.

Source: Statewide CASE Team analysis of data presented in D+R (2020).

3.3.2 Matched Models Analysis

To begin assessing energy savings potential of SNE models that are subject to the VA, the Statewide CASE Team conducted a "matched models" analysis, in which models that receive both the same base allowance and the same or similar functional adders were grouped to begin to identify the most efficient models in the dataset. Because so many unique combinations of base allowance and adders exist within the 71 models reported in 2019 (D+R 2020), it was challenging to find models that were exact matches, but some do exist. Table 2 shows four groups of SNE models that are of the same base type and have the same, or nearly the same, features. The rightmost column estimates the savings potential of a given model if its power is reduced to the lowest power achieved in the group. In the examples presented here, savings potential ranges from ten to 31 percent.

Table 2: Matched Models Analysis

Brand	Model	Base type	Base Allow-ance (W)	Additional Functions that Qualify for Adders: Functions	Additional Functions that Qualify for Adders: Total Adder (W)	Tier 2 Target Power (W)	Reported Idle Power (W)	Tier 2 Pass Margin (%)	Potential Savings (%)
ARRIS	SB8200	Modem with DOCSIS 3.1 WAN interface	13.6	2 gigabit Ethernet LAN ports	0.4	14.0	10.8	23%	-
ARRIS	CM8200A/ P2						12.0	14%	10%
Ubee	E31U2V1	IAD with DOCSIS 3.1 WAN interface	15.1	1 gigabit Ethernet LAN port; 2 phone ports	0.8	15.9	8.0	49.7%	-
Technicolor	E31T2V1						9.0	43.4%	11%
Hitron	E31N2V1						10.5	34.0%	24%
NETGEAR	D2200D	IAD with ADSL2plus WAN interface	3.7	4 Fast Ethernet LAN ports; 1 low power Wi-Fi IEEE 802.11n radio; 1 connected PCIe interface	2.0	5.7	4.2	26.3%	-
Dlink	DSL-2750B			4 Fast Ethernet LAN ports; 1 low power Wi-Fi IEEE 802.11n radio; 1 USB2 interface (not connected)	1.9	5.6	5.1	9.8%	17%
Actiontec	GT784WNV						6.06	-8.2%	31%
Actiontec	GT784WNV						6.09	-8.7%	31%

Brand	Model	Base type	Base Allow-ance (W)	Additional Functions that Qualify for Adders		Tier 2 Target Power (W)	Reported Idle Power (W)	Tier 2 Pass Margin (%)	Potential Savings (%)
				Functions	Total Adder (W)				
ARRIS	SBV2402	IAD with DOCSIS 3.0 WAN interface	6.0	5 Additional groups of 4 downstream simultaneous WAN interfaces; 1 Gigabit Ethernet LAN port; 1 phone port	7.0	13.0	7.8	41%	-
ARRIS	TM1602G			5 Additional groups of 4 downstream simultaneous WAN interfaces; 1 Gigabit Ethernet LAN port; 1 phone port; 1 backup battery	7.4	13.4	10.5	23%	23%

Source: Statewide CASE Team analysis.

Statewide CASE Team analysis of models in the 2018 VA annual report (D+R 2019) suggests that if all models installed by VA signatories were as efficient as the most efficient models in the VA annual report data, IADs, modems, and LNE power draw could be reduced by ten, 15, and 25 percent, respectively.[7] Scaling this level of savings to the stock of WAN (IADs and modems), and LNE in California, the Statewide CASE Team estimates savings of 280 to 340 GWh/year in California by improving all SNE to the most efficient products that fall under the VA. The Statewide CASE Team presents potential savings as a range due to uncertainty in LNE stock, discussed above in Section 3.2.2.

These figures are presented as preliminary estimates based on the data that are available but have several limitations. First, the savings estimates are model-weighted rather than sales-weighted and based on a relatively small dataset. In addition, the estimates are based only on models reported for the VA. More efficient models may be available on the market, and the market baseline may be more or less efficient than the models represented in the VA. The analysis, however, does suggest that some models can perform the same functions more efficiently than others (as the examples in Table 2 show), and therefore it is likely that more stringent requirements could increase energy savings without affecting product performance.

3.3.3 EU CoC and STB VA Targets

Using another approach to assess the stringency of the U.S. SNE VA, the Statewide CASE Team compared SNE VA power allowances and adders to comparable metrics in the EU CoC (Bertoldi and Lejune 2020). The EU CoC's scope differs from the VA, covering WAN equipment as well as upstream network equipment, such as that in data centers. However, several base allowances for IADs (termed "home gateways" in the CoC) map directly to allowances in the VA. In addition, some but not all of the adders claimed by models in VA annual reports (D+R 2019, 2020) can be compared to equivalent adders in the CoC. These comparisons are presented in Table 3 for applicable targets in 2020. Wi-Fi functions are intentionally omitted from the table because the VA and CoC segment adders by protocol, frequency, and transmit power differently. Although direct comparisons cannot made, these Wi-Fi adders are of similar magnitude in the two sets of targets. Table 3 shows that power allowances and adders in the CoC are the same as or lower than the equivalent targets in the VA. In particular, the allowances and adders for WAN and LAN interfaces are significantly lower in the CoC compared to the VA. If the VA base allowances and adders in Table 3 were reduced to the equivalent targets in the CoC, 63 percent of the IAD models listed in the 2019 VA annual report (D+R 2020) would meet CoC targets. If all IAD models in the VA dataset met the CoC targets, power draw would decrease by a model-weighted average of ten percent.

[7] Note that the Statewide CASE Team analysis was carried out on data published in the 2018 annual report (D+R 2019) before the 2019 annual report was published in August 2020 (D+R 2020).

Table 3: Comparison of U.S. VA and EU CoC Power Allowances and Adders

	Power Allowance or Adder (W)	
	U.S. VA	**EU CoC**
IAD Base Allowances		
IAD ADSL2plus	3.7	2.0
IAD DOCSIS 3.0	6	5.0
IAD DOCSIS 3.1	15.1	9.8
IAD SFP GPON	5	3.0
IAD VDSL2	4.5	3.0
IAD 10G EPON	13	3.3
IAD Gigabit Ethernet	4	2.3
Adders		
Gigabit Ethernet Backup WAN Interface	0.4	0.3
VDSL2 Backup WAN Interface	0.7	0.4
VDSL2 Simultaneous WAN Interface	3.2	1.6
DOCSIS 3.0 additional allowance for each additional 4 downstream channels	1.3	1.2
Fast Ethernet LAN Port	0.2	0.2
Gigabit Ethernet LAN Port	0.2	0.2
MoCA	2.2	1.5
FXS (phone)	0.3	0.2
USB 2	0.1	0.1
USB 3	0.2	0.1
BATTERY	0.4	0.1
Bluetooth	0.5	0.1
ZigBee	0.2	0.1
Z-wave	0.2	0.1
PCIe	0.2	0.2

Source: Statewide CASE Team summary of SNE VA Signatories (2020) and Bertoldi and Lejune (2020).

The Statewide CASE Team also compared Wi-Fi adders that exist in both the SNE VA and STB VA to assess their relative stringencies. A direct comparison of adders cannot be made because STB adders are annual energy allowances and SNE adders are power allowances. Assuming that the state of the Wi-Fi connection in both SNE and STB is idle and not passing traffic, which is the state tested for SNE, then the adders are equivalent. However, STBs, when tested using CTA-2043 (the test procedure specified by the STB VA), may use Wi-Fi connections to receive video data. The STB adder, therefore, may apply to a Wi-Fi connection that is sometimes active, rather than always idle.

This suggests that the SNE Wi-Fi adders may have room for improvement, because they apply to a Wi-Fi connection that is always idle.

3.3.4 Constraining Energy Savings Potential

The Statewide CASE Team is beginning testing and research to better constrain the energy savings potential of SNE, and the design improvements that can achieve energy savings without impacting the consumer experience (e.g., without decreasing data transfer rates or increasing latency). These improvements may include strategies employed in other energy efficient designs, such as improved power supply efficiency, more aggressive power management to reduce power to components when they are not in use, and power scaling techniques that match power draw to the level of service provided by a product at any one time.

4. SNE Test Procedures and Recommendations for the LPM DCP

In order to collect the data needed to establish energy efficiency targets for the LPM Roadmap, the Energy Commission has indicated it will develop an LPM DCP for stakeholders to use to collect and report LPM power consumption data for in-scope products (Figure 1). This DCP will include guidance on how to set up a product for testing and how to put it into the correct state, or LPM, for the test.

4.1 ENERGY STAR for SNE

The first and current version ENERGY STAR specification for SNE was finalized in 2013, offering a voluntary recognition label for high-efficiency SNE. The scope of the program included cable and digital subscriber line modems, ONT, IAD, routers, switches, and access points. Energy efficiency criteria apply both to the SNE device and to any associated power supply. There are base power consumption allowances for different types of SNE equipment with allowable power consumption adders for SNE with specific additional functions.

As of September 3, 2020, only two products, a router and an access point, were listed in the ENERGY STAR database of certified SNE products. The ENERGY STAR 2018 Unit Shipment Data Summary Report[8] estimated zero percent penetration for ENERGY STAR labeled products into the U.S. SNE market. Given the lack of industry participation, EPA has not prioritized this program, and both the ENERGY STAR specification and SNE test method were last revised in 2013. Though now somewhat dated, the ENERGY STAR SNE test method remains relevant and may serve as the starting point for the SNE-specific instructions in the DCP.

The ENERGY STAR SNE test method applies to LAN and WAN equipment and requires testing the equipment in a variety of states, depending on equipment type. For general test requirements the ENERGY STAR SNE test method references International Electrotechnical Commission test procedure 62301:2011, the international standard for measuring power draw of low power operating modes, with additional requirements for ambient temperature, relative humidity, input voltage, and power meter attributes. When using this test method, products must be tested in their default, as-shipped condition.

[8] https://www.energystar.gov/sites/default/files/asset/document/2018%20Unit%20Shipment%20Data%20Summary%20Report%20.pdf

The ENERGY STAR test method describes the number and type of wired and wireless connections to make for the test. Products are connected to a live WAN with a wired connection. Wired LAN connections are made via Ethernet, connected so that they can provide the highest link rate the port is capable of. For products with multiple wireless network protocols, the protocol used during the test is selected from a list, which essentially gives precedence to the highest bandwidth Wi-Fi protocol present and the highest frequency available. The Statewide CASE Team notes that when the test method was written, Institute of Electrical and Electronics Engineers (IEEE) 802.11ac was the highest bandwidth Wi-Fi protocol, and the link precedence list is limited to Wi-Fi protocols only.

The test method requires an "idle state" test with no network traffic, plus WAN and LAN tests as applicable for the type of equipment under test, as shown in Table 4. WAN and LAN tests are carried out for two traffic speed conditions: low traffic (one kilobit per second (kb/s)) and the highest rate supported. For the wired LAN test, half of the LAN Ethernet ports in the unit under test (UUT) are connected and put under the required traffic conditions. For the wireless LAN test, one or two radios are connected and subjected to the low and high traffic conditions if the UUT is capable of a single or dual frequency bands, respectively.

Table 4: Tests Required by ENERGY STAR SNE Test Method

Test	Product Type	WAN Connection	Wired LAN Connection	Wireless LAN Connection	Traffic Speed
Idle State	All	1	1	1 (if single band) 2 (if dual band)	0 kb/s
Wired WAN	WAN	1	0	0	1 kb/s and highest rate supported
Wired LAN	IADs, LNE	1	Connect half the ports available on UUT	0	1 kb/s and highest rate supported
Wireless LAN	IADs, LNE	1	1	1 (if single band) 2 (if dual band)	1 kb/s and highest rate supported

Source: Statewide CASE Team summary of U.S. EPA (2013).

Once the UUT is set up for a test, it is powered for five minutes before the test begins. Power is logged every second or less for five minutes, and the measurements are averaged to report the average power draw of the UUT over its five-minute test period.

Many technological advances have occurred since the ENERGY STAR test method was published in 2013, and more are on the horizon. Wi-Fi protocols continue to evolve, and the new IEEE 802.11ax protocol will allow 1 gigabit per second bandwidth. WAN has been constrained to wired connections, but the 5G wireless broadband network will allow wireless WAN connections. New LNE, such as Wi-Fi range extenders and mesh systems, have also been introduced and are gaining broad market adoption. To continue to be applicable, it is likely that the ENERGY STAR test method will need to be updated in the near future.

4.2 ANSI/CTA-2049

ANSI/CTA-2049 is the industry test standard for measuring idle state power of SNE. The procedure is similar to the ENERGY STAR test method and follows the same setup and measurement procedures. The main difference between the two test methods is that ANSI/CTA-2049 requires only the idle state test described in Table 4. ANSI/CTA-2049 defines idle state as a condition in which the equipment is "powered on, but not actively passing traffic" (ANSI/CTA 2015). It does not explicitly state that traffic speed is limited to zero kb/s during the idle state measurement, but the Statewide CASE Team interprets that to be the intent. As in the ENERGY STAR test method, power is measured and averaged over a five-minute test period.

4.3 Applicability to the LPM Roadmap

Both the ENERGY STAR test method and ANSI/CTA-2049 provide many of the SNE-specific instructions that would be necessary to include SNE in the LPM DCP, including how to set up and establish network connections for the test. However, the goal of the DCP is fundamentally different from the ENERGY STAR and ANSI/CTA-2049 test methods; the DCP aims to explore product power behavior when it is not providing its primary function,[9] whereas ENERGY STAR and ANSI/CTA-2049 test methods test compliance to energy efficiency targets for a constrained operating mode. As a result, the Statewide CASE Team has identified three main aspects of the existing test procedures that should be modified for use in the DCP to better represent product behavior in LPM and expand data collection to better understand how products may operate under real-world conditions. These include:

- The existing test methods prescribe very low or no network traffic during testing, rather than allowing SNE to pass traffic and operate as it normally would on an otherwise quiet network. If tested in this manner, the five-minute test period required by the existing test methods may not be long enough to fully capture behavior of the product.
- The existing methods test only one network technology, picked from a prioritized list. A product with multiple network technologies is likely to exhibit different power requirements depending on what technology is connected for the test.
- The existing test methods do not specify how multi-component products like whole-home Wi-Fi systems should be tested.

The Statewide CASE Team therefore recommends that the Energy Commission consider using the ANSI/CTA-2049 test method for SNE-specific instructions, with the following modifications:

1. **Rather than prescribing network traffic, allow the UUT to utilize its connection as it would under normal, inactive operation.** The Energy Commission has stated that "LPM includes any mode or state other than 'Active' mode" (CEC 2019). Applied to SNE, the Statewide CASE Team interprets the active mode as the period in which the network equipment transfers user-initiated information between an edge device and the LAN or WAN. When the equipment is waiting to transfer user-initiated information, it is inactive and therefore in LPM. LPM activities may include sending or receiving information over the network connection to keep the link established and maintained. Therefore, the Statewide CASE Team suggests that rather than prescribing

[9] The Statewide CASE Team assumes SNE's primary function is to move user-generated traffic, but that SNE handles other traffic in LPM, such as that required to maintain a network link.

zero network traffic during the test, the DCP should allow the product to transfer the data it needs to in order to maintain its functionality.

2. **Extend test duration to capture product behavior in LPM**. Because LPM can contain multiple operating modes, a test period of only five minutes may fail to capture the average behavior of the product under test. The Statewide CASE Team recommends extending the test so that it captures the full behavior of the product in LPM.
3. **Test all network technologies rather than just one**. Both ENERGY STAR and ANSI/CTA-2049 require testing of only one WAN and LAN network technology from a preferred list. The DCP should require testing all technologies that exist in a product to characterize the range of power it might draw based on how it is used. This includes new technologies like 5G WAN, and wireless technologies other than Wi-Fi.
4. **Test and report aggregate power for devices that are sold as a system.** Multi-component systems, such as whole-home Wi-Fi systems that are sold to the consumer as a single product, should be tested as a single product.

5. Conclusion

With respect to SNE savings potential, the Statewide CASE Team analysis demonstrates that there is additional energy savings potential in SNE beyond what has been achieved by the VA which could be achieved through the LPM Roadmap. This additional savings potential exists due to gaps in market coverage, especially for LNE, and because of the potential for more stringent targets for both LAN and WAN equipment.

The analysis presented in this paper estimates that between 80 to 89 percent of U.S. WAN equipment shipments, but only about half of U.S. LNE shipments, are subject to the current VA indicating a potential gap in LNE coverage. Further, there are also more LNE vendors and the product category is experiencing more market turnover as new vendors enter the field with nascent technologies. Therefore, there is a large (and potentially growing) coverage gap for LNE that could be addressed through the LPM Roadmap.

The Statewide CASE Team estimates a maximum technical savings potential of 280 to 340 GWh/year if all SNE were required to be as efficient as the most efficient products that fall under the current VA scope. Overall, this analysis estimates that power consumption by WAN equipment would be reduced by ten to 15 percent and that LNE power consumption would be reduced by 25 percent. The LPM Roadmap could achieve these energy savings through more stringent requirements than those of the current VA.

With respect to test procedures, the Statewide CASE Team believes that with select modifications (described above), the ANSI/CTA-2049 test method could be effectively used with SNE for the purposes of the LPM Roadmap. The Statewide CASE Team would not recommend developing an entirely new test method for SNE for purposes of collecting data to inform the LPM Roadmap; however, select modifications to ANSI/CTA-2049 would make it more realistic and representative for the context of the LPM DCP.

6. References

ABI Research. 2018. Wireless Connectivity ICs.

ANSI/CTA (American National Standards Institute/Consumer Technology Association). 2015. Determination of Small Network Equipment Average Energy Consumption. ANSI/CTA-2049.

Bertoldi, P. and A. Lejeune. 2020. Code of Conduct on Energy Consumption of Broadband Equipment. European Commission, Ispra 2020, JRC119761. https://e3p.jrc.ec.europa.eu/publications/eu-code-conduct-energy-consumption-broadband-equipment-version-7-0.

CEC (California Energy Commission). 2019. Low Power Mode Roadmap Overview and Comments Review. https://efiling.energy.ca.gov/GetDocument.aspx?tn=226376&DocumentContentId=57150

CTA (Consumer Electronics Association). 2018. CTA Consumer Technology Extended Forecast 2017-2022.

D+R [D+R International]. 2019. 2018 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Small Network Equipment. https://www.energy-efficiency.us/library/pdf/SNE-AnnualReport-2018.pdf.

D+R [D+R International]. 2020. 2019 Annual Report: Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Small Network Equipment. https://www.energy-efficiency.us/library/pdf/SNE-AnnualReport-2019.pdf.

Informa Tech. 2020a. Home Network Intelligence Service Broadband Consumer Premises Equipment Market Tracker Database.

Informa Tech. 2020b. Home Network Intelligence Service Consumer Wi-Fi Market Tracker.

SNE VA Signatories [Signatories of the Voluntary Agreement for Small Network Equipment]. 2020. Voluntary Agreement for Ongoing Improvement to the Energy Efficiency of Small Network Equipment (revised). https://www.energy-efficiency.us/library/pdf/SNE-VoluntaryAgreement.pdf.

U.S. EPA (United States Environmental Protection Agency). 2013. ENERGY STAR Test Method for Small Network Equipment. Final Test Method Rev. Nov-2013. https://www.energystar.gov/sites/default/files/FINAL%20Version%201.0%20SNE%20Program%20Requirements%20%28Rev%20Oct-2014%29.pdf.