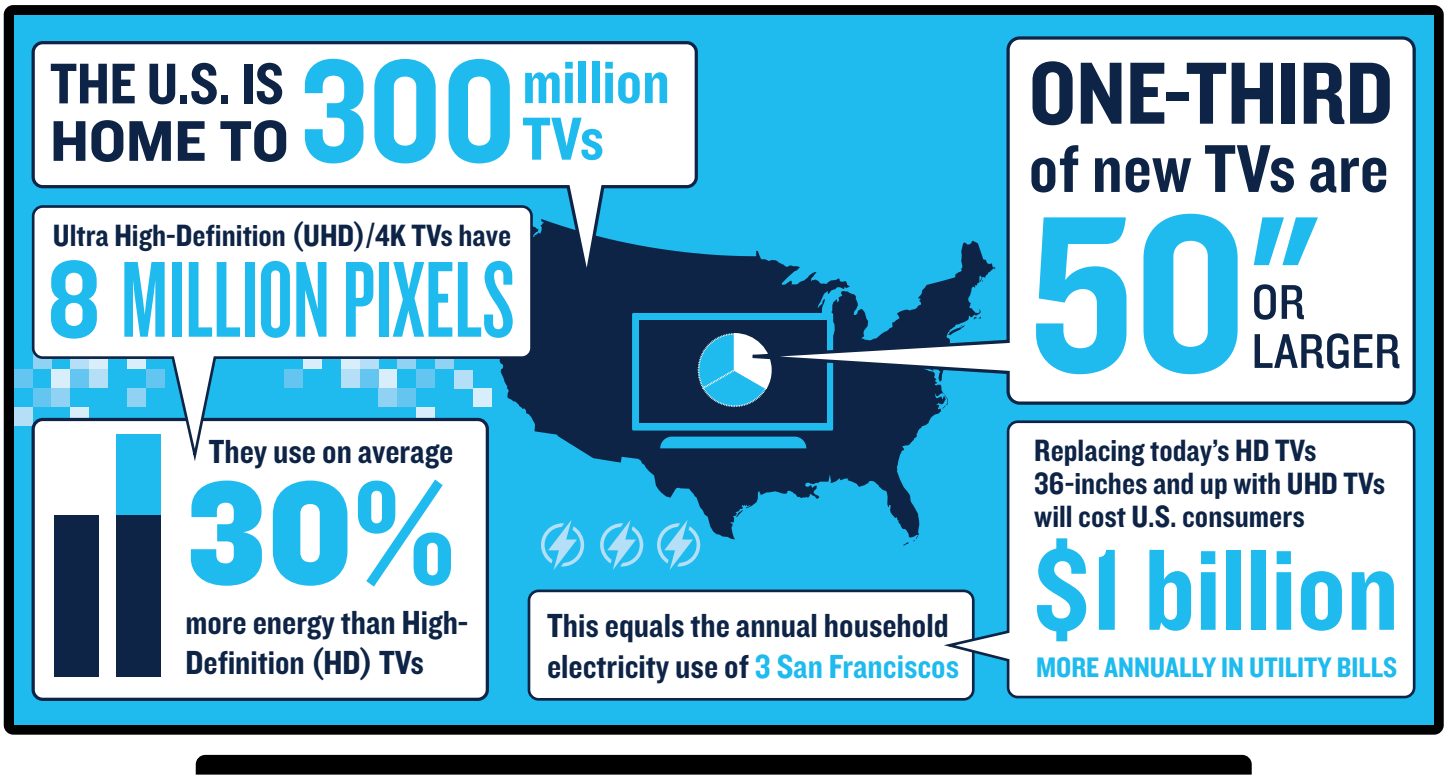
NOVEMBER 2015
R-15-10-B

THE BIG PICTURE:
ULTRA HIGH-DEFINITION TELEVISIONS COULD ADD $1 BILLION TO VIEWERS' ANNUAL ELECTRIC BILLS

EXECUTIVE SUMMARY

With an estimated 300 million installed televisions in the United States—almost one per person—it is clear that Americans love their televisions, and many of them are constantly seeking bigger and better models. The newest variety quickly entering the market is known as ultra high-definition (UHD) due to its superior picture quality, with 8 million or more pixels; sometimes these are called 4K TVs because the images are about 4,000 pixels wide, with four times as many pixels as a high-definition (HD) television. Unfortunately, our analysis shows current UHD models use on average about 30 percent more energy than HD models of the same size. As the shift to UHD televisions is now in its early stages, there is still time for manufacturers to incorporate more efficient designs and components into all new models and prevent much of this potential additional electricity use and resultant pollution.



Going forward, consumers will likely be buying new UHD/4K televisions instead of an HD version for all models 36 inches and larger. As the higher resolution provided by 4K TV will not be readily noticeable by consumers on television screens smaller than 36 inches, they likely will stay with HD for these smaller screen sizes. Once this transition is completed, we estimate U.S. consumers will need to pay an extra $1 billion annually to operate their new TVs unless further energy efficiency improvements are made. In fact, the increased energy use of UHD televisions could potentially undo some of the hard-earned television energy savings achieved over the past decade due to a combination of government labeling programs—ENERGY STAR© and the yellow EnergyGuide label—providing consumers with more information about television energy consumption, utility rebates for energy-saving models, and mandatory standards in California that removed the least efficient models from the market.

As noted earlier, UHD televisions offer four times the picture resolution of HD televisions and are commonly referred to as 4K TVs. The acronym UHD has often been used interchangeably with 4K, but UHD capability involves much more than picture resolution. Essentially, all UHD televisions will have 4K or greater resolution, but not all 4K TVs will deliver the full range of UHD capabilities. Additional features sometimes include more dramatic contrast, bolder colors, and Internet connectivity, each of which can potentially increase energy consumption. At the same time, technology advances have led manufacturers to incorporate such energy-saving features as automatic brightness control and advanced backlight controls that can dynamically respond to the lighting conditions in the room and the scene being viewed, respectively, in order to reduce energy use.

Prior to this study conducted by the Natural Resources Defense Council (NRDC) and its consultant, Ecos Research, very little was known about the precise energy impact of the recent changes in the television market and the technology advancements that are occurring. In this study, we analyzed public databases of UHD television energy use and market share sales data, and we performed power use measurements on 21 televisions representing a cross-section of 2014 and 2015 models. Our testing focused on 55-inch TVs because they are the most prevalent size and represent the best value among UHD televisions on the market today.

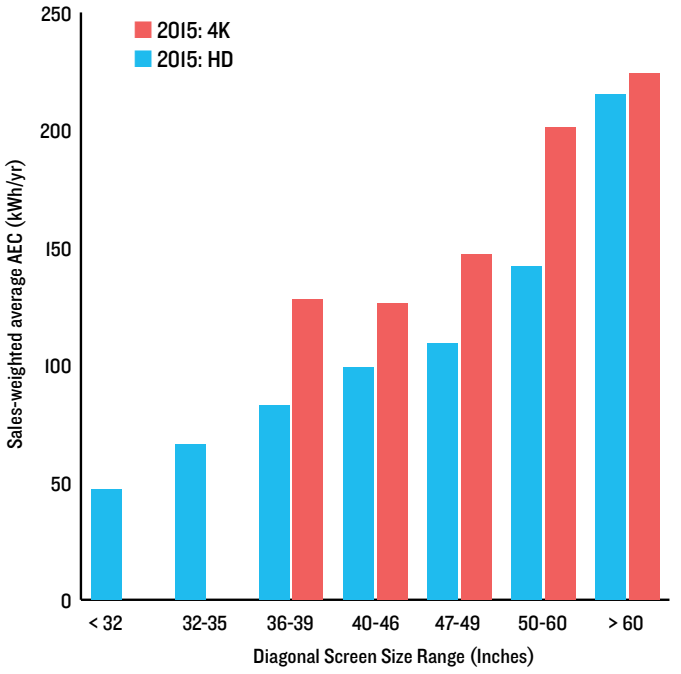
We found that UHD televisions use an average of 30 percent more power than HD televisions of a similar size (see Figure ES-1). However, there were dramatic differences in the power consumption among models of the same size, with the least efficient model we tested using almost three times more power during active operation than the most efficient models. This indicates that the technology already exists to make energy-saving improvements to the most inefficient UHD televisions. Improvements to the energy efficiency of UHD and 4K televisions are in their infancy as our modeling showed only a 4 percent reduction in the energy use of 2015 models from similar-sized 4K TV 2014 models.

In addition, our analysis indicates that the size of television screens is growing quickly, as manufacturers promote them as the best vehicles for optimum viewing of 4K content. Almost one-third of all new televisions being sold today have a screen size of 50 inches or greater, which is important from an energy standpoint as the amount of power used by a television normally increases with screen size. However, this is not always true; some of the most efficient 55-inch 4K TVs we tested use less power than 50-inch models, even though they have roughly 20 percent more screen area.

We also modeled a scenario whose starting point was the assumption that all of America's 300 million televisions were using the same amount of energy as today's HD televisions. What would happen if each of these sets larger than 36 inches was replaced by today's 4K televisions? We found the national impacts would include:

- 8 billion kilowatt-hours (kWh) in additional electricity use per year, or as much electricity as 2.5 large (500 megawatt) power plants produce annually. That is three times the amount of electricity consumed by all the homes in San Francisco each year.
- $1 billion in additional annual costs to consumers to operate their televisions.
- 5 million extra metric tons of carbon dioxide pollution emitted annually due to the additional electricity use.

Figure ES-I: Comparison of UHD and HD TV Annual Energy Use by Screen Size



KEY TEST FINDINGS

We also tested UHD TVs on the market in 2014 and 2015 to determine the energy consumption of various features and settings, including:

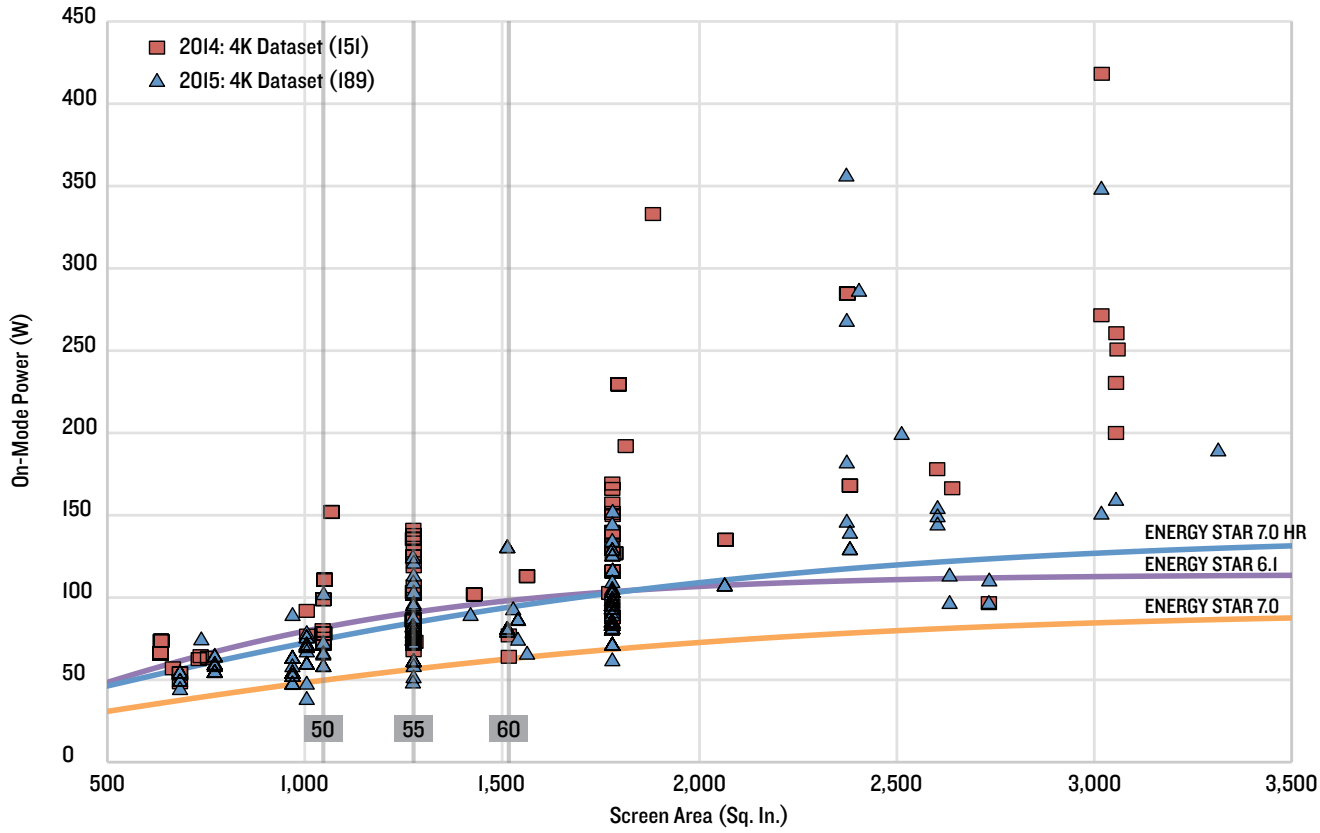
ON-MODE POWER: We measured the amount of electricity consumed when televisions are turned on for active viewing and found that some models consume more than 2.5 times as much power as others with the same screen size. The least efficient designs are most often found in the largest screen sizes, and some models consume more electricity annually than a new midsize refrigerator.

At the other end of the spectrum, several UHD TV models already qualify for the ENERGY STAR label, which is reserved for the top 25 percent of all televisions in terms of energy efficiency and is often used as the eligibility criterion for utility rebates. Other UHD TVs could also earn the label with minor modifications.

Figure ES-2 shows how the reported power use for these UHD TVs compares with the maximum qualifying levels for on-mode power in the current ENERGY STAR Version 6.1 and the new Version 7 specification effective October 30, 2015. Above 60 inches, 4K power use rises dramatically. Meanwhile, the U.S. Environmental Protection Agency (EPA) provided an almost 50 percent additional power allowance (adder) for 4K televisions to qualify for its ENERGY STAR Version 7. (When EPA set the specification, there were few UHD models on the market, and the data at that time indicated that a 50 percent additional power allowance was warranted. More models are on the market today, and some have made sufficient efficiency improvements that qualify for ENERGY STAR without this allowance—or to come very close.) The higher energy use levels are shown in the curve labeled ENERGY STAR 7.0 HR, where HR stands for high resolution.

AUTOMATIC BRIGHTNESS CONTROL (ABC): From our testing of 50-inch to 55-inch televisions, we found that enabling the ABC feature, which adjusts screen brightness in real time in response to changes in room light levels, had a huge impact on energy consumption, causing TVs to use half as much power, on average, as they otherwise would. However, the actual energy reduction varied widely among models, ranging from 17 percent to 93 percent. The most efficient televisions had ABC implemented by default (meaning it arrived enabled in consumers' homes without them having to take any action), while none of the least efficient televisions did. For reasons that are unclear, some manufacturers chose not to even offer the ABC feature or did not enable it by default, resulting in a lost opportunity for significant energy savings. In some cases, failing to ship

Figure ES-2: Reported 4K TV Power Use Relative to ENERGY STAR Qualifying Levels (HR indicates the high-resolution allowance provided in ENERGY STAR Version 7)



the TV with ABC enabled meant the manufacturer missed a chance to otherwise qualify for an ENERGY STAR label and potential utility rebates.

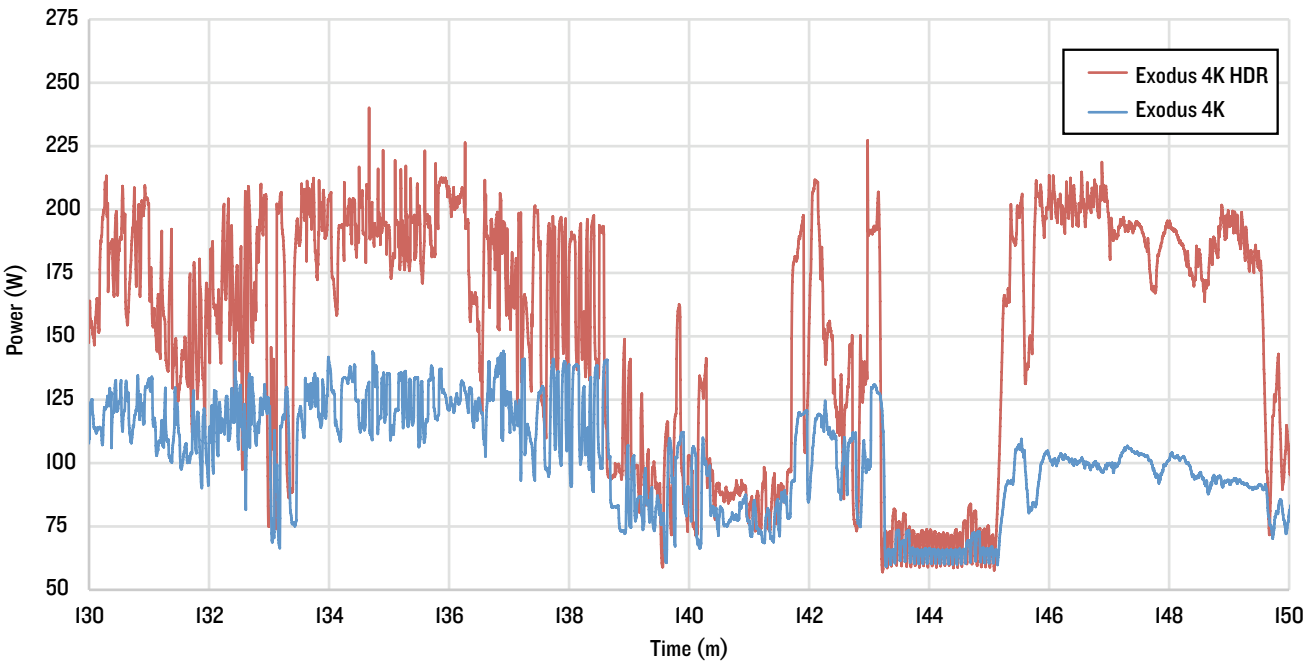
SMART/INTERNET-CONNECTED TELEVISIONS: Prior to this research it was not well understood how much power "smart" televisions use when the consumer thinks the television is turned off but in reality it remains connected to the Internet. These televisions are increasingly popular (about 60 percent of new television sales today) because consumers can stream content from services like Netflix directly to their television without the need for a computer or supplemental streaming device. However, this can lead to designs that have a high-energy-consuming quick start mode, which allows the television to boot up more quickly after the consumer turns it back on. The good news is that our testing identified models from Samsung and LG that used less than one-half watt in standby mode while still booting up quickly (in less than 7 seconds) when turned back on. However, models from Sharp and Sony were much slower to start up and could use far more power in standby mode if consumers decide at a later time to enable the quick-start option. One television consumed a whopping 37 watts for six hours a day in standby with quick-start enabled, even though the television appeared to be turned off.

HIGHER-RESOLUTION CONTENT: Feeding a 4K television, a higher-resolution (4K) version of HD video material did tend to increase energy use by an average of 10 percent, but there were large differences between models. Meanwhile, streaming higher-resolution content via the Internet instead of playing it from a disc did not make a significant difference in energy use, which is good news as people increasingly stream content over the Internet.

HIGH DYNAMIC RANGE (HDR): Some of the 4K televisions on the market today are capable of producing superior picture quality (e.g., brighter whites, darker blacks, and superior contrast ratios) when they receive HDR content. These televisions, generically referred to as 4K HDR or HDR-capable UHD TVs, are expected to be heavily promoted to, and sought by, consumers in the near future. As no information was available about the potential energy impact of playing HDR content on these models, we tested two movies on the Samsung UHD TV model UN55JS9000, first with the 4K version of content and then with the 4K HDR-encoded edition. On average, the HDR version of the movie caused this television to use 47 percent more energy than the non-HDR version (Figure ES-3). Even though the power use of the two versions was similar for very dark scenes, it was dramatically higher (often double) on extremely bright scenes, as evident by the energy usage spikes in the graph below of a 20-minute segment from *Exodus—Gods and Kings*.

The lesson from this testing is that HDR could have a bigger impact on television energy use than the jump to 4K by itself, particularly in combination with the other, optional UHD features and the continuing push for ever-bigger screens. If the least efficient design strategies for implementing 4K dominate sales and HDR becomes

Figure ES-3: On-mode Power Testing on Samsung Model UN55JS9000 Playing 4K and 4K with HDR Content



widespread, average 4K TV energy use could more than double from today's HD models. More testing is needed to determine if the very large power increase we observed is representative of the 4K HDR models entering the market. (Note: We performed testing on only one TV model due to the limited budget of this study and the market scarcity of 4K HDR models and HDR-encoded content.)

CONCLUSIONS AND RECOMMENDATIONS

While our analysis shows the potential for very large deleterious energy, environmental, and economic impacts due to the shift to 4K/UHD televisions, the good news is that today's best designs consume very little extra power when operating, compared with their similar-size HD counterparts. In addition, most (but not all) of the smart TVs use very little standby power (0.5W or less) and are able to reboot within 10 seconds or less. Given that the technology exists and is already being incorporated into the most efficient UHD television models, our collective challenge is to ensure that the vast majority of the market moves in the direction of greater energy efficiency. Complicating the matter are new UHD features that have not yet been widely implemented, such as 4K televisions with HDR, whose power use may rise significantly when displaying HDR-encoded content.

As Table ES-1 shows, there are steps that consumers can take to lower their utility bills, as well as changes that manufacturers can incorporate to reduce the energy waste of their televisions. However, there also is a need for policymakers and government agencies to act to ensure that our televisions do not waste electricity, leading to an increased need to burn polluting fossil fuels to generate it. A critical element is ensuring that the tests used to measure the energy use of new televisions are continually updated by the U.S. Department of Energy so that they capture the amount of consumption from such new developments as 4K video shot with HDR cameras.

Our recommendations for measures that will ensure progress are summarized in Table ES-1.

Table ES-I: Ways to Improve the Energy Efficiency of 4K Televisions

Consumers	TV Manufacturers/Industry	Policymakers/Government
■ Buy ENERGY STAR–qualified models ■ Review the FTC EnergyGuide label while shopping to compare the energy use and operating cost of models you are considering	■ Optimize 4K TVs for energy efficiency ■ Ship TVs with ABC enabled	■ Update test methods: include 4K and HDR content; revise standby testing for Internet-connected TVs
■ Make sure automatic brightness control (ABC) is enabled	■ Get ahead of HDR: develop consensus test clip, perform testing, and bring down energy use	■ EPA: Reduce (and possibly eliminate) the additional power allowance for 4K/UHD TVs in the next revision of ENERGY STAR specifications ■ Utilities: Offer rebates for the most-efficient models on the market
■ Avoid quick-start mode if you can	■ Limit growth in standby power as new apps/features are added	■ Consider mandatory standards at the state or federal level to remove the least-efficient models from the market