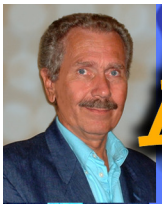

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4K & UHDTV Technologies & Economics of the Next TV Transition

Pre-NAB-2014 Issue —By Tore B. Nordahl— Responsible for publishing: nordahl.tv LLC at Porter Ranch, Calif.
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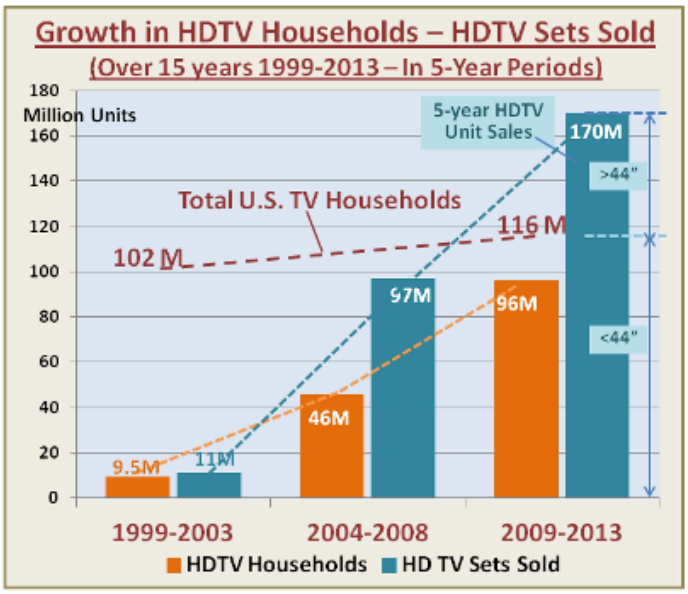
96 Million U.S. TV Households now have HDTV. It took 15 years . . . What about Ultra-HD Growth?

That's 83% of all 116 million TV Households as we enter 2014. The first substantial HD (DTV-ATSC) broadcasts started in 1999 coinciding with the availability of HD TV sets, first "tube sets" and later both rear projection DLP and plasma flat panel TVs.

From 1999 through 2003 (the first 5-year period), 11 million consumer HD TV sets shipped, going into nearly 10 million U.S. TV households. (NOTE that a fair number of these were DTV 960x480p sets, but this is not significant 15 years later.) During the following 5-year period (from 2004 through 2008), the total U.S. HDTV households increased to 46 million, with about 97 million HDTV sets sold. From 2009 through 2013 (the last 5-year period), HDTV households increased by 50 million, to 96 million with shipments at about 170 million HDTV sets.

Thus around 278 million HDTV sets have shipped in the U.S. from 1999 through 2013, making the average number of HDTV sets per household about 2.9. These numbers are in line with various CE industry sources. **Look at the Chart**.



Yes, 4K/UHD will really happen

There will indeed be a HD-to-4K/UHD transition over the next 15 years, with an estimated 80% of all U.S. TV households owning one or more UHDTV sets by 2028.

What will be the Adoption Rate?

The purpose of this issue of the Executive HDTV Report is to predict the future likely adoption rate of consumer Ultra-HDTV (UHD) sets **for the next (first) 5-Year UHD period (2014—2018)** by analyzing the 15-year adoption history of HDTV and consider other factors substantially affecting future sales levels of UHDTVs, positively and negatively.

Briefly about Ultra-HD & 4K

The standard HDTV full raster is 1920x1080 with square pixels and an aspect ratio of 1.78 (16:9). In consumer and professional video, Ultra-HD (UHD) refers to an image raster (video frame) where each horizontal line is made up of approximately 4,000 pixels, specifically 2x 1920 = 3840 pixels across and 2x 1080 = 2160 pixels vertically, UHD producing 4x the spatial resolution of HD. However, the first 4K standard to emerge about 7 years ago was developed by DCI (Joint Venture of the major Hollywood film studios). Needing a wider aspect ratio of 1.9, the 4K digital cinema raster of 4096x2160 was established and referred to as 4K. The consumer and professional video standard is referred to as UHD in here, not 4K.

Continue on Page 2

96 Million U.S. TV Households now have HDTV.

Continued from Page 1

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4K & UHDTV Technologies & Economics of the Next TV Transition

UHDTV—4 times the Resolution, subject to . . .

UHDTV offers 4x the spatial screen resolution of HDTV. BUT the consumer's ability to visually experience the UHD resolution requires two basic conditions, that:

- The program material is acquired, processed and delivered in UHD
- The audience is sitting close enough to the UHDTV screen in order to visually resolve (nearly) down to the UHD pixel level

A 70-inch HDTV (1080) gives a fully resolved view (see each pixel) at a distance of about 8 feet (viewer with 20-20 vision), with the recommended viewing distance for maximum resolution and enjoyment being 9 to 10 feet. The 9 feet distance is also the average distance for watching TV in the average U.S. living/family room.

However, a 70-inch UHDTV will require the (20-20 vision) viewer to move much closer to the UHDTV screen in order to see each pixel, down to a distance of 4 feet! (Each UHD pixel is just half the width and half the height of a HDTV pixel.) The recommended viewing distance for this 70-inch UHDTV becomes about 5 feet for maximum resolution and enjoyment (short of seeing the individual pixels). You can easily realize that a 5-foot viewing distance may not be a workable living/family room TV environment.

Consider a smaller UHDTV . . . like a 50-inch where the optimum viewing distance is significantly less than 5 feet (about 3.5 feet fully resolved to pixel detail). Imagine several family members huddle around the 50-inch UHDTV only about 4 feet from the screen, to see real UHD! It's a difficult situation. Moving back to the HD (1080) recommended viewing distance (or to the average U.S. living room TV viewing distance of 9 feet) will cause the observed UHD resolution to be substantially reduced.

Not only 4x the spatial resolution, but UHD is fully progressive and not interlaced like HDTV (1080i60). This is a substantial advantage making UHD (p60) also a great viewing environment for fast action video, like sports, provided the UHD program is acquired and delivered in 60p.

Consumers are generally Informed

Remember 3-D. It did not take the consumers long before they rejected it, making 3-D in the home a CE failure. 3-D glasses turned viewers off, but also that "natural 3-D" in the living room was not "natural" after all.

UHD is different from 3-D, primarily because it is a natural advancement in TV viewing resolution, and not a different form of presentation. But the consumers will realize soon enough the viewing distance compromises one needs to adopt in order to get the maximum "resolution enjoyment" out of the larger screen UHDTV. They will also soon learn that a UHD originated program delivered to their large screen HDTV (1080) set will present a gorgeous picture after quality down-conversion by the in-home (down conversion capable) STB. **The HD-to-UHD transition** will be difficult for the HD/UHD set manufacturers to manage through the initial 5 years, especially to balance the availability and pricing of HDTVs vs. UHDTVs. Competition will be fierce which is good for the consumers.

Younger Audiences prefer Social Media & Smartphones

Prior to 2008, there were no Smartphones or Tablets available, and Social Media was not yet a factor in consuming lots of "online time" by the younger audiences (up to 30 age group). We can reasonably presume that today's younger audiences are NOT prime candidates for buying UHDTV sets anytime soon.

What about the "gamers", sitting close to the screen and wanting UHD resolution. BUT the "gamers" will opt for PC UHD monitors, already available as large as 32-inch models, with the 28-inch currently selling for less than $1,000. These are PC monitors, and NOT counted as UHDTVs.

Older Audiences are quite satisfied with their HDTVs

The 60+ age group, many retired, were the ones buying the large majority of larger HDTVs back 5, 10 or even 15 years ago, when they were in their 40s and 50s. They are likely to have one or more 50-inch+ HDTV sets and be quite satisfied with 1080.

Continue on Page 3

96 Million U.S. TV Households now have HDTV.

Continued from Page 2

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Brand Name or not?

HDTV unit sales came to about 34 million units in 2013, a drop of 3.5 million units from 2012, after selling about 60,000 UHDTVs in 2013. Dollar value declined 12% to $23 billion. 2013 was a tough year for HDTV set manufacturers, with the average HDTV set selling at about $680. CEA projects 485,000 UHDTVs to be sold in 2014 at an average price of about $2,000 producing dollar sales of about $1 billion. What size TV will you buy for $680 in 2014? A 60-inch Sharp 1080p OR a the off-brand Seiki 50-inch UHDTV.

A Lack of UHD programming

No UHD TV broadcasting (OTA) for many years if ever. Certainly not during the first 5-Year UHD period (2014-2018). 15 years ago, in 1999, the DTV broadcasting of HDTV was getting into gear, pushing the SD-to-HD transition at home. And HDTV was clearly a huge improvement over NTSC/SD at that time.

Not so today; improvement, yes, but not huge under normal home viewing conditions. In 1999, Hollywood movies had been transferred to HD for several years already, so there was a readily available large library of HD movies being DTV broadcast and delivered by cable. The current availability of UHD programs and movies is low, and it will take a year or two to substantially increase the UHD program supply over cable, satellite and internet. The good news is that several OTT and cable channels including Netflix have announced start of UHD streaming trials in 2014.

Installed STBs cannot handle UHD

All UHD program streaming over CATV, Satellite and Internet will require HEVC encoding (High Efficiency Video Coding compression). Mass produced Set Top Boxes (STBs) able to decode HEVC encoded UHD are just being announced for soon delivery. Currently installed STBs (an estimated 200+ million units) are generally NOT upgradable by software download. There are about 100 million MVPD (Multi-channel Video Program Distributors = Cable + Satellite + IPTV) subscribers in the U.S.. This lack of current UHD decoding capability in 100 million TV homes is a serious matter for the MVPDs AND for the UHDTV set manufacturers. OTT streaming also requires UHD capable boxes for subscriber decoding. Built-in STBs in UHDTVs?

Up-converting . . . An essential part of UHD success

These are very important capabilities in the early selling of UHDTVs. Consumers having purchased a relatively expensive UHDTV realizing that UHD program availability is very limited. STBs have the capability now to output uncompressed 1080p60 over HDMI to the UHDTV, with high quality up-conversion (1080 > UHD) in the UHDTV. And a high quality 1080p60 video up-converted to UHD will look stunning. At average living room TV viewing distance of 8 to 10 feet, it may be difficult for the average audience to see a difference between up-converted 1080p60 and original UHD, unless the UHDTV screen is very large.

Who needs Down-converting?

Answer: All the UHD players! Down-converting from UHD to HD may not seem advantageous to the UHDTV manufacturers, but it certainly is important to the overall success of the HD-to-UHD transition. The UHDTV manufacturers want the MVPD program originators and OTT streaming companies to speed up the production and availability of UHD programs, as that will speed up the sales and penetration of UHDTVs. The Cart before the Horse?

So, the cable/OTT channels seek the largest possible TV audience as early as possible, as an incentive to produce ever more UHD programs, not caring whether the viewers are watching on a UHDTV or down-converted to an existing HDTV, potentially enabling millions of existing HD sets to display UHD programs to millions of HD viewers.

Thus the new STBs, capable of receiving and decoding UHD, must also have the capability to down-convert the UHD to HD 1080p60 to supply over HDMI to the HD set.

How about adaptive streaming (like VOD/OTT)? The UHD stream will automatically reduce to HD, switching to a lower bitrate and resolution (i.e. from UHD to 1080 to 720 to SD) if the internet path and/or display cannot support the higher resolution. Not so with TV/Cable/Satellite channels, transmitted with a fixed resolution, and there is no available cable spectrum for dual channel carriage (UHD and HD). **The answer is down-conversion in the STB**.

Continue on Page 4

96 Million U.S. TV Households now have HDTV.

Continued from Page 3

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4K & UHDTV Technologies & Economics of the Next TV Transition

UHD-to-HD Down-converter: A Positive or Negative?

Admittedly, the consumer may be so impressed with the UHD program displaying in 1080p60/120 which may delay the purchase of a UHDTV. OR the impressed consumer may want the real UHD presentation and make the UHDTV purchase decision earlier rather than later. It can go either way, although it's a definite positive for UHD program producers and MVPDs. Remember the CATV-SatelliteTV competition of 10 years ago? Touting how many real HD channels they offered.

New HDTVs to have "Disruptive" built-in UHD-to-HD Down-converter

The most "disruptive" HDTV move of this decade? For second Tier HDTV set manufacturers to include a built-in UHD-to-HD down-converter in any larger size HDTV, from 42-inch up to 75-inch+, having powerful selling points of lower price and "near UHD presentation capabilities". This may extend the life cycle of HDTVs and enable increased market share vis-a-vis UHDTVs in the longer term. Added manufacturing cost is insignificant. A negative for the major UHDTV set manufacturers, but again a likely positive for UHD program producers and MVPDs.

2014 Selling Prices of UHDTV sets

Here are typical selling price ranges for UHDTVs, announced by several suppliers as of March 2014:

UHD size (diagonal)	Selling Prices (@ March 2014)	Projected Avg. through 2014
50/55-inch	$900 to $2,900	$1,600
60/65-inch	$1,900 to $3,900	$2,700
70/75-inch	$? to $5,900	$3,900

The primary addressable market for UHDTVs are the size range from 50- to 75-inch. Smaller sizes do not make sense from a visual experience while larger sizes are generally too expensive. However, there is one newcomer (SEIKI) to the U.S. market which may upset market pricing.

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SEIKI (China—U.S. subsidiary in Calif.) is currently offering a 55-inch UHDTV at a U.S. MAP (Minimum Advertised Price) of $999. A 28-inch PC friendly UHDTV has a MAP of $399. SEIKI offers a total of 10 4K/UHD models, but may not deliver all the features of the major manufacturers.

The Author has estimated the approximate average CE industry-wide selling price for each size through 2014. The best selling size in terms of dollar volume is likely to be the 60/65-inch class. The CEA has estimated the average UHDTV will sell for about $2,100 in 2014 with total UHDTV retail sales of about $1 billion at 485,000 units. Pricing is assumed to include (average) Smart-TV and 3-D features.

Reviewing 1999—2003 The First 5-Year Period of HDTV

For the first 5-Year period (1999-2003) of the HD transition, only about 11 million HDTVs were sold compared to 170 million HDTVs in the last 5-Year period (2009-2013):

1999—2003	**11 million (4%)**
2004—2008	97 million (35%)
2009—2013	170 million (61%)
Total 15 Years	278 million (100%)

Note that about 70% of the units above are HDTV screen sizes of 42-inch and below, where UHD resolution is not as an obvious improvement over plain HD at traditional viewing distances for the typical audience. That's one reason why the Tier-1 TV manufacturers (Samsung, Sony, LG, Sharp, Panasonic etc.) generally limit the UHDTV screen sizes to minimum 50-inch and up.

The CEA projects that 485,000 UHDTVs will be sold in the U.S. in the first full year of availability (2014). Compare with 100,000 HDTVs in in the first full year of 1999. That's a multiple of nearly 5. Does it makes sense?

Yes, it makes sense. In 1999, 42-inch plasma flat screen HDTVs had list prices over $10,000! The "cheap" HDTV sets were still picture tube-based and selling for several thousand dollars. That's why only 100,000 HDTVs were sold in 1999. CEA's projection of 485,000 UHDTVs shipping in 2014 is indeed reasonable, as 2014 UHDTV pricing is very reasonable in comparison to 1999—2003 prices.

Continue on Page 5

96 Million U.S. TV Households now have HDTV.

Continued from Page 4

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Size does matter!

Of the approximately 278 million units of HDTVs sold during the past 15 years, it is estimated that more than 70% were 42-inch or less, as America's most popular sizes were the 32-inch and 40/42-inch classes. Considering that UHD resolution in those smaller sizes are not readily distinguishable from flawless 1080p by the average consumer at normal viewing distance, substantially fewer UHDTVs in those sizes will be sold as compared to past HDTV sales in those same sizes. The smallest UHD screen size with early consumer demand is likely to be the 50-inch class, with the most popular in the 60/65-inch class.

Who are the Prime Target Buyers for UHDTVs during 2014—2018?

So, during the **first 5-Year UHD period**, (2014-2018) we look at the prime target customers being the age group from 30 to 54, which is a narrower range than what we saw 15 years ago (25 to 55+). Furthermore, it is reasonable to conclude that most TV households having managed without buying HD for 15 years, 14% of 116 million = 16 million, will continue watching their old analog/DTV sets through the first 5-Year UHD period if the set holds up. Here are likely Prime Target Buyers (2014—2018):

Replacing HDTV sets at Home

Replacing 720p60 sets (and DTV sets)
Replacing early DLP rear projection sets
Replacing early Plasma TVs
(All above good UHDTV selling points)

Addition of TV sets at Home

Adding larger size display (50-inch+)

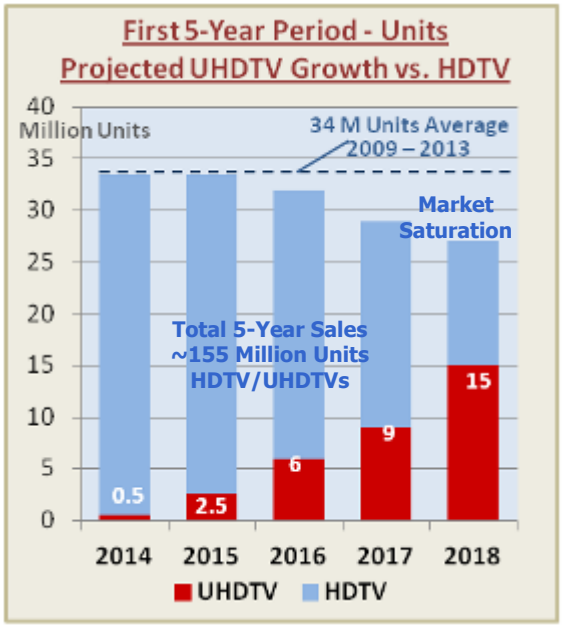
First time buyers of TV sets at Home

New TV Households (likely younger people)
(Online Generation not interested as much in larger sizes)
TV Households will increase by 4+ million over the current 5-year period . . . and they alone will buy an estimated 6+ million UHD/HDTV sets, or ONLY about 4% of all UHD/HDTV sets sold.

Replacing/Addition in existing TV Households will account for 96% of all units sold during 2014—2018 5-Year period, UHDTV & HDTV.

The First 5 Years of UHD: 33 Million UHDTV Units

The average annual HDTV unit sales over the past 5 years (2009-2013) is about 34 million. HDTV sales is at or near saturation, and UHDTVs unit sales is NOT able to increase this unit average in the next 5 years (2014-2018). Total unit sales for the following 5 Years is likely to decline. However, sales of "pricier" UHDTVs will likely modestly increase the total dollar value of HDTVs and UHDTVs combined, although unit pricing for UHDTVs will substantially and steadily decline over the next 5 years.



UHD is it . . . 8K is not for the Home

Please don't tell me 8K is around the corner. There is absolutely no need or reason at this time to believe that 8K is for home television. With 4K/UHD, we have reached the limit of display resolution which can reasonably be observed in a home television environment.

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