UNIVERSITEIT GENT

FACULTY OF ENGINEERING AND ARCHITECTURE

Academic year 2010-2011

“Video in a Green-ICT era”

by BERNAT ILLA ROSICH

Promoter: Sr. Jan de Cock

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Ghent, February, 2011.

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ABSTRACT

Television diffusion is an unknown field for most of the TV viewers. Most of them do not know the origin of the signal and which are the involved devices on the distribution chain, affecting the production, broadcast or customer level.

Only a reduced number of TV users comprehend the meaning of the main technical specifications of each product, for example, what means a 1080p60 video resolution.

Apart from that features there are also more important characteristics such as the power consumption of a device.
The election of a device, in the user case a television, with an ecological consumption can save to the user an important quantity of money, for instance in the user case, on the electricity bill.

In this thesis is going to be studied the video transition to high definition, analysing which devices differ from the previous transmissions, which requirements do they need and how many energy consume, discovering the variables that directly affect to the power consumption of each device of the distribution chain, from when the video is done and needs to be compressed through a standard format, until the visualisation of that video in the households.

1. INTRODUCTION

Since prehistoric times, man had the need to evolve and create new items to help them advance in society. Since the construction of the first flint as cutting tool to the latest medical advances to treat diseases like Alzheimer or AID. Passing the discovery of the wheel, the discovery of penicillin. The telephone, electricity, television are other inventions that man with the ability to evolve has been performed.

Nowadays, more and more people are engaged in research of new tools and increasingly have more resources so that these researchers can make more relevant discoveries. Not only money tools but also machinery or government support.

One of the main discoveries is the television. Anyone in homes has a minimum of one television and most of the users is able to see the television in HD. At the date, most of the countries emit television using the Digital Terrestrial TV after the “analogical switch-off” giving way to the digital age.

If the user navigates on the programmes guide will be able to notice that there are lots of channels and part of them are HD channels, but probably not all of the TV consumers are able to watch them.
The ones who are able to, sure will be capable to notice the quality difference compared with the standard definition.

In this thesis we will try to show to the reader the most relevant changes between the transition to the digital SD era to HD era.

Will be focused on :

- What is needed to create television.
- What is involved inside the transition from SD to HD.

The intention is to try to convey to the user the enough knowledge in order to making himself able to talk about television with a deeper view additionally keeping an eye on the environment.

To create new technology, new media is needed. Talking in a technical way, it affects directly to software. On the network hand, new devices are required. Arguing in a economic way, more among of money is needed.
Finally, on the sustainable way, those new devices need more power and more energy.

On “Video in a Green-ICT era” the reader will be able to see the comparison about that, and which variables are affected in this digital evolution in order to make it ecological.

2. CHAPTER ONE: DIGITAL TERRESTRIAL TELEVISION

2.1 DTT INTRODUCTION

In recent years the media have echoed on a really important change on the television. Technically called "Analogical switch-off", consists of changing the analog television to digital terrestrial television.

This change occurred slowly within a progressive way and always informing about the state of change, and how to make it. One of the things that has sounded more about the transfer to digital television without problems is the digital receiver. Is a required device for the user that is the responsible of receiving digital signal, necessary to produce the digital television. Is called Set-top Box and normally is set in the top of the television, that's the reason of the name. Nowadays, the STB is integrated with the television.

2.2. DIGITAL TERRESTRIAL TELEVISION

Digital television (DTV) is the transmission of audio and video by digital signals, in contrast to the analog signals used by analog TV.
Is the result of applying digital technology to the TV signal, then transmit it via terrestrial airwaves, i.e., those that are transmitted through the air without a cable or satellite received by conventional UHF antennas.

There are different types of DTV, depending on the method of transmission, in Europe there are this different types:

- DVB-T (Terrestrial)
- DVB-S (Satellite)
- DVB-C (Cable)
- DVB-H (Mobile Phone)

The picture 1.1 shows the division of digital transmissions by countries. This thesis will only focus in DVB-T due that is the most used in Europe and is the one that Belgium and Spain use.

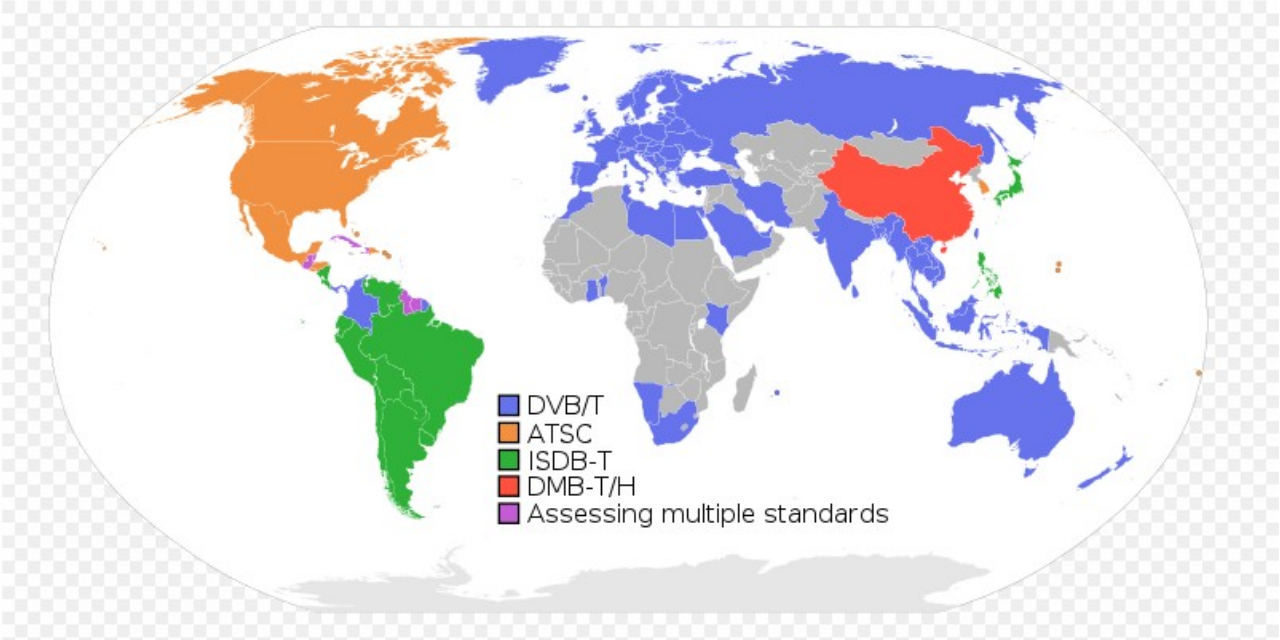

Figure 1.1. Distribution of the digital transmissions around the world

DVB-T is an abbreviation for Digital Video Broadcasting — Terrestrial. It is the DVB European-based consortium standard for the broadcast transmission of digital terrestrial television. This system transmits compressed digital audio, video and other data in an MPEG transport stream, using coded orthogonal frequency-division multiplexing (COFDM or OFDM) modulation.

The process of change from analogue to digital television, will be called: “Digital television transition”.

The digital television transition is the process in which analog television broadcasting is converted to and replaced by digital television. This primarily involves both TV stations and over-the-air viewers; however it also involves content providers like TV networks, and cable TV conversion to digital cable. Most of the countries had a deadline to do the transfer.

The main reason of that transition is that most of analog formats were standardized between 1940s and 1950s so they now have to be adapted to the new technological requirements; the formats had to change all the time, from black and white, to colour formats, stereo sound.

This implies a change on the broadcasting, so the necessary bandwidth is higher than the previous. A Digital television transmission is more efficient, easily integrating other digital processes, for features completely unavailable or unimaginable for analog formats. For the end-user digital television offers a quality like a HD home video or blu-ray with digital multiplexing.

As someone can see, this transfer implies several changes in the structure of the television transmission. Only in the customer level, a TV-consumer needs to buy a new digital receiver or a Set-Top Box (STB). This device needs energy to work, so has a power consumption.

Not only implies customer new devices but also network changes. New antennas, new encoders, transcoders in order to transform the signal in a digital signal, non an analog signal like before.

With the HD transition, all this devices should be more powerful, so it will consume more energy, so more power consumption.

This will be our principal theme about the thesis, calculate the viability based always on the power consumption.

2.3. TDT TRANSMISSION

During the process of making television, there are three important parts in which we should focus in it. So, the distribution chain is divided in:

1. PRODUCTION
2. BROADCASTING
3. CUSTOMER

2.3.1.PRODUCTION

This part will discuss the production of the video. But not the creation of the video from

the movie maker, this part is when the video is already done.

One of the most important parts will be the election of the medium to watch. Depending if the video is designed and transmitted for watching through internet, or if is for television.

Leaning on one or the other the requirements will be different. First of all for the size of the file. Is noticed that the quality of the image in a DVD or in a TV program is better than the quality in an online transmission on a PC; higher quality implies higher size and vice versa.

As a result of, is interesting for a online view smaller file extension for a clearer transmission. A DVD movie can be like 4 Gigabytes hence would not be worth to view by internet streaming connection.

The term streaming means that it is a direct current (without interruption). The user can listen or watch when they want. This technology allows to be stored in a buffer that will be listened or viewed. Streaming makes possible to play music or watch videos without having to be downloaded first.
Up-to-date there are new software applications to listen music via streaming. Spotify uses those technology to listen music only needing an internet connection and the program.

Besides, bigger size needs more bandwidth to be transferred by the network. Additionally, the file must be smaller than the original.
Thenceforth a more powerful compression is needed for reduce the size of the movie file. For more compression, more energy and so on more power consumption. Furthermore there are new algorithms with the aim of reduce the size relevantly but also with a minor quality decrease.

Consequently is important to select the correct devices related with the type of transmission and which compression is required.

Before making the choice is useful to know which compression tools are craved.

Here is a list of the different video coding standards:

- MPEG-1 : Is the standard of audio and video compression. Provides video at a resolution of 350x240 at 30 frames per second. This produces video quality slightly below the quality of conventional VCR videos. Includes audio compression format of Layer 3 (MP3).

- MPEG-2 : audio and video standard for broadcast of television quality. Offers resolutions of 720x480 and 1280x720 at 60fps with audio CD quality. Matches most of TV standards even HDTV. The principal use is for DVDs, satellite TV services and digital TV signals by cable.
  An MPEG-2 compression is able to reduce a 2 hour video to few gigabytes. While decompressing a MPEG-2 data stream no needs much computer resources, the encoding to MPEG-2 requires more energy to the process.

- MPEG-3 : Designed for HDTV but was replaced for MPEG-2

- MPEG-4 : Standard algorithm for graphics and video compression based on MPEG-1, MPEG-2 and Apple QuickTime technology. The MPEG-4 files are smaller than JPEG or QuickTime, therefore are designed to transfer video and images through a narrow bandwidth and sustain different mixtures of video with text, graphics and 2D or 3D animation layers.

- MPEG – 7 : Formally called Multimedia Content Description Interface, supplies a set of tools for multimedia content. Performed to be generic and not aimed at a specific use.

- MPEG – 21 : Allow a Rights Expression Language (REL) and Rights Data Dictionary. Describes a standard that defines the description of the content and the processes to access, search, store and protect the copyright of the content discordant with other MPEG standards that define compression coding methods.

The above-mentioned are the standard but each one has specific parts depending on the use.
Among these types the most important contemporaneously are:

- MPEG-2
- MPEG-4 → Particularly the part number 10 which without increasing the complexity of design and the file size, implements good video quality at lower bit rates than the previous. Technologically called MPEG-4 H.264 / AVC.

2.3.1.1. MPEG-2 (H.262)

MPEG-2 is a standard for “the generic coding of moving pictures and associated audio information”. Is an extension of the MPEG-1 international standard for digital compression of audio and video signals created to broadcast formats at higher bit rates than MPEG-1.

Initially developed to serve the transmission of compressed television programs via broadcast, cablecast, and satellite, and subsequently adopted for DVD production and for some online delivery systems, defines a combination of lossy video compression and lossy audio data compression using the actual methods of storage, like DVDs or Blu-Ray, without a bandwidth restriction.

The main characteristics are:

- New prediction modes of fields and frames for interlaced scanning.
- Improved quantification.
- The MPEG-2 transport stream permits the multiplexing of multiple programs.
- New intra-code variable length frame (VLC). Is a code in which the number of bits used in a frame depends on the probability of it. More frame probability implies more bits intended by frame.

- Strong support for increased errors.
- Uses the discrete cosine transform algorithm and motion compensation techniques to compression.
- Provides for multichannel surround sound coding.

MPEG-2 contains different standard parts to suit to the different needs. Also annexes various levels and profiles.

2.3.1.1.1 MPEG-2 FUNDAMENTALS

Nowadays, a TV camera can generate 25 pictures per second, i.e. , a frame rate of 25Hz. But in order to convert it to a digital television is necessary to digitalise the pictures in order to be processed with a computer.

An image is divided in two different signals: luminance (Y) and chrominance (UV). Each image has one luma number and two chrominance components. The television colour signal Red-Green-Blue (RGB) can be represented with luma and chrominance numbers. Chrominance bandwidth can be reduced relative to the luminance signal without an influence on the picture quality.

An image can also be defined with a special notation (4:2:2 , 4:2:0). These are types of chroma sub-sampling relevant to the compression of an image, storing more luminance details than colour details. The first number refers to the luminance part of the signal, the second refers to the chroma.

In 4:2:2 luminance is sampled 4 times while the chroma values are sampled twice at the same rate. Being a fact that the human eye is more sensitive to brightness than colour, chroma is sampled less than luminance without any variation for the human perception.

Those signals are also partitioned in Macro blocks which are the basic unit within an image. A macro block is formed by more blocks of pixels. Depending on the codec, the

block will be bigger or smaller. Normally the size is a multiple of 4.

MPEG-2 coding creates data flow by three different frame date: intra-coded frames (I-frames), predictive-coded frames (P-frames), and bidirectionally-predictive-coded frames (B-frames) called “GOP structure” (Group Of Pictures structure).

- I-frame: Coded pictures without reference to others. Is compressed directly from a original frame.
- P-frame: Uses the previous I-frame or P-frame for motion compensation. Each block can be predicted or intra-coded.
- B-frame: Uses the previous I or P picture and offers the highest compression. One block in a B-picture can be predicted or intra-coded in a forward, backward or bidirectionally way.

A typical GOP structure could be:

$$B_1\ B_2\ I_3\ B_4\ B_5\ P_6\ B_7\ B_8\ P_9\ B_{10}\ B_{11}\ P_{12}$$

I-frames codes spatial redundancy while B-frames and P-frames code temporal redundancy.

MPEG-2 also provides interlaced scanning which is a method of checking an image. The aim is to increase the bandwidth and to erase the flickering showing the double quantity of images per second with a half frame rate. For example, produce 50 images per second with a frame rate of 25Hz.

The scan divides a video frame in two fields, separating the horizontal lines in odd lines and even lines. It enhances motion perception to the viewer.

Depending on the number of lines and the frame rate, are divided in:

- PAL / SECAM : 25 frames per second, 625 lines per frame. Used in Europe.
- NTSC : 30 frames per second, 525 lines per frame. Used in North America.

2.3.1.1.2. PROFILES & LEVELS

MPEG-2 encoding is organized into profiles. A profile is a "defined subset of the syntax of the specification". Each profile defines a range of settings for different encoder options. As most of settings are not available and useful in all profiles, these are designated to suit with the consumer requirements. A computer will need a hardware specific for the use, the same with a television or a mobile phone, but it would be capable to rate it in a particular profile.

Indoors each profile are multiple levels. A level is a "defined set of constraints on the values which may be taken by the parameters of the specification within a particular profile", i.e. a level is the quantitative capabilities restrictor which fixes characteristics like the bit rate or the maximum frame size.

Based on the limitations the list is divided in four levels: Low Level, Main Level and High 1440 and High Level.

For a specific use a combination of profile and level is applied noted as Profile@Level, for instance, Simple Profile and Main Level will be written as SP@ML.

The table 1.1 shows the Profile @ Level combinations used for the DVB-T broadcasts.

Profile @ Level	**Resolution**	**Maximum frame rate**	**Sampling**	**Bit Rate**
Main profile @ Main Level	720x480	30	4:2:0	15Mbps
Main Profile @ High Level	1080i with 1920 pixels/line or 720p with 1280 pixels /line	1080i: 30 or 720p: 60	4:2:0	80Mbps
422 Profile @ Main Level	720x480	30	4:2:2	50Mbps
422 Profile @ High Level	1080i with 1920 pixels/line or 720p with 1280	1080i: 30 or 720p: 60	4:2:0	300Mbps

	pixels /line			

Table 1.1. Specifications of the MPEG-2 Profiles and Levels combination.

Then a encoder is needed to finish the compression. Although each encoder can be used with several combinations of profiles and levels, most of them only support up to MP@ML.

2.3.1.1.3 MPEG-2 COMPRESSION BASICS

2.3.1.1.3.1. SPATIAL REDUNDANCY

A technical compression type which consists on grouping the pixels with similar properties to minimize the duplication of data in each frame.
Involves an analysis of a picture to select and suppress the redundant information, for instance, removing the frequencies that the human cannot percept.
To achieve this is employed a mathematical tool: Discrete Cosine Transform (DCT).

2.3.1.1.3.2. INTRA-FRAME DCT CODING

The Discrete cosine Transform (DCT) is a based transform with Fourier Discrete Transform with many applications to the science and the engineering but basically is applied on image compression algorithms. Is employed to decrease the spacial redundancy of the signals.

This function has a good energy compaction property and so on accumulates most of the information in few transformed coefficients. In consideration of this the signal is converted to an new domain, in which only a little number of coefficients contain most of the information meanwhile the rest has got unappreciated values. In the new domain, the signal will have a much more compact representation, and may be represented mainly by a few transform coefficients.

It is independent of the data. The algorithm is the same, regardless of the data applied in the algorithm. It is a lossless compression technique (negligible loss).

The DCT is capable of interpret the coefficients in a frequency point. As a result of that, can take a maximum of compression capacity profit.

The result of applying DCT is an 8x8 array composed of distinct values divided in frequencies:

- Low frequency implies more sensitive elements for the human eye.
- High frequency means less cognizant components.

2.3.1.1.3.3. TEMPORAL REDUNDANCY

Temporal compression is achieved having a view in a succession of pictures.

Situation: An object moves across a picture without movement. The picture has all the information required until the movement and is not necessary to encode again the picture until the alteration.

Thereafter, is not necessary to encode again all the picture but only the part that contains the movement owing that the rest of the scene is not effected by the moving object because is the same scene as the initial picture.

The notation with is determined how much movement is contained between two successive pictures is motion compensated prediction.

As a result of isolating a picture is not a good fact because probably an image is going to be constructed from the prediction from a previous picture or maybe the picture may be useful to create the next picture.

2.3.1.1.3.4. MOTION COMPENSATED PREDICTION

Identify the displacement of a given macroblock in the current frame respect from the position it had in the frame of reference. The steps are:

- Search for the same macroblocks of the frame to be encoded in the frame of reference.
- If there is not the same macroblock then the corresponding motion vector is encoded.
- The more similar macroblock (INTER) is chosen and later on is necessary to encode the motion vector.
- If there is no similar block (INTRA) these block is encoded using only the spatial

redundancy.

2.3.1.2. H.264 / MPEG-4 AVC

H.264 or MPEG-4 part 10 defines a high-quality video codec compression developed by the Video Coding Expert Group (VCEG) and the Motion Picture Experts Group (MPEG) in order to create a standard capable of providing good quality image, but using rates actually lower than in previous video standards such as MPEG-2 and without increasing the complexity of its design, since otherwise it would be impractical and expensive to implement.

A goal that is proposed by its creators was to increase its scope, i.e., allow the standard to be used in a wide variety of networks and video, both high and low resolution, DVD storage, etc.

In December 2001 came the Joint Video Team (JVT) consisting of experts from VCEG and MPEG, and developed this standard to be finalized in 2003. The ISO / IEC (International Organization for Standardization / International Electrotechnical Commission) and ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) joined this project. The first is responsible of the rules for standards by focusing on manufacturing and the second focuses mainly on tariff issues. The latter planned to adopt the standard under the name of ITU-T H.264 and ISO / IEC wanted to name him MPEG-4 Part 10 Advanced Video Codec (AVC), hence the name of the standard.

To set the first code they firstly based on looking at the previous standard algorithms and techniques to modify or if not create new ones:

- DCT structure in conjunction with the motion compensation of previous versions was efficient enough so there was no need to make fundamental changes in its structure.
- Scalable Video Coding: An important advance because it allows each user,

regardless of the limitations of the device, receives the best possible quality, issuing only a single signal. This is possible because it provides a compressed stream of video and users can take only what you need to get a better video quality according to their technical limitations of receipt.

The MPEG-4 has more complex algorithms and better benefits giving a special quality improvement, which provides a higher compression rate than MPEG-2 for an equivalent quality.

2.3.1.2.1. MAIN ADVANTAGES

For the MPEG-4 AVC the main important features are:

1. Provides almost DVD quality video, but uses lower bit rate so that it's feasible to transmit digitized video streams in LAN, and also in WAN, where bandwidth is more critical, and hard to guarantee.

2. Dramatically advances audio and video compression, enabling the distribution of content and services from low bandwidths to high-definition quality across broadcast, broadband, wireless and packaged media.

3. Provides a standardized framework for many other forms of media — including text, pictures, animation, 2D and 3D objects – which can be presented in interactive and personalized media experiences.

4. Supports the diversity of the future content market.

5. Offers a variety of so-called “profiles,” tool sets from the toolbox, useful for specific applications, like in audio-video coding, simple visual or advanced simple visual profile, so users need only implement the profiles that support the functionality required.

6. Uses DCT algorithm mixed with motion compensation.

7. It clearly shows that MPEG4 wants to be a content-based representation standard independent of any specific coding technology, bit rate, scene type of content, etc. This means it shows at the same time why and how MPEG4 is different from previous moving pictures coding standards.

8. Low latency

9. The most important and relevant are:
    1. Reduces the amount of storage needed
    2. Increases the amount of time video can be stored
    3. Reduces the network bandwidth used by the surveillance system

2.3.1.2.2. MAIN NEW FEATURES

- Type of image: Adding two extra frames, apart from I, P, B, the SP (Switching P) and SI (Switching I) which allows passing from one video to another applying the temporal or spatial prediction with the possibility to reconstruct accurate values of the sample even when using different reference images than the images used in the prediction process.

- Motion compensation: With variate sizes of the sub-blocks; 16x8, 8x16, 8x8 pixels, 8x8 size can be partitioned into 8x4, 4x8 or 4x4 groups of pixels to providing a greater accuracy into the estimation.

- Transform: a DCT modification with a 4x4 pixel size, using Integer coefficients to avoid the approximation errors, getting a better precision to calculate the coefficients.

- Entropy coding: Coding method without errors that consist in treating all the transform array in a zigzag way, bringing together groups with similar frequencies, insert coded zeros and applying VLC coding for the rest. This technique reduces in a 5% the file size but with a larger coding and decoding time.

2.3.1.2.3. PROFILES AND LEVELS

The chart 1.2 exposes the combinations of Profiles @ Levels of MPEG-4 AVC used in the DVB-T.

Profile @ Level	Resolution	Maximum frame rate	Sampling	Bit Rate
Main profile @ Level 3	720x480	30	4:2:0	10Mbps
Main Profile @ Level 4	1280x720 1920x1088	1080i: 30 or 720p: 68,3	4:2:0	20 Mbps
Baseline Profile @ Level 4	1280x720 1920x1088	1080i: 30 or 720p: 68,3	4:2:0	20 Mbps
High Profile @ Level 3	720x480	30	4:2:0	12,5 Mbps
High Profile @ Level 4	1280x720 1920x1088	1080i: 30 or 720p: 68,3	4:2:0	25 Mbps

Table 1.2. Combination of Profiles and Levels with the specifications.

The combinations used for the SDTV are MP@L3 and Hp@L3, and for the HDTV: BP@L4, MP@L4 and HP@L4.

2.3.1.3 DEVICES

2.3.1.3.1 ENCODER

A encoder is a device used to convert analog video signals into digital video signals. Most of them compress the information so it can be stored or transmitted in the minimum space possible. To achieve this it takes advantage of video sequences that have spatial or temporal redundancy. Therefore, eliminating redundant information obtains that encode information more optimal.

The spatial redundancy is erased with DCT coefficient coding. To delete temporal redundancy is used the motion compensation prediction, with motion estimation between successive blocks.

The operation method is:

- signals are separated luma (Y) and chroma (C).
- Find the error of estimation to made the DCT.
- The coefficients are quantified and entropy coded (VLC).
- Coefficients are multiplexed and passed to the buffer. The buffer control the quality of signal.
- Check that the outflow bit stream of the buffer is not variable, because the signal is thought to be transmitted on a channel with a steady speed.
- The quantified image is reconstructed for future reference for prediction and motion estimation.

The DCT algorithm and the block quantification can cause visible discontinuities at the edges of the blocks leading to the known “Blocking effect”, because the DCT omits the 0 in the matrix, so may produce imperfections. As a result of, new standard video coding like H.264/MPEG-4 ACV, includes filter algorithms able to decrease that effect.

2.3.2. BROADCAST

Once the video is encoded in the desired format (MPEG-2 or MPEG-4/H.264 AVC) will have to be put on the network to be distributed and transported to the end user.

In this field there are different connections, satellite, terrestrial, cable, etc.. Depending on the type of means used in transport will have different formats, but mostly in terrestrial digital television will use a terrestrial connection (DVB-T) mixed with a connection via satellite (DVB-S). These connections will be in charge of transmitting the digital signal to the end user, but first this signal must be created, since only at this point you have video signals, audio and data.

When the video is finally created and edited the next step to do is to encode it by an encoder where it is compressed using the techniques previously exposed and decide the format to use. Once we have the different signals coded (Video, Audio, Data, etc.), those will be sent to a multiplexer. This device will be the responsible of gathering all the input signals into an only output signal. Using a container format (MPEG-TS or MPEG-PS) the signal will be transported to the modulator to limit the frequency and to the upconverter

and hence will go via satellite to the National Antenna. This will receive the signal in the national headend and there will be treated, in case you have to convert the signal from MPEG-2 to MPEG-4 for example, a transcoder will be used. Then the multiplexer to finally go via the regional antenna to antenna community, where the home decoder will detect the signal (explained in the following paragraph) and decode it to be viewed on television. The transmission between the regional antenna to the communities also can be done with an HFC network (Hybrid Fiber-Coax) network.

Previously it was mentioned "container format". A container format is a file type that has the function of storing information of various types, both audio, video, pictures, captions or metadata, synchronized by a clock with a certain standard format, given the latter by a specific type of compression.

One one hand will exist containers for a particular type of information, while others may combine various types of information. Looking at the video field, there will be containers which allows the bidirectional prediction (B-frames).

Related with the video transmission, there will be two different types of container formats:

- MPEG-PS (Program Stream) : Is a multiplexation format oriented to one or multiple streams of PES (Packaging Elementary Stream) packages. Is a specification in the MPEG-2 part 1 which defines the transport of several ES (Elementary Stream, output of an audio or video encoder) and is composed of them. These will be encoded by the same reference clock, STC (System Time Clock). May contain video streams, audio and extra data and moreover integrates clock information for the correct decoding. The bit rate of MPEG-2 PS can be variable or fixed, which is determined by the SCR (System Clock Reference). Its design is geared towards storing a program encoded on a single channel error-free data because does not concert about the error rate.

- MPEG-TS (Transport Stream) : It is a communication protocol for the audio, video and data transmission in a noisy susceptible media, which is specified in MPEG-2

part 1 (ISO / IEC 13818-1). Allows multiplexing of different types of content, without the necessity of being from the same source, to demultiplex and receive it synch. It is used in the DVB and ATSC (digital TV in North America). This manages the error protection, thus differs from MPEG-PS.

2.3.2.1 DEVICES

2.3.2.1.1. UPCONVERTER

Upconverter is used to convert television signals to VHF or UHF signals regardless if is a digital signal or analog signal. The device detects the kind of incoming signal and being based on if is a digital or analog, creates the suitable reference signal.

2.3.2.1.2. TRANSCODER

Presently, video content really is one of the most important aspects in the technology, with more and more features every day, and as the world is evolving around high definition, these features increases dramatically.
Transcoding is really important to carry content over networks and transporting it to televisions, computers or other electronic devices specially when a device cannot hold a format or when does not have capacity to store the file and needs a conversion with lower file size.

A transcoder is a device that codes and recodes digital standards between a compressed format to another to permit the transmission over various devices. For instance, the transcoder can be used to the conversion from MPEG-2 or MPEG-4 to H.264.
Also there is the transcoding of resolution, which is charged, for example, to the downgrading of HD to SD or lesser resolution.

2.3.2.1.3. RECEIVER

A headend receiver is used for the reception of satellite digital TV programs and to distribute this channels in a centralized antenna with terrestrial signals.

The receiver is comprised of a plurality of analog front end circuits coupled to the various

HFC systems, each selective coupled to any one of a plurality of digital front end receivers.

2.3.2.1.4. MODULATOR

In the televisions systems, signals can be carried between a limited frequency spectrum, which a concrete lower and upper frequencies.

A modulator is a device charged of transporting a signal inside another signal to be transmitted. Is able to transform a low-frequency signal into a other frequency signal. As a result of, the frequency can be controlled and the problem above can be solved.

Mainly, the aim of modulate a signal consist in changing a parameter of the wave according to the variations of the modulation signal (information to be transmitted).

2.3.2.1.5. MULTIPLEXER

A multiplexer is a switching device that combines two or more signals. In the digital world, the thing that is combined is a video track, audio tracks and subtitle tracks into a signal. So the multiplexer receives the video, audio and signals with different signals, and combines to form only one signal.

2.3.3. CUSTOMER

2.3.3.1. REQUIREMENTS

Today everyone knows the digital terrestrial television and could know the needed requirements in order to obtain a digital signal. But many people still do not know what their system needs must have. When talking about DTT reception is compulsory think to buy a digital content receiver (Set-top Box), but the fact is that is not the only step to receive the signal, in fact is the last level to comply. So previously, there was the purchase of many DTT receivers without being firstly ascertained the need to make any changes.

First of all the problem is the coverage. DTT households is received by the antenna and to receive the signal the antenna must be in the coverage area. If not a change in antenna is required to receive the signal.

The first requirement to check is the aforementioned, being in a coverage area. The coverage of each country is determined by the national decree of digital terrestrial television. In addition it also includes information about the DTT establishment phases with an estimated national coverage of each period to be reached just before the final phase, the "Analogical switch-off." Each country will have its implementation phases.

The next check to make is knowing whether the current antenna is ready to receive the digital signal. Although you can usually get through the signal by the conventional antenna, sometimes is desirable to make any changes on it. If necessary it is best to contact a registered telecommunications installation company. Depending on the complexity of the installation, status and seniority of both it and the building, some other modifications will be required.

In case you need to change a considerable part, the installation company must justify these changes written, enclosing a list of new items that will be integrated and, if necessary, the old ones that will have to replace.

If the event demands a higher modification, a preliminary analysis by the installation company before acting or even a study made by a telecommunications engineer with all the formalities this study requires.

The last step to complete is to get a digital TV receiver (Set-top Box). This device receives and decodes transmissions for viewing on an analog television. This device can be external, connected to the TV via a SCART normally, or internal, coming this integrated with television. Furthermore, if the device has the technology MHP (Multimedia Home Platform) is able to access bonus content such as interactive applications.

Is important to notice that one STB is only for one television. On the assumption that the user has more televisions, the same number of set-top boxes such as televisions will be required.

2.3.3.2. DEVICES

2.3.3.2.1. SET-TOP BOX

As mentioned before, is a device used to receive and decode the transmissions required to view the digital television.

The name of set-top box is because normally are placed in the top of the television, the external ones only.

Nowadays, an among quantity of televisions include an integrated STB but also the old televisions need an external device.

Is normally connected with a SCART connection to the television but also with a RCA connection or antenna connection, and includes a large range of TV channels with the EPG and radio channels.

Later we will talk about the STB relating it with the power consumption.

2.3.3.3. DTT FOR PC

As it is now possible to receive analog TV signal on your computer by using a tuner card and connecting an antenna cable to the CPU, is also easy to receive digital programming on your PC. With the card installed, besides being able to convert the monitor to a TV screen, will be possible to record and store on the hard drive any program broadcasted by DTT, since the issue is done in MPEG2, a standard that computer support without processing needed.

2.4. DTT IN SPAIN

The acronym DTT, Digital Terrestrial Television means from a technological point of view the replacement of the standard analog spread and transmission by the DVB-T digital system (Digital Video Broadcasting Terrestrial). This change leads to a inherently better quality of picture and sound, a more considerable list of channels and the possibility of beginning with the interactive television.

2.4.1 REGULATION

The National Technical Plan for Digital Terrestrial Television was approved by “Real

Decreto 944/2005" of July 29th. This established the deadline for the "Analogical switch-off" (April 3rd , 2010) for the cessation of terrestrial television broadcasting with analog technology. Furthermore, sets the stage for this transition from analogue to digital technology and the point after the cessation of terrestrial television broadcasting with analog technology.

The table 1.3 shows the first national channels in Spain. The regional channels are not included.

RGE network	**Channel 66**	**Channel 67**	**Channel 68**	**Channel 69**
TVE1	Teledeporte	Cuatro	Telecinco	Antena 3
TVE2	Veo TV (1)	CNN+	Telecinco (2)	Antena 3 (Nova)
24 horas	Veo TV (2)	40 Latino	FDF (Telecinco)	Antena 3 (Neox)
Clan TVE	Net TV (1)	La Sexta (1)	Net TV (2)	La Sexta (2)
Data	*Data*	*Data*	*Data*	*Data*

Table 1.3. First DTT national channels

This technical plan also established the radio-electric channels for the regional zones. Radio channels that comprise the global network of state coverage (RGE) with capacity to carry make territorial disconnections of autonomous field are:

Andalucía: Channel 57.
Aragón: Channel 61.
Asturias: Channel 64.
Balears (Illes): Channel 63.
Canarias: Channel 60.
Cantabria: Channel 58.
Castilla-La Mancha: Channel 59.
Castilla y León: Canal 57.
Catalunya: Channel 64.
Comunidad Valenciana: Channel 58.
Extremadura: Channel 63.
Galicia: Channel 63.

Madrid: Channel 58.

Murcia: Channel 61.

Navarra: Channel 59.

País Vasco: Channel 63.

Rioja: Channel 64.

Ceuta: Channel 65.

Melilla: Channel 64.

In the aforementioned plan and the second additional provision of "Real Decreto 920/2006" of July 28th , there were set the phases and the coverage to be achieved represented in the table 1.4

PHASE	POPULATION COVERED
December 31th of 2005	80%
July 31th of 2007	85%
July 31th of 2008	87%
December 31th of 2008	90%
July 31th of 2009	93%
April 3th of 2010	96% (private televisions) / 98% (public televisions)

Table 1.4. Phases of the introduction and the relative population covered.

2.4.2. IMPLEMENTATION

The DTT Spanish distribution is divided in three parts: signal contribution from the production studios to the headend, the distribution and dissemination of the signal and the reception in the receiver facility.

1. In the phase of the signal contribution the signal is coded and multiplexed at the headend, charged to add the service information and generate the transport stream. This could lead incidents in the headend equipment or coordination problems in the technical management of the multiplexer. Both content generators as the manager of the multiplexer are participating in this paragraph.
2. During the distribution and dissemination, the signal is carried from the headend to the emitting centers and leading in turn to the signal modulation and amplification, a necessary previous step for the diffusion heating system to the

territory. Possible problems that might arise would be related to network equipment, network timing or interferences.

3. In the building facilities the signal is received by radio-frequency, distributed along the homes and receiving equipment is demodulated, decoded and presented to the end-users. Associated problems could be inadequate signal levels or facilities, incidents with the decoders or improper antenna pointing.

2.4.3 MAIN CHARACTERISTICS

The DTT Spanish network (TDT) contains 4 multiple SFN (Single Frequency Network) associated with private broadcasters and various regional SFN assigned to the RTVE (Radio Televisión Española) corporation composed by 18 territorial disconnections, one for each of the regions, so that is structured with an autonomic field.

The image, audio and associated data is digitally encoded in MPEG-2 and the binary data encoding is transmitted using COFDM modulation (Coded Orthogonal Frequency Division) which divides the flow into several sub-flows. This has three modes; One based on 2048 orthogonal frequencies, another with 4096 frequencies and another with 8192.

According to the DVB-T standard, channels can have from 6 to 8 MHz bandwidth. Those channels use the UHF frequencies (from 470 to 892 MHz) with 8Mhz of bandwidth.

The UHF frequencies are:

- 830 to 862 MHz : National channels operating overall the country with no regional disconnections.
- 758 to 830 MHz : Regional field with disconnections between the different autonomous communities.
- 470 to 758 MHz : Local channels in local regions with licenses.

Other properties:

- Modulation : 64-QAM
- FEC (Forward Error Correction): 2/3. 2 bits used and the last is for redundance to

correct the transmission errors.

Using this parameters the bit rate acquired is : 19,91 Mbps.

2.4.4. HEADEND CENTER

The Headend center is where the encoding and multiplexing TDT signals is done. For this proposal, is composed by an encoding part, multiplexers, network and SFN adapters in a redundant configuration.

The coding for each TDT signals is performed with the following features:

- MPEG-2 encoding: 4:2:0 ML @ MP
- Video inputs : Digital SDI and analogical video.
- Audio encoding / processing : MPEG-1 Layer II and Dolby Digital / 8 monos and 4 stereo.
- Audio inputs : analogical and digital (AES-EBU with SDI).

The headend create three new generic parameters : original_network_id + transport_stream_id + service_id; necessary for the user to receive all the regional signals from more than only one emitter, based on this the user will be able to get the channels not only from the user region but also from the neighbour zone.

Then the TV digital signal from digital encoding systems, the subtitles, the service information tables and the radio digital signals are token by the multiplexer. Conjointly the multiplexer is the responsible of coupling all the aforementioned signals in one.

Finally is sent to the distribution network SFN signal, with the MIP field, to be transmitted through the network to the emitter centers to be propagated.

At DVB-SI table level, and next to the multiplexer, injectors are used for service information. The following DVB-SI tables are injected:

- NIT (Network Information Table) : Contains terrestrial information and transport

streams. Including “original_network_Id” (8916 in Spain) and “Network_Id” (256 values).

- SDT (Service Description Table) : Includes the information related with the digital channels in conjunction with the “Transport_Stream_Id” and the “Service_Id”.

- EIT (Event Information Table) : Includes data elements transmitted on an MPEG stream containing the TV program details such as the program name, start time, duration, etc.
  Used by the Set-top Box to create an Electronic Program Guide.

- TDT (Time and Data Table) : Contains the UTC (Universal Time) coded as MJD (Modified Julian Date).

- TOT (Time Offset Table) : Provides information attending on the local time offset from the UTC time to define the local time.

2.4.5. TRANSPORTATION AND DISTRIBUTING NETWORK SIGNAL

The transport and distribution network is responsible of carry the signal from the headend to the broadcast network to be finally transmitted to the end user. Contains a terrestrial part composed of radio links and fiber optics and satellite elsewhere.

Terrestrial:

- From the headend center to the regional headends.
- From the regional headends to the distribution transmitter centers until a certain coverage.

Satellite:

- From the headend center to the regional headends.
- From the regional headends to the distribution transmitter centers to reach all the rest of the centers.

2.5. DIGITAL TELEVISION IN BELGIUM

Each community in Belgium (Flemish, French and German-speaking) have the responsibility for audiovisual communication and they do not share the market. Every region constituted during the last three decades separate markets and they created their own systems of regulating the audiovisual media. The VRT is the public service broadcaster of the Flemish part.

The main Flemish TV players are the VRT with the most audience Flanders TV channel, Eén with a share of 30%; and VMMa with the second most important channel, VTM with a share of 21%.

Telenet is the country primary cable operator with the 50% of coverage. The second important broadcast distribution is the IPTV followed by the Satellite TV.

In November 2008 was the analogical switch off in the Flemish Community. VRT Eén and VRT Ketnet/Canvas analogue terrestrial TV transmissions, ended on November 3, 2008.

2.5.1. DVB-T

The Flemish public TV network broadcasted via digital terrestrial transmission is the VRT.

It was a movement to lower frequencies and this may result in a slight increase in coverage area of the transmissions.

The images are created in the study. The obtained signal is really large (270 Mbps) so should be reduced by MPEG-2 codification. Audio is encoded by MPEG-1 Layer II, 7 times smaller than a CD.

Inside the reception area there are several posts that spread the signal over the air. Later on the signal is converted to digital image for be received in a TV or Hi-Fi system. The transmitters operate in UHF frequency (470 – 862 MHz).

At that date, there are network stations in Schoten, Antwerpen, Sint-Pieters Leeuw, Veltem (Leuven control), Egem (Tielt), Genk and two for Brussels.

Table shows the list of multiplexers of VRT transmissions and the area of coverage.

OLD MUX	NEW MUX	REGION
40 (626 MHz)	22 (482 MHz)	Egem

41 (634 MHz)	25 (506 MHz)	Genk
59 (778 MHz)	25 (506 MHz)	Antwerpen and Schloten
22 (482 MHz)	22 (482 MHz)	Brussels, Gent, Sint-Pieters-Leew and Veltem

Table 1.5 Distribution of MUX per area in Flanders.

2.5.2. DVB-S

Is the other important way of broadcasting the Flemish TV. The most important supplier is TV Vlaanderen. Is a subsidiary of the Airfield Holding who own the Dutch DTH platform called CanalDigitaal.

This company is broadcasting the television via the Astra 1G satellite with more than 60,000 subscribers.

2.5.3. POPULATION COVERAGE

	2009	
	Number	**Rate of Penetration (&HH)**
Population	10827000	-
Households	4568000	-
TV Households	4506000	98,6
Households with DTT receivers	73000	1,6
Total digital TV households	2096000	46,5

Table 1.6. 2009 Flemish coverage for DTT television.

3. CHAPTER TWO: THE TRANSITION

3.1. TRANSITION TO HD

The term HD (High Definition) is a name that has become increasingly popular in all worlds. Recently it was necessary to go to the cinema to watch a movie with good quality, but year after year, the technology has advanced and has achieved that television can have an excellent quality in homes.

HD provide a higher image quality so that implies larger amount of information. This change also claims more power supply for completing the work. Treating bigger data numbers or signals require more powerful electronic compressors, processors, so in that way, more energy. The clear example is a television: HD resolution has more lines per image than SD definition. A high quality image also require more brightness, colour and pixels. To accomplish that a bigger amount of energy supply is needed so that the power consumption increases significantly.

But this process has required some changes during the process of implementation, not just buy a TV that allows high-definition display. This chapter explains the major changes needed to make this transfer but without going into detail on the energy consumption of each item.

The explanation is divided into three parts: first discuss the production stage, where the video file is compressed to high definition, the second part will be the broadcast which refers the used devices in the distribution and what changes are needed to be HD compatible, ultimately the consumer, adjustments and changes that have to do to display high-definition television.

3.2. TELEVISION IN HD

The HDTV is the latest step in the evolution of television prior to 3D TV. HDTV (High Definition Television) differs from the SDTV (Standard Definition) by its image quality. The image quality is far superior to the quality of previously used systems (PAL, NTSC and SECAM).

The number of lines per image dramatically increase, in this way is talked about a considerable increase in resolution, such as PAL system had a resolution of 768x576 and used the 4:3 format, the bottom side of the picture is 4 / 3 times larger than the lateral side, fitting to the shape of television to occupy almost all of it.

HDTV uses a resolution of 1920x1080, i.e., takes many more samples of the image with compression algorithms, and also uses a 16:9 (16 parts wide by 9 high), format used in cinemas. Furthermore, the HD has more than seven billion colours and over two million pixels (the SD has 450,000) this implies a considerable increase image quality. This represents a wealth of information 5 times higher than in PAL.

The high-definition broadcasts have two formats: 720p and 1080i. 720p, 720 lines are scanned progressively while 1080i has 1080 scanning lines. Each offers different advantages, for example 720p has a higher quality offering a clear and stable picture getting better results on images of fast motion, while 1080i offers more detail in the images.

- 1080i (1080 lines using the “i” method (interlaced or interleaved). To get a smoother image in case of higher resolution emissions, making a screen refresh changing interlaced odd and even lines alternately 60 times every second. The model is called 1080i or 1080i60 because it uses a frequency of 60Hz. Using the 1080i there are other alternative systems for lower quality TVs that use the refresh with a frequency of 50Hz and is called 1080i50. The resolution of 1080i is 1920x1080 .

- 720p (720 lines using “p” scanning (progressive). Used in television standards of lower resolution with fewer lines, in this case is 720 and the refresh is made in full, in which all box lines change at once normally operating with 60Hz frequency.

There is another format which is used in the Blu-Ray and higher definition television; the 1080p, which also uses progressive scan technology.
Later the consumer section will discuss the distinct HD types and what everyone means.

3.3. PRODUCTION

Previously were explained the devices required in the production part of the distribution chain. In this part the device needed is an encoder to compress the signal into a standard coding format. Each format combines different profiles and levels to obtain the best quality depending on the final user demand.

The transform from a video signal to a digital signal, made by an encoder, produces a large amount of data not supported for the existing dissemination systems. To achieve the challenge is needed a compression.

In HDTV the most used coded formats will be MPEG-2 and MPEG-4/AVC. Those combines the profiles (each profile defines the compression mode) with the levels (represent the image resolution and the maximum bit rate associated with each profile).
The combinations of this profiles @ levels for the HDTV are:

- MPEG-2
  - Main Profile @ High Level (MP@HL) instead of MP@ML used in SDTV.
- MPEG-4/AVC
  - High Profile @ Level 4 (HP@L4)
  - Main Profile @ Level 4 (MP@L4)

The standard definition Profile@level combination, MP@ML allows pictures as large as 720x576 pixels for picture. The high definition format allows pictures until 1920x1080 pixels per image. Because of the larger amount of data required to represent a HDTV frame those decoders need to support much higher data rates than SDTV decoders.

In the terrestrial broadcast system, the maximum data rate is 19.39Mb/s, though in the real world, the ceiling is closer to 18Mb/s. HD programs are encoded in a 4:2:0. A HDTV encoder requires additional memory in comparison with SDTV decoder also combined with an increased complexity makes a HDTV decoder more expensive than an SDTV encoder

3.3.1. ENCODER REQUIREMENTS

VIDEO RESOLUTION	720p, 1080i
VIDEO CHROMA	4:2:0
VIDEO INPUT	HD-SDI
VIDEO RATE	Up to 80Mbps
VIDEO ENCODING	MP @ HL (MPEG-2) MP @ L4 (MPEG-4 AVC)
OUTPUT TS RATE	Up to 120Mbps
VIDEO INVERSE	3:2 pulldown
VIDEO MODE	CBR and VBR
AUDIO ENCODING	MPEG-1 Layer II or Dolby Digital

Table 3.1. Main HD Encoder requirements

3.4. BROADCASTING

The devices that will change depending on the quality of the transmission (SD or HD) are:

3.4.1. MULTIPLEXER

Multiplexer is a device that needs to change if is an HD or SD transmission. Due that this device treats different types of information (Audio, Video, etc.) by the multiplexer inputs, is necessary to define the bit rate for each input and if the input is in HD the bit rate will be higher than SD.

Basically is difficult to establish precise requirements, however a high bit rate is necessary. Also is necessary an HD input. Part of the input encoders hold 1 or 2 inputs but normally several only support 1 HD entrance, aside of HD audio inputs and other data.

3.4.2. TRANSCODER

The transcoder requirements will be partially the same than the encoder requirements. This device needs to adapt to HD transmission because it function is to convert a format to another format.

Normally the type of conversion will be from MPEG-2 to MPEG-4 AVC format due that actually the HDTV is broadcasted with MPEG-4 AVC standard. HDTV requires a high quantity of information and due to the limited bandwidth the compression of MPEG-4 is necessary.

Contemporary the JCT-VC (Joint Collaborative Team on Video Coding), joint programme between MPEG and VCEG, is developing a new video coding standard, the HEVC (High Efficiency Video Coding) or also called H.265.
The aim of HEVC is to improve the coding efficient compared to the previous standards. HEVC will reduce the bit rate for a equivalent quality in order to be more useful for the actual transmissions but specially for the future transmissions such as Ultra HDTV (7680x4320) with a larger amount of data information.

3.4.2.1. REQUIREMENTS

VIDEO RESOLUTION	720p, 1080i
VIDEO FORMAT INPUT	MPEG-2, MPEG-4 AVC
VIDEO FORMAT OUTPUT	MPEG-2, MPEG-4 AVC
VIDEO TRANSCODING	MP @ HL (MPEG-2) MP @ L4 (MPEG-4 AVC)
VIDEO INVERSE	3:2 pulldown
VIDEO MODE	CBR and VBR
AUDIO ENCODING	MPEG-1 Layer II or Dolby Digital
OUTPUT BITRATE	10 to 25Mbps

Table 3.2. Main HD Transcoder requirements

3.5. CUSTOMER

This paragraph will refer to the requirements, at the consumer level, that are needed to view HDTV.

3.5.1. SET-TOP BOX

The device needed will be different than the SDTV digital decoder. The main difference is that the STB should be adapted to receive and decode high definition digital signals and in main cases to decode not only MPEG-2 but also MPEG-4 AVC transmissions.

3.5.2. TELEVISION

The HDTV has a larger resolution formats, a 16:9 screen format and wealthier information per image than in the SDTV. Therefore, it is necessary to have a TV capable of displaying this resolution. When selecting a HDTV is important to consult at the following features.

3.5.2.1. DIMENSION

For that a screen is considered high definition at least must be able to have a 16:9 aspect ratio and have at least 720 lines. To find the correct screen size it is necessary to know the viewing distance, because depending on it will be more convenient one size or another. The viewing distance is calculated to considering to the diagonal dimension.

$$d\ (m) = 42{,}5 \times D\ (\text{inches}) / N\ (\text{number of lines})$$

If it is wished to see through two meters how many inches are need for a resolution of 1280x700 is:

$$2 = 42{,}5 \times D / 720 \Rightarrow D = 32{,}94 \text{ inches.}$$

Below this size, high definition is not well appreciated. Otherwise with a larger screen size than required, it produces the opposite effect, too much detail are seen and produces a whole viewing loss.

HDTV supports a 16:9 aspect radio, unlike the 4:3 used by the SDTV. When a image in standard definition is displayed in a high definition screen there are some drawbacks. Firstly the constraints of the standard definition are perceived with higher detail. Secondly the image distortion during the 4:3 to 16:9 transform. Finally, the pixelation created refreshing the image with a progressive scan instead of interlaced.

3.5.2.2. RESOLUTION

Any HD television must support the tv broadcasts with standard definition contents, so that the screen resolution in this case does not match the sharpness of the image to display.

To make these adjustments is needed a scaling process, which adjusts the image to the screen resolution trying to lose as little quality as possible. This action requires the use of a scaler.

The scaler performs two functions depending on the modification required:

- Upscaling : When the screen resolution is higher than the definition of the image.
- Downscaling : When the image is sharper than the resolution of the TV screen.

It should be noted that the screen resolution is not the same as the video resolution set out in the beginning of this chapter.

3.5.2.3. LOGO

There are different standard for high definition televisions. These badges help the user to know which requirements does the TV meet. These set out below are the standard, there are others such as "Full HD" logos that belong to private labels. The requirements of each logo are defined by the EICTA (European Information, Communications and Consumer Electronics Technology Industry Associations).

HD Ready: For a TV has this label must meet the following requirements:

- Screen resolution of at least 1080x720 pixels
- 16:9 Aspect Ratio
- YPrPb analog connection for the compatibility with previously devices.
- HDMI digital connection that supports the video formats:
  - 1280x720 at frequencies of 50 and 60Hz coupled with progressive scan.
  - 1920x1080 with frequencies of 50 and 60Hz plus interlaced scanning.

HD Ready 1080p: To possess the HD Ready 1080p logo a TV must have the HD Ready features adding the following functionalities:

- Screen resolution of 1080 lines minimum (1920x1080).
- The video formats are fundamental to be reproduced without distortion in the aspect ratio conversion.
- Allows 1080p video formats.
- HDMI connection with HDCP support as anti-piracy system supporting video formats of HD Ready:
    - 1920x1080 accompanied by frequencies of 24 and 50Hz and progressive scan.
- It must play lossless video formats with 1920x1080 HD resolution.

In case that the television includes an integrated decoder, will annex the HDTV and HDTV1080p logos. Lately this requirements will be specified.

3.5.2.4. LUMINOSITY

Luminosity shows the amount of the screen light and in turn is responsible for controlling the brightness and colour of the image. A high luminosity image helps to accurate problems like screen reflections but consuming more energy.

3.5.2.5. CONTRAST

Measures the difference between the black and white colour of an image using a relation variable. With bigger this variable better quality and the image will be sharper. The contrast needs to be adjusted depending on the luminosity and vice versa.

3.5.2.6. SCREEN LIFETIME

Directly involved with the quality of the image. Time over time screens are being degraded depending on the amount of use and the image quality decreases.

The manufacturer recommends a limit of use for avoiding that. Depending on the type of

television the lifetime will be longer or not, LED screens lifetime is longer in consequence of the diode technology but are more expensive.

Apart from the television requirements is also necessary to have a specific HD decoder to receive high definition digital TV signals. This decoder can be integrated in the television set and is noted iDTV (Integrated Digital TV).

An iDTV is capable of receiving and decoding the digital television signal without the need of another external device. In case that the television does not integrate the decoder, or if the internal decoder is not able to allow high definition signals, an external device is needed. It is important to know that a SD decoder will not receive HD signals.

There are some standards which determine the features needed.

HDTV: An HDTV budget, apart from having the following requirements, is necessary to know that also needs the HD Ready features. HD Ready logos are only related with the viewing conditions, and HD TV logos define the audio and video attributes:

- AUDIO
  - MPEG-1 Layer II
  - AC3/DD Plus
- VIDEO
  - MPEG-4/AVC HP@L4 50Hz.
  - MPEG-2 MP@HL, at least 720p50 and 1080i

HDTV 1080p: Besides the HDTV requirements, HDTV 1080p imposes more stringent requirements. Also defines the capacity to decode the 1080p format and the HE-AAC audio format. In Set-top Box field all the connectors are indicated, both video (YPrPb and HDMI or DVI) and audio (S / PDIF, RCA, HDMI). For the screens with an integrated decoder there is no need of video output but also a

S/PDIF input for multichannel audio is required.

The customer is an important part in the calculation of energy consumption. Despite the production and transmission he is the one who will choose the desired TV benefits and also choose the set-top box to receive television signals in HD.

On the other hand, it is important for the proper functioning of the devices that the customer purchased, reducing the On-mode TV hours, the choice of the right configuring settings, the size and resolution of the image, cause after all this device will most affect the power consumption.

According to [1], the "Big Three" of energy consumption in TV are the size, type and settings, but the use is also important.

3.5.2.7. SIZE

The size of the TV is really important as it directly affects consumption. Larger TVs consume more than small screen televisions as well as it progresses in technology and quality, since it exceeds in performance to the old cathode ray tube screens, but in terms of energy consumption it is significantly higher.

3.5.2.8. TYPE

There are three types of televisions: Plasma, LCD and LED. The one who wastes most energy is Plasma. The method of functioning by divided crystal in cells in which there is a mixture of noble gases (neon and xenon) so that when those gases with an energy reception, become plasma and begin to emit light. As the light is contained inside this phosphorus, the main advantage is that it is generated a deep black, but for brighter scenes larger amount of energy is necessary to emit the light clearer. Moreover, when the resolution increases from 720p to 1080p the consumption is significantly increasing even more, since the individual light intensity of each pixel must be greater to increase the brightness of the entire image.

The LCD screen is more independent of the resolution of the screen, consisting of liquid crystal molecules located in different layers that rotate and are polarized depending on the colour desired. An external light reflector is applied which, by rotation of the

molecules is reflected and transmitted. So this light, which is external to the screen is independent of the resolution and the consumption is lower than plasma TVs. Also, some LCD can dim the light in dark scenes and increase in lighter scenes improving the efficiency of the consumption.

Finally, LED televisions. These are the most efficient since the diodes are scattered throughout the display illuminated more or less depending on the area depending on the brightness of the image and this will reduce energy consumption. Furthermore, another important factor for the environment is the absence of mercury in this type of TV. In the previously mentioned article quoted a TV LED can save up to $20 per year.

3.5.2.9. IMAGE SETTINGS

It is another factor that influences the power consumption. The brightness of the image is a really important point, as more brightness more consumption, and it is important to fit the picture correctly, as the contrast, named previously.

Most modern TVs have the ability to let you just listen to the audio without any image. In this case the consumption is significantly reduced, the LCD also has the ability to choose the amount of reflective light desired to control the energy.

Apart from these variables, the use also could be a variable.

3.5.2.10. USE

Depending on the type of use of TV, consumption is reduced considerably and besides the life cycle of a television is increased. For example, a TV does not consume the same when is on, off or in standby.

Of the three, the least consumed is OFF mode and the highest is the ON mode. But the standby is important to highlight. In all studies of television consumption is an important fact because it is an unnecessary energy consumption when not using television.

3.5.2.11. REQUIREMENTS

SCREEN SIZE	32"
SCREEN RESOLUTION	720p, 1080i
ASPECT RATIO	16:9
INPUT	HDMI, DVI, Component Video Cable
SCREEN FINISH	Mate or glossy
REFRESH RATE	60Hz

Table 3.3. Main HD televisions requirements

4. CHAPTER THREE: POWER CONSUMPTION

4.1. ENERGY STAR

Energy Star is a joint program between the U.S. Environmental Protection Agency and U.S. Department of Energy whose role is to help consumers protect the environment and significantly reduce their consumption of electronic devices thus also reducing energy costs.

To achieve this goal Energy Star puts some restrictions about consumption that each electronic device must comply, depending on their characteristics, to acquire the Energy Star label on it. Therefore, all electronic devices with the Energy Star logo indicate that a product consume low energy. In summary, its main objectives, specified by as energy star, are:

- Reduce greenhouse gas emissions and other pollutants caused by the inefficient use of energy.
- Make it easy for consumers to identify and purchase energy-efficient products that offer savings on energy bills without sacrificing performance, features, and comfort.

From time to time the requirements are reviewed specifically for getting the latest version of Energy Star logo. Energy Star 3.0 emerged in November 2008, but these specifications were not too strict, which made most HD televisions comply that version; Energy Star 4.0 created a new standard reducing to 40% the energy consumption required in the previous version for the same device.

The organism responsible for setting these specifications and to revise is the EPA (Environmental Protection Agency).

4.1.1. POWER CONSUMPTION CALCULATION METHOD

To calculate the consumption of television, are important the three different modes:

4.1.1.1. ON-MODE

When the TV is connected to the power source and it is displaying images and / or sound. Also called active mode.

The restrictions for this calculation will be:

Televisions with the Automatic Brightness Control (ABC) set to default power consumption is calculated by the equation:

$$P_{ON} = \left(0.55 \times P_{0\_BROADCAST}\right) + \left(0.45 \times P_{ABC\_BROADCAST}\right)$$

where:

- PON is the calculated On Mode power
- P0_BROADCAST is the measured On Mode power when tested with a minimum ambient light level of 300 lux,
- PABC_BROADCAST is the measured On Mode power when tested with an ambient light level of 0 lux.

Must be less than or equal to the Maximum On Mode Power Requirement given in the table below. The requirements are equivalent to the last amendment to Energy Star (version 4.1) in force since the start last May 1, 2010.

SCREEN AREA (square inches)	Maximum On Mode Power Consumption in Watts (A expressed in square inches)	Maximum On Mode Power Consumption in Watts (A expressed in square centimeters)
A < 275 square inches (1774 square centimeters)	(0.190 * A) + 5.0	(0.029 * A) + 5.0
A ≥ 275 square inches (1774 square centimeters)	(0.120 * A) + 25.0	(0.019 * A) + 25.0

Table 4.1. Restrictions for the Energy Star 4.1 Version effective from May 1st 2010.

4.1.1.1.1. EXAMPLE. Calculation of the consumption of a 20-inch screen with a

16:9 aspect ratio.

1. Take height and width measures of the screen.

   For a 20-inch display the measurements are: 17.4 x 9.8

2. Calculate the Area:

   17.4 x 9.8 = 170.5 , less than 275.0

3. Finally, check the maximum on mode possible consumption:

   (0.190 x 170.5) + 5.0 = 37.4 W

If consumption is measured in a 20 inches TV and the result is higher than 37.4W are above the EPA restrictions specified and can not get the Energy Star label ensures that the TV meets ergonomic standards and responsible consumption.

A new version, Energy Star 5.1, is already designed and will be launched the following May 1st, 2012. The chart 4.2. shows the requirements:

SCREEN AREA (square inches)	**Maximum On Mode Power Consumption in Watts (A expressed in square inches)**	**Maximum On Mode Power Consumption in Watts (A expressed in square centimeters)**
A < 275 square inches (1774 square centimeters)	(**0.130** * A) + 5.0	(**0.020** * A) + 5.0
A ≥ 275 square inches (1774 square centimeters)	(**0.084** * A) + **18.0**	(**0.013** * A) + **18.0**
A > 1068 square inches (6890 square centimeters)	**108**	

Table 4.2. Restrictions for the Energy Star 5.1 Version effective from May 1st 2010.

In bold the modifications in comparison with the previous version.

For the example calculated above using version 4.1, for the version 5.1, the maximum consumption of a 20-inch TV will be: 27.17 W maximum power. The reduction has been made for larger size screens, focusing indirectly HD televisions.

4.1.1.2. SLEEP-MODE

Also called standby mode, when the device is connected to the power source but does not provide a major role. Connected to electricity but produces neither sound nor picture, not broadcasting any program information, or doing any update, just wait to be back on using the remote control for example.

Measured Sleep Mode power (P_{SLEEP}) shall be less than or equal to 1.0 W.

4.1.1.3. OFF MODE

Mode when the television is connected to the power source but not in on mode or in standby, when is turned off using the button on the screen. Is the way that consumes less.

4.1.1.4. DOWNLOAD ACQUISITION MODE (DAM)

When the product is connected to the power source, without producing a sound or a picture, but is doing an actualisation or is downloading the information for the channels according to the schedule in the electronic program guide.

Specification Version	Maximum Allowable Energy in DAM (kilowatt-hours/day)
Version 4.1	0.08
Version 5.1	0.02

Table 4.3. DAM Energy differences requirements

In each update of a standard agreed with EPA Energy Star specifications are more stringent. The following graph shows the evolution of the relationship Power Consumption - screen size for the latest developments in Energy Star

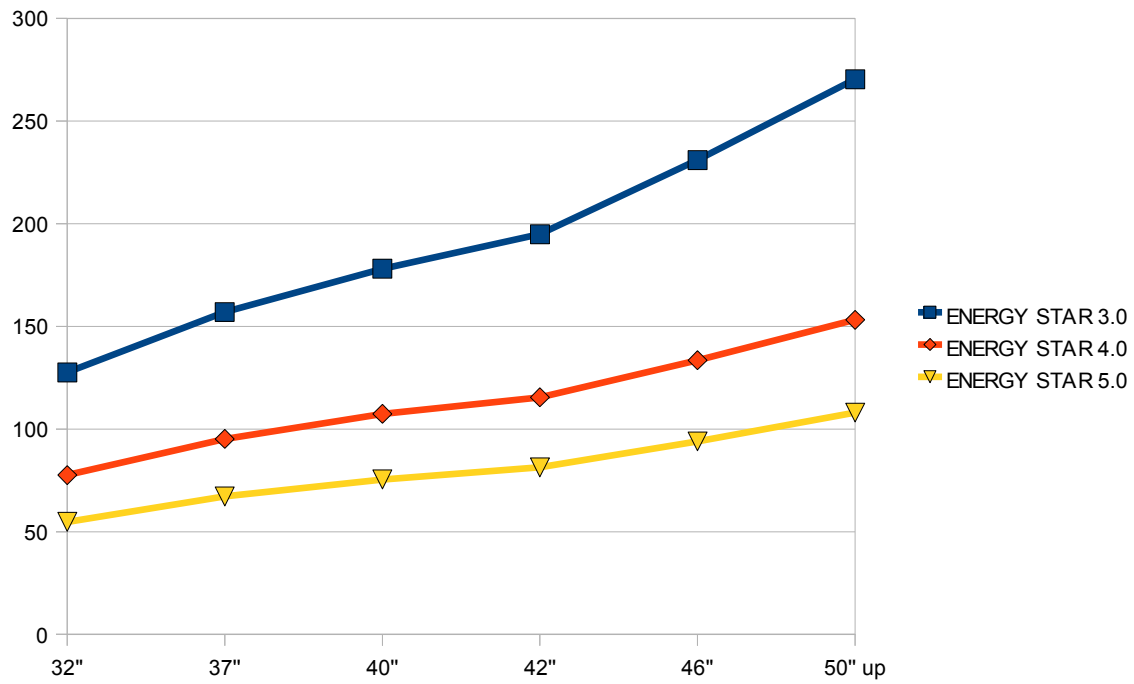

Figure 4.1. Evolution of the consumption thresholds related to the screen size.

Energy Star 3.0 was effective on November 1, 2008.

The figure 4.1. exposes how important is the power consumption. All these requirements are calculated in On Mode. The requirements are more strict in each new Energy Star Version. In 4 years, the televisions must reduce the consumption in 40%.

This implies new techniques and technology to develop for the manufacturers and also new investment. In the next chapter there will be an example of Sony that uses an ecological range of televisions with different techniques to reduce considerably the energy consumption.

4.2. PRODUCTION

4.2.1. ENCODER

Table 4.4. shows a different list of SD encoders with its power consumption. The compress format is an important point due to the reduction of the compression. Most of the encoders possess two kinds of consumption, with options or without options. Normally, the eligible options are the 4:2:2 sample format, the picture in picture

technology, Dolby audio encoding, VBR or the dual power supply. Unfortunately it was not possible to determinate exactly how much consumption each feature produces.

Below the table 4.5. exposes the list of HD encoders with the same characteristics than the standard definition devices. The HD encoders are complex compared to SD encoders. More bandwidth is needed to transmit more data (SD – 6 Mbps maximum / HD – 15 Mbps minimum).

4.2.1.1. STANDARD DEFINITION

BRAND MODEL	COMPRESS FORMAT	MAX. RESOLUTION	CHROMA	PROFILES	POWER CONSUMPTION (W)
Thomson EM1000/2000	MPEG-2 H.264 / MPEG-4 AVC	576i (PAL) 480i (NTSC)		MP @ ML MP / HP@L3	70 160 (with options)
Cisco D9022	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0	MP @ ML	45
Cisco D9032	MPEG-2	576i (PAL) 480i (NTSC)	4:2:2	MP @ ML	≤ 75
Cisco D9040	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0	MP @ ML	90 (one Pw Supply) 95 (both inlets)
Edje 5110	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0 4:2:2 (option)	MP @ML 4:2:2 @ ML (option)	60 70(with options)
Ericsson E5710	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0 4:2:2 (option)	MP @ML 4:2:2 @ ML (option)	100 250 (with options)
Ericsson E5720	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0 4:2:2 (option)	MP @ML 4:2:2 @ ML (option)	100 250 (with options)
Ericsson E5770/E5775	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0 4:2:2 (option)	MP @ML 4:2:2 @ ML (option)	85 150(with options)
Grass Valley VIBE Dual Pass Encoder	MPEG-2	576i (PAL) 480i (NTSC)	4:2:2	MP @ ML	17

MPEG Corona	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0	MP @ ML	< 35
MPEG Legend	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0	MP @ ML	< 50
Tandberg E5710	MPEG-2	576i (PAL) 480i (NTSC)	4:2:0 4:2:2 (option)	MP @ML 4:2:2 @ ML (option)	85 150 (with options)
BE7400	H.264/ MPEG-4 AVC	576i (PAL) 480i (NTSC)	4:2:2	MP @ L3	61
Cisco D9034	H.264 / MPEG-4 AVC MPEG-2 (option)	576i (PAL) 480i (NTSC	4:2:0	MP @ L3 MP @ ML	≤ 90
Cisco D9034	H.264 / MPEG-4 AVC MPEG-2 (option)	576i (PAL) 480i (NTSC	4:2:0	MP @ L3 MP @ ML	1 PW: ≤ 107 (110V) ≤ 104 (220V) 2 PW : ≤115 (110V) ≤113 (220V)
Dicas 2010	H.264 / MPEG-4 AVC	576i (PAL) 480i (NTSC	4:2:0	Baseline / SP / MP @ L3	200
Nextiva S1800e	H.264 / MPEG-4 AVC	576i (PAL) 480i (NTSC)		MP @ ML	20 – 29
Nextiva S1816e	H.264 / MPEG-4 AVC	576i (PAL) 480i (NTSC)		MP @ ML	< 25
BE7110	H.264/ MPEG-4 AVC	576i (PAL) 480i (NTSC)	4:2:2	MP @ L3	70
Cisco D9093	H.264/MPEG-4 AVC	576i (PAL) 480i (NTSC)	4:2:0 4:2:2CSC	MP, HP @ L3	≤ 60 (at 100 VAC) ≤ 90 (with options, 100bernaVAC)
AVERAGE					72,7

Table 4.4. List of Standard Definition Encoders with the features and power consumption.

4.2.1.2. HIGH DEFINITION

BRAND MODEL	COMPRESS FORMAT	MAX. RESOLUTION	CHROMA	PROFILES	POWER CONSUMPTION (W)
Dicas 2030	H.264 / MPEG-4 AVC	1080i, 720p			200
Tandberg EN5990	H.264 / MPEG-4 AVC	1080i, 720p		MP, HP @ L4	150
Fujitsu IP-920E	H.264 / MPEG-4 AVC	1080i, 720p		HP@L4; MP@L4	38

Fujitsu IP-900E	H.264 / MPEG-4 AVC	1080i, 720p		HP@L4; MP@L4	38
Fujitsu IP-9500	H.264 / MPEG-4 AVC	1080i, 720p	4:2:0, 4:2:2	HP@L4; MP@L4; 422CSC	60
Ericsson EN8190	H.264 / MPEG-4 AVC	1080i, 720p	4:2:0	MP @ L4	110
Cisco D9054	H.264 / MPEG-4 AVC	1080i, 720p	4:2:0	MP @ L4	≤ 500
Dveo NCoder HD II	MPEG-2	1080p	4:2:2 4:2:0		60
NTT Electronics HE5100	MPEG-2	1080p	4:2:2 4:2:0	MP@HL, 422P@HL	60
Cisco D9050	MPEG-2	1080i, 720p	4:2:0, 4:2:2	MP @ HL	≤ 60
NTT Electronics HVE9100	H.264 / MPEG-4 AVC	1080i, 720p	4:2:2	HP, MP @ L4 MP@HL, 422P@HL	60
Ambrado HCE1604	MPEG-2 H.264 / MPEG-4 AVC	1080p, 1080i, 720p	4:2:0 (both) 4:2:2 (MPEG-2)	MP, 422P@HL, 422P@ML, (MPEG-2) BP @ L4	40
AVERAGE					114,67

Table 4.5. List of High Definition Encoders with the features and power consumption.

4.3. BROADCAST

4.3.1. MULTIPLEXER

Multiplexer is one of the most important devices in the transmission. Transforms video, audio, data signals into one container format (normally MPEG-2 TS) to be finally broadcasted. The study will calculate the power consumption of that device related with the number of inputs, and the container format.

4.3.1.1. SD

BRAND / MODEL	NUMBER OF INPUTS	MPEG-TS BITRATE	POWER CONSUMPTION

			(W)
DIBSYS MUX7100	8	200 Mbps	25
Advanced Digital MXA 107	8	180Mbps	30
Continuum DVP D9616	5	200Mbps	50
CODICO RTM-3300	10	120Mbps	70
CODICO RTM-3800	25	120Mbps	110
Hangzhou Digicast DMB-9110	8	270Mbps	25
Digital-ST DST 9110	8	270Mbps	25
DEXIN NDS 31021	12		25
Hangzhou Digicast DMB-9100	8	270Mbps	25
JIE HAO JXDH-6102	8	270Mbps	25
Eastec E-2101	8	270Mbps	25
Colable COL-5282A	8	120Mbps	25
Wellav UMH 5100	8	80Mbps	20
Screen Service XBT 525	8	155Mbps	30
AVERAGE			36,43

Table 4.6. Set of HD multiplexers with the related power consumption.

4.3.1.2. HD

BRAND / MODEL	NUMBER OF INPUTS	MPEG-TS BITRATE	POWER CONSUMPTION (W)
Ericsson MX8400	8	250 Mbps	80
ATSC HD Blaster	6		184
Scopus IVG - 8300	16	170Mbps	120

Continuus D9616	16	214 Mbps	50
AVERAGE			108,50

Table 4.7. Set of HD multiplexers with the related power consumption.

4.3.2. MODULATOR

Modulator is one of the devices independent on the kind of transmission. Modulators do not change even the quality is in HD or SD. They are part of the physical layer so the device do not differentiate between the information coded.

Depending on the device there are 1 or more TS inputs. The signal received is a Transport stream. Modulator converts the signal into RF output to be received by the antennas. Table 4.8. contents the list of the results about the encoders found with the power consumption.

MODEL	OUTPUT FREQUENCY (MHz)	BANDWIDTH (MHz)	MODULATION	POWER CONSUMPTION (W)
SR-Systems Modulator v7	3.5 – 70	5, 6, 7, 8	QPSK, 16QAM, 64QAM	5
Alitronika iMod AT278USB		6, 8	16QAM, 32QAM, 64QAM, 128QAM, 256QAM	7,5
Cisco D9630	45 – 870	6, 7, 8	64QAM, 256QAM	< 50
Cisco D9634 D9638	45 – 870	6, 7, 8	64QAM, 256QAM	< 50
Cisco D9476	150 – 750		16QAM, 64QAM, 128QAM, 256QAM	50
Cisco D9482	54 – 550			< 65
Cisco D9479 Gigabit	91 – 867			151
Cisco DVP D9600	45 – 870	6, 7, 8		< 50
Blankom AMA 299	45 – 862			18
Digicast DMB-2018	170 - 860	5, 6, 7, 8	QPSK, 16QAM, 64QAM	40
Digicast DMB-2028	30 - 1000	5, 6, 7, 8	QPSK, 16QAM, 64QAM	40
Teamcast MHX – 3000		1.7, 5, 6, 7, 8		38

Pro Television Technologies PT2080	30 - 1000	5, 6, 7, 8	QPSK, 16QAM, 64QAM	75
Pro Television Technologies PT2082	30 - 1000	1.7, 5, 6, 7, 8	QPSK, 16QAM, 64QAM, 256QAM	75
Fanamoj FNJ D-1202	470 - 862	5, 6, 7, 8	QPSK, 16QAM, 64QAM	50
Cisco Quantum RF Modulator / Up converter	45 – 870	6, 7, 8		< 30
AVERAGE				42,66

Table 4.8. List of Modulators with the features and power consumption.

4.3.3. RECEIVER

The receiver will be independent of the kind of transmission used. Many manufacturers which develop a device not only for the receiver but also for a combination about receiver-transcoder or receiver-decoder. Chart 4.9. shows a summary about the consumption about this kind of devices.

BRAND / MODEL	POWER CONSUMPTION
HRX-200	11
HRX-100	14,3
Titan MKII	10
Apollo	15
Teleste HDO202	10
Titan DVB-receiver	30
Colable COL5822A	20
Cisco D9854	37
AVERAGE	18,41

Table 4.9. Receivers with their power consumption.

4.3.4. TRANSCODER

In that case will be used to compress to MPEG-2 to MPEG-4 AVC, or directly in MPEG-4 AVC in IPTV cases due to the limited bandwidth. The power consumption will depend on

the compression standard and the definition.

4.3.4.1. STANDARD DEFINITION

BRAND / MODEL	OUTPUT FORMAT	MAX. RESOLUTION	POWER CONSUMPTION (W)
Ecrin	H.264/MPEG-4 AVC	SD: 480i, 576i	80
Beijing Realmagic Technology RM5000-SD	H.264/MPEG-4 AVC (SD)	SD: 480i	< 30
Desai DX201T	H.264/MPEG-4 AVC	SD: 480i, 576i	17,6
AVERAGE			42,53

Table 4.10. Standard definition transcoders grouped by resolution and output format.

4.3.4.2. HIGH DEFINITION

BRAND / MODEL	OUTPUT FORMAT	MAX. RESOLUTION	POWER CONSUMPTION (W)
Cisco D9900	H.264/MPEG-4 AVC	SD: 525i, 625i HD:1080i,720p	350
Cisco D9901	H.264/MPEG-4 AVC	SD: 525i, 625i HD:1080i,720p	190
Memphis SD and HD		SD: 480I, 576I HD:1080i,720p	200
Cisco D9858	MPEG-2	SD: 480I, 576I HD:1080i,720p	110
NEXIO® PRX Transcoder	H.264/MPEG-AVC	HD 1080i, 720p SD 525i, 625i	< 296

Harmonic ProStream -1000	IPTV: H.264/MPEG-AVC TV: MPEG-2	HD 1080i, 720p SD 525i, 625i	< 380
Telairity BT8500	H.264/MPEG-4 AVC	SD: 480I, 576i HD:1080i,720p	260
Arris VIPr 2800	MPEG-2	SD: 480I, 576i HD:1080i,720p	250
Ericsson RX8250	MPEG-2	HD:1080i,720p	45
Ericsson MPEG-4 AVC UltraCompression-2	H.264/MPEG-AVC	SD: 480I, 576i HD:1080i,720p	< 160
AVERAGE			224,1

Table 4.11. High definition transcoders grouped by resolution and output format.

4.3.5. UPCONVERTER

The Upconverter is the device needed to convert the signal into UHF signal to be transmitted for the antennas. Table 4.12. shows a list of converters with the related power consumption and the OF range.

BRAND / MODEL	Output frecuency range (MHz)	POWER CONSUMPTION (W)
DHDP Series converter	54 - 860	3,2
DVIP AT2800USB	50 - 1000	7,5
DVIP AT2700PCI	50 - 1000	7,5
Blankom Digital PVA 850	47 - 860	< 18
Blankom Digital PVA 851	47 - 860	< 18
WISI COMPACT	45 – 862	< 10

Headend Converter		
Sotca STC8360UD		20
Sotca STC83601UD		20
AVERAGE		13,03

Table 4.12. List of Upconverter devices with their power consumption.

4.4. CUSTOMER

4.4.1. SET-TOP BOX

The set-top box is the device used to receive the signals. Although nowadays that device is integrated to the television, is important to know that the consumption is mainly different depending on the use of that device.

4.4.1.1. STANDARD DEFINITION

BRAND / MODEL	P. CONSUMPTION ON MODE (W)	P. CONSUMPTION STANDBY (W)
Strong SRT 5205	4,40 (typ) – 5(max)	1,2
Sagem DTR67500T	13	1,4
Philips DTR230	5	1
Philips DTR222	7	5
Philips DTR220	7	5
Philips DTR210	12	6
Hitachi HDR252	10	0,9
Hitachi	18	1

HDR165		
Grundig GUDB20USB3	5	4,6
AVERAGE	9,04	2,9

Table 4.13. Standard definition STB with the consumption in On Mode and Standby.

4.4.1.2. HIGH DEFINITION

BRAND / MODEL	P. CONSUMPTION ON MODE (W)	P. CONSUMPTION STANDBY (W)
Sharp TU-T2	7,5	0,8
Grundig GUD300HD	5,6	
Toshiba HDR5010	< 30 (max)	< 1
TechniSat HDFS 0008/4750	15,74	0,2
Sharp TU-T2HR32	8	0,8
Sagem RTI90-320	13	0,8
Sagem DRT 67320	18	1
Philips HDT8520	12	1,1
Philips DTR5520	6	1
Metronic Sat HD 100	16,4	1
Humax HD-Fox T2	13,3	0,67 (saving on) 2,61 (saving off)

AVERAGE	11,55	0,82

Table 4.14. High definition STB with the consumption in On Mode and Standby.

4.4.1.3. ADDITIONAL POWER CONSUMPTION FEATURES

Table 4.15 shows optional features for STB specifications. In the second column is given the power consumption needed for each component.

FEATURE	POWER CONSUMPTION (W)
Internal hard disk drive	2,2
IEE1934 interface	0,8
Ethernet interface 100 Mbit	0,4
Wireless interface	0,7
Serial USB interface	0,3
Home automation interface	0,4
ADSL modem	2
Extra cable modem	0,7
Additional LNB feed	1,3
Additional tuner	2
Powered remote IR receiver	0,25

Table 4.15. Optional STB features with the related Power Consumption required.

4.4.2. TELEVISION

The other important device. In the following chart there is shown and a relation between standard televisions with their maximum resolution, the screen size and the power consumption. Nowadays is difficult to find standard televisions because most of them are with HD technology, and the kind of TV that still persist are the CRT Televisions.

4.4.2.1. STANDARD DEFINITION

The next chart 4.16. shows three of the top five most sold CRT standard televisions in 2011. With that televisions it will be good to compare with the HD televisions.

BRAND / MODEL	MAX. RESOLUTION	SCREEN SIZE (inches)	POWER CONSUMPTION (W)
Haier TCF20	480i	20	90
Haier HTR20	480i	20	85
Sansui DTV1300		13	60
AVERAGE			78,33

Table 4.16. Standard definition televisions with the consumption in On Mode.

Today is almost impossible to buy a LCD television with only Standard Definition. LCD SD screens consumes less than CRT television. For instance, the LCD 10" viore model consumes 10W.

According to [2], LCD televisions can reduce display energy by 60%. The author gives an example about a 15" LCD screen, the CRT equivalent area is a 17" screen; for the LCD TV the consumption is around 25W in operational mode and 3W while the TV is in standby. The CRT consumes 80W and 5W respectively. So there is a save of 55W in the operational mode.

4.4.2.2. HIGH DEFINITION

The table 4.17 shows for a set of televisions tested to measure the power consumption of its, through a study of CNET, the consumption related to its size and its calibration.

CNET STUDY				ENERGY STAR TEST				PASS THE ENERGY STAR 4.1	PASS THE ENERGY STAR 5.1
						4.1.	5.1		
Model	HDTV type	Screen size	POWER CONSU-MPTION	Screen size (HxL)	Screen size (square inches)	MPO (watts)	MPO (watts)		
Insignia NS-LCD32	LCD	32	143,2	27,9 x 15,7	438,0	77,56	54,79	NO	NO
LG 32LG30	LCD	32	117,88	27,9 x 15,7	438,0	77,56	54,79	NO	NO

LG 32LG40	LCD	32	116,19	27,9 x 15,7	438,0	77,56	54,79	NO	NO
LG 32LH20	LCD	32	82,05	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Panasonic TC-32LX85	LCD	32	97,79	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Panasonic TC-L32X1	LCD	32	92,1	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Samsung LN32A450	LCD	32	130,65	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Samsung LN32B360	LCD	32	75,11	27,9 x 15,7	438,0	77,56	54,79	YES	NO
Sharp LC-32D44U	LCD	32	126,25	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Sharp LC-32D47UT	LCD	32	71,68	27,9 x 15,7	438,0	77,56	54,79	YES	NO
Sony KDL-32L5000	LCD	32	91,47	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Sony KDL-32M4000	LCD	32	112,94	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Toshiba 32AV502U	LCD	32	87,9	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Toshiba 32CV510U	LCD	32	131,34	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Vizio VO320E	LCD	32	87,4	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Vizio VO32L	LCD	32	104,9	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Vizio VO32LF	LCD	32	121,58	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Westinghouse SK-32H640G	LCD	32	89,28	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Vizio VP322	plasma	32	122,97	27,9 x 15,7	438,0	77,56	54,79	NO	NO
Hitachi UT37X902	LCD	37	183,73	32,2 x 18,1	585,0	95,2	67,14	NO	NO
Panasonic TC-37LZ85	LCD	37	142,69	32,2 x 18,1	585,0	95,2	67,14	NO	NO
Vizio VOJ370F	LCD	37	145,84	32,2 x	585,0	95,2	67,14	NO	NO

				18,1					
Westinghouse VK-40F580D	LCD	40	246,81	34,9 x 19,6	683,7	107,04	75,43	NO	NO
Sony KLV-40ZX1M	LED	40	160,65	34,9 x 19,6	683,7	107,04	75,43	NO	NO
Honeywell Altura MLX	LCD	42	207,27	36,6 x 20,6	753,8	115,45	81,32	NO	NO
LG 42LH30	LCD	42	127,38	36,6 x 20,6	753,8	115,45	81,32	NO	NO
LG 42LH55	LCD	42	137,65	36,6 x 20,6	753,8	115,45	81,32	NO	NO
Philips 42PFL5603D	LCD	42	91,23	36,6 x 20,6	753,8	115,45	81,32	YES	NO
Philips 42PFL6704D	LCD	42	136,8	36,6 x 20,6	753,8	115,45	81,32	NO	NO
Toshiba 42RV530U	LCD	42	218,08	36,6 x 20,6	753,8	115,45	81,32	NO	NO
Insignia NS-PDP42	plasma	42	216,76	36,6 x 20,6	753,8	115,45	81,32	NO	NO
Panasonic TC-P42S1	plasma	42	187,17	36,6 x 20,6	753,8	115,45	81,32	NO	NO
Panasonic TH-42PX80U	plasma	42	260,18	36,6 x 20,6	753,8	115,45	81,32	NO	NO
Vizio VP422	plasma	42	283,83	36,6 x 20,6	753,8	115,45	81,32	NO	NO
JVC LT-46P300	LCD	46	132,78	40,1 x 22,6	904,2	133,5	93,95	YES	NO
Mitsubishi LT-46148	LCD	46	263,78	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Mitsubishi LT-46249	LCD	46	187,76	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Samsung LN46A550	LCD	46	137,12	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Samsung LN46A750	LCD	46	184,62	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Samsung LN46B650	LCD	46	174,1	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Sharp LC-46D85U	LCD	46	182,32	40,1 x 22,6	904,2	133,5	93,95	NO	NO

Sony KDL-46VE5	LCD	46	125,31	40,1 x 22,6	904,2	133,5	93,95	YES	NO
Sony KDL-46W4100	LCD	46	274,43	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Sony KDL-46W5100	LCD	46	169,87	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Sony KDL-46Z4100	LCD	46	268,57	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Toshiba 46XV545U	LCD	46	178,59	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Samsung LN46A950	LED	46	145,98	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Samsung UN46B6000	LED	46	106,4	40,1 x 22,6	904,2	133,5	93,95	YES	NO
Samsung UN46B7000	LED	46	106,77	40,1 x 22,6	904,2	133,5	93,95	YES	NO
Samsung UN46B8000	LED	46	114,48	40,1 x 22,6	904,2	133,5	93,95	YES	NO
Sharp LC-46LE700UN	LED	46	101,58	40,1 x 22,6	904,2	133,5	93,95	YES	NO
Sony KDL-46EX700	LED	46	87,22	40,1 x 22,6	904,2	133,5	93,95	YES	YES
Toshiba 46SV670U	LED	46	174,87	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Panasonic TC-P46G10	plasma	46	168,78	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Panasonic TH-46PZ85U	plasma	46	454,51	40,1 x 22,6	904,2	133,5	93,95	NO	NO
Haier HL47K	LCD	47	237,3	41,0 x 23,0	943,9	138,27	97,29	NO	NO
LG 47LG60	LCD	47	267,21	41,0 x 23,0	943,9	138,27	97,29	NO	NO
LG 47LH50	LCD	47	186,55	41,0 x 23,0	943,9	138,27	97,29	NO	NO
LG 47SL80	LCD	47	187,29	41,0 x 23,0	943,9	138,27	97,29	NO	NO
Philips 47PFL9732D	LCD	47	250,1	41,0 x 23,0	943,9	138,27	97,29	NO	NO
Toshiba 47ZV650U	LCD	47	181,26	41,0 x	943,9	138,2	97,29	NO	NO

				23,0		7			
Vizio SV470XVT	LCD	47	239,59	41,0 x 23,0	943,9	138,27	97,29	NO	NO
Vizio VO47LF	LCD	47	277,52	41,0 x 23,0	943,9	138,27	97,29	NO	NO
LG 47LE8500	LED	47	90,01	41,0 x 23,0	943,9	138,27	97,29	YES	YES
LG 47LH90	LED	47	140,86	41,0 x 23,0	943,9	138,27	97,29	NO	NO
Hitachi P50H401	plasma	50	336,1	43,6 x 24,5	1068,2	153,19	108	NO	NO
LG 50PG20	plasma	50	284,64	43,6 x 24,5	1068,2	153,19	108	NO	NO
LG 50PG30	plasma	50	401,67	43,6 x 24,5	1068,2	153,19	108	NO	NO
LG 50PG50	plasma	50	401,02	43,6 x 24,5	1068,2	153,19	108	NO	NO
LG 50PS80	plasma	50	384,98	43,6 x 24,5	1068,2	153,19	108	NO	NO
Panasonic TC-P50V10	plasma	50	255,61	43,6 x 24,5	1068,2	153,19	108	NO	NO
Panasonic TC-P50X1	plasma	50	217,95	43,6 x 24,5	1068,2	153,19	108	NO	NO
Panasonic TH-50PF11UK	plasma	50	449,62	43,6 x 24,5	1068,2	153,19	108	NO	NO
Panasonic TH-50PZ800U	plasma	50	535	43,6 x 24,5	1068,2	153,19	108	NO	NO
Panasonic TH-50PZ850U	plasma	50	163,8	43,6 x 24,5	1068,2	153,19	108	NO	NO
Pioneer PDP-5020FD	plasma	50	293,33	43,6 x 24,5	1068,2	153,19	108	NO	NO
Pioneer PRO-111FD	plasma	50	333,54	43,6 x 24,5	1068,2	153,19	108	NO	NO
Samsung PN50A550	plasma	50	446,6	43,6 x 24,5	1068,2	153,19	108	NO	NO
Samsung PN50A650	plasma	50	380,58	43,6 x 24,5	1068,2	153,19	108	NO	NO
Samsung PN50B650	plasma	50	252,04	43,6 x 24,5	1068,2	153,19	108	NO	NO

Samsung PN50B850	plasma	50	207,01	43,6 x 24,5	1068,2	153,19	108	NO	NO
Vizio VP505XVT	plasma	50	474,03	43,6 x 24,5	1068,2	153,19	108	NO	NO
Olevia 252T FHD	LCD	52	257,29	45,3 x 25,5	1155,4	163,65	108	NO	NO
Samsung LN52A650	LCD	52	219,9	45,3 x 25,5	1155,4	163,65	108	NO	NO
Samsung LN52B750	LCD	52	191,15	45,3 x 25,5	1155,4	163,65	108	NO	NO
Sharp LC-52D65U	LCD	52	210,35	45,3 x 25,5	1155,4	163,65	108	NO	NO
Sony KDL-52V5100	LCD	52	242,62	45,3 x 25,5	1155,4	163,65	108	NO	NO
Sony KDL-52XBR6	LCD	52	272,63	45,3 x 25,5	1155,4	163,65	108	NO	NO
Sony KDL-52XBR7	LCD	52	285,68	45,3 x 25,5	1155,4	163,65	108	NO	NO
Sony KDL-52XBR9	LCD	52	237,52	45,3 x 25,5	1155,4	163,65	108	NO	NO
Sony KDL-52NX800	LED	52	122,55	45,3 x 25,5	1155,4	163,65	108	YES	NO
Panasonic TC-P54G10	plasma	54	282,85	47,1 x 26,5	1246,0	174,52	108	NO	NO
Panasonic TC-P54Z1	plasma	54	274,28	47,1 x 26,5	1246,0	174,52	108	NO	NO
Vizio VF550XVT	LCD	55	221,03	47,9 x 27,0	1292,6	180,11	108	NO	NO
Samsung UN55C8000	LED	55	129,46	47,9 x 27,0	1292,6	180,11	108	YES	NO
Samsung UNB558500	LED	55	136,16	47,9 x 27,0	1292,6	180,11	108	YES	NO
Sony KDL-55XBR8	LED	55	239,83	47,9 x 27,0	1292,6	180,11	108	NO	NO
Vizio VF551XVT	LED	55	161,95	47,9 x 27,0	1292,6	180,11	108	YES	NO
Vizio VF552XVT	LED	55	191,14	47,9 x 27,0	1292,6	180,11	108	NO	NO
Panasonic TH-	plasm	58	562,52	50,6 x	1437,4	197,4	108	NO	NO

58PZ750U	a			28,4		9			
Panasonic TH-58PZ800U	plasma	58	196,37	50,6 x 28,4	1437,4	197,49	108	YES	NO
LG 60PG60	plasma	60	507,83	52,3 x 29,4	1538,3	209,59	108	NO	NO
Samsung HL61A750	RPTV	61	171,24	53,2 x 29,9	1590,0	215,8	108	YES	NO
Samsung PN63A760	plasma	63	509,24	54,9 x 30,9	1696,0	228,51	108	NO	NO
Panasonic TH-65VX100U	plasma	65	575,56	56,7 x 31.9	1805,3	241,64	108	NO	NO
Mitsubishi WD-65735	RPTV	65	219,27	56,7 x 31.9	1805,3	241,64	108	YES	NO
Mitsubishi WD-65737	RPTV	65	208,45	56,7 x 31.9	1805,3	241,64	108	YES	NO
AVERAGE								214,87	

Table 4.17. High definition televisions with the consumption in On Mode calculed by CNET and if the television is able to earn Energy Star 4.0 or Energy Star 5.0 level.
MPO: Maximum Power in Operational Mode according to Energy Star thresholds.

Beside the relevant calculations are made to see if the TV is in the Energy Star 4.1 standard and see how much will be reduced to get the 5.1 version in May 2012. This calculation is quite relevant because is a study made measuring the consumption directly with the television. Is an study made from January 2008 to April 2010, with the Energy Star 3.0 requirements. Next chart displays a list of energy star qualified LCD products. The products are selected depending on the screen size and the type of television.

BRAND / MODEL	TYPE	SCREEN SIZE	POWER CONSUMPTION	POWER CONSUMPTION STANDBY	ANUAL ENERGY USE (kW-hrs/Year)
VIZIO E320VP	LCD	32"	36	0,6	69.86
LG 37LE5300	LCD	37"	62	0,1	113,84
JVC LT-32E710	LCD	32"	62,3	0,8	119,25
Samsung UN37C5100QF	LCD	37"	45	0,1	82,82

Samsung UN46C5000QF	LCD	46"	48	1	94,54
Sony KDL-46EX521	LCD	46"	65	0,2	127,31
LG 42LE7300	LCD	42"	70	0,1	128,44
Sharp LC-40LE810UN	LCD	40"	70	0,5	131,22
LG 47LE5300	LCD	47"	75	0,1	137,57
Sharp LC-52LE920UN	LCD	52"	85	0,5	158,59
Sony KDL-55EX720	LCD	55"	85	0,2	163,81
LG 55LE5400	LCD	55"	91	0,1	166,77
Samsung UN65C6500VF	LCD	65"	136	0,1	248,89
VIZIO XVT3D650SV	LCD	65"	185	0,7	342,48
AVERAGE			79,66	0,36	155,04

Table 4.18. List of Energy Star qualified LCD televisions with the power consumption in Operational Mode and the Energy used.

All of the previously exposed charts also calculate the average power consumption of the devices. Mainly the average power consumption is slightly higher in HD devices caused by the quantity of information to treat (compress, transcode, multiplex).

This average although is not well precised, is an overview median measurement grouped by device and definition. In order to do a better comparison, next chapter is going to select which models of each device are useful to get a more precise calculation.

5. CHAPTER 4: DISCUSSION OF THE RESULTS

5.1. CUSTOMER

5.1.1. TV

Seeing the results in chapter 3 consumption differ widely depending on the specifications and brand of each product. Therefore the study was based on a comparison taking the 5 TVs sold of each type in 2010 and consumption are positive proof and it will be possible to decide what kind of TV is more suitable for a green consumer. Those are:

5.1.1.1. LED

TV MODEL	SCREEN SIZE	RESOLUTION	HD/SD	POWER CONSUMPTION (ON)	POWER CONSUMPTION (STANDBY)	ECOLOGIC LABEL	GREENPEACE MARK
Samsung UN46C7000	46"	1920x1080p	HD	170	0,2	Energy Star 4.0	5,3
Samsung UN55C6500	54,6"	1920x1080p	HD	190	0,1	Energy Star 4.0	5,3
LG 47LE5500	47"	1920x1080p	HD	97,7	0,20	Energy Star 4.0	3,5
Samsung UN55C8000	55"	1920x1080p	HD	129,46	0,07	Energy Star 4.0	5,3
Sony KDL-40EX600	40"	1920x1080p	HD	69,62	0,23	Energy Star 4.0	5,1

Table 5.1. Most sold LED TVs in 2010 with the power consumption

5.1.1.2. LCD

TV MODEL	SCREEN SIZE	RESOLUTION	HD/SD	POWER CONSUMPTION (ON)	POWER CONSUMPTION (STANDBY)	ECOLOGIC LABEL	GREENPEACE MARK
Samsung UN46C7000	46"	1920x1080p	HD	170	0,1	Energy Star 4.0	5,3
Sony KDL-55EX710	55"	1920x1080p	HD	141 (shop) 101 (home)	0,2	Energy Star 4.0	5,1
Samsung UN46C6500	46"	1920x1080p	HD	150	0,1	Energy Star 4.0	5,3
LG 47LE5400	47"	1920x1080p	HD	103	0,1	Energy Star 4.0	3,5
Samsung LN46C630	46"	1920x1080p	HD	153,26	0,05	Energy Star 4.0	5,3

Table 5.2. Most sold LCD TVs in 2010 with the power consumption

5.1.1.3. PLASMA

TV MODEL	SCREEN SIZE	RESOLUTION	HD/SD	POWER CONSUMPTION (ON)	POWER CONSUMPTION (STANDBY)	ECOLOGIC LABEL	GREENPEACE MARK
Panasonic TC-P50S2	50"	1920x1080p	HD	353	0,3	Energy Star 4.0	5,1
Samsung PN50C550	50"	1920x1080p	HD	345	0,15	Energy Star 4.0	5,3
Samsung PN50C7000	50"	1920x1080p	HD	169,01	0,08	Energy Star 4.0	5,3
Panasonic TC-P46C2	46"	720p	HD	105	0,5	Energy Star	5,1

						4.0	
LG 50PK550	50"	1920x1080p	HD	202	0,1		3,5

Table 5.3. Most sold Plasma TVs in 2010 with the power consumption

All the most TVs sold in 2010 belongs to HD. Within these different types of television, the ones with a higher power consumption are PLASMA. These have a very high consumption by its performance. Of all these notes model Sony KDL-55EX710 (LCD range) because household consumption is the minimum even though with a screen size of 55".

Is important to note that the previous kind of televisions consume less than the CRT equivalent working with an SD resolution. In the previously chapter was shown that a 20" CRT screen consumes around 90 W, so in this way there is no doubt choosing HD definition televisions.

LCD SDTV were more respectful with the environment. The consumption was lower also than the HDTV LCD television, but is important to note that LCD standard televisions are really difficult to find in a store because all of the LCD screen manufacturers only sell HDTV, as it was exposed that most sold TVs in 2010 were all of them with the HD technology.

5.1.1.4. AVERAGE

5.1.1.4.1. ON MODE

LED	LCD	PLASMA
170	170	353
190	101	345
97,7	150	169,01
129,46	103	105
69,62	153,26	202
131,36	135,45	234,8

Table 5.4. Power consumption average in ON mode for each type of most sold TVs grouped by category.

5.1.1.4.2. STANDBY

LED	LCD	PLASMA
0,2	0,1	0,3
0,1	0,2	0,15
0,20	0,1	0,08
0,07	0,1	0,5
0,23	0,05	0,1
0,16	0,11	0,23

Table 5.5. Power consumption average in standby mode for each type of most sold TVs grouped by category.

5.1.1.4.3. SUMMARY

ON MODE	STANDBY
167,2	0,17

Table 5.6. Power consumption average of all most sold televisions grouped by mode of operation.

Moreover these televisions bring also the STB integrated so that is important to save the customer the need to buy a new receiver and saves extra consumption.

Making a comparison between LCD and LED can be appreciated that LEDs are more environmentally friendly, and most influential of the size of your screen for the consumption.
LCD technology due to it works by reflecting light there is not a strict relationship between screen size and consumption.

In this project, only focusing into the power consumption in order to calculate the final consumption of the distribution chain devices, the television elected will be LED. Previously, LED TVs were much more expensive than the others, but nowadays the price is not a bad point compared with the power savings with a LED TV.

Beside the television models there is the environmental requirements met. All of them acquire the Energy Star 4.0 requirements. One important point for the responsible

consumption will be that every television must have at least the most recent Energy Star label.

Greenpeace also evaluates the TVs. This part is an study about the technical specifications and features, the power consumption and also the materials used to create the hardware. If the components are kind to the environment, Greenpeace will give a higher note, in case the constitution is more harmful, the qualification will be lower.
After the year the association develops a list of the most respectful brands with the environment. This list is very prestigious and all the companies are interested to be as high as possible on this list. The criteria are explained in [9].

Summarizing the consumer paragraph, given that the chosen type is LED TVs, it will be an average consumption of:

ON MODE	STANDBY
131,36	0,16

Table 5.7. Power consumption average in LED TVs distributed by operational mode.

All LED TVs range can afford a resolution up to 1920x1080 with progressive scan. Although that resolution is mainly for HD DVD or Blu-Ray applications, the requirements of the previously devices in the distribution chain should be able to produce higher resolutions in order to take advantage of the TV features. Depending on the type of consumption and the advantages of each standard, the encoders will compress into MPEG-2 or H.264 / MPEG-4.

On the other hand, there are also TV ecological ranges. Sony, for instance offers to the final consumer a varied range of televisions with a important power consumption decrease. Is interesting to take a look on it and to know which steps are important for that ecological in order to differ from the rest. According to Sony, the most important features to minimize the environmental impact are:

1. **Ambient light Sensor:** A sensor that adjust the picture settings automatically according to the room's light to save energy and reduce the bills, and also implies

that with a brightness decrease, the power consumption will be significantly reduced. The calculated reduction is 30W

2. **Presence Sensor:** Turns off the picture when no movement is detected.

3. **Idle TV Standby mode:** Sets the TV to standby mode after inactivity.

4. **Energy Saving Switch:** only consumes practically 0W when the TV is in the off mode. It's a important point because is one of the most accidentally waste of energy at home.

5. **Power Saving Mode:** Mode with a reduced brightness in order to view the picture in a dim light getting a reduction in the energy consumption.

6. **PC Power Management mode:** Sets TV to standby when a PC signal is not detected.

There are many examples of ecological televisions. The minimum screen size for which Sony introduces this features is 32". Below this size we can consider that the power consumption will not be relevantly decreased and will be no useful because more saving tips implies also more price on the product, and a important decrease of the power consumption is required. Note than the Sony KDL-37W5710 is not using any environmental tips and the power consumption is really bigger than the 37" TV with environmental tips, but the price is 20% cheaper.

TV MODEL	SCREEN SIZE	RESOLUTION	HD/SD	TYPE	POWER CONSUMPTION (ON)	POWER CONSUMPTION (STANDBY)	ENVIRONMENTAL TIPS
KDL-32NX503	**32"**	**1080i, 720p, 1080p**	**HD**	**LCD**	**66**	**0,20**	**1, 3, 5, 6**
KDL-26S5500	**36"**	**1080i, 720p**	**HD**	**LCD**	**75**	**< 0,5**	**3, 5, 6**
KDL-37EX401	**37"**	**1080i, 720p, 1080p**	**HD**	**LCD**	**95**	**0,19**	**1, 3, 5, 6**
KDL-37W5710	***37"***	***1080i, 720p, 1080p***	***HD***	***LCD***	***140***	***0,17***	

KDL-55EX713	**55"**	**1080i, 720p, 1080p**	**HD**	**LED**	**101**	**0,20**	**1, 2, 3, 4, 5, LED**
KDL-46EX713	**46"**	**1080i, 720p, 1080p**	**HD**	**LCD/ Edge LED screen**	**86**	**0,20**	**1, 2, 3, 4, 5, LED**
KDL-46W5500	***46"***	***1080i, 720p, 1080p***	***HD***	***LCD***	***172***	***0,17***	***1, 3, 5, 6***
KDL-40EX43B	**43"**	**1080i, 720p, 1080p**	**HD**	**LCD**	**107**	**0,20**	**1, 3, 5, 6**

Table 5.8. List of ecological Sony televisions with its power consumption and the ecological saving tips.

All of that televisions are ecological but there are some differences about the consumption. The fact is that not all the TVs incorporate all of the mentioned saving energy techniques. That's the reason, besides there are the numbers. Each number means one of the saving features. In LED screens there is also a LED saving tip. The saving tip is based on the efficient LED backlight that cuts power consumption significantly compared to the W550 series.

In the chart there is the comparison between that kind of televisions. The consumption is reduced with the LED technology into 50%.

5.1.2 SET TOP BOX

The difference for this device is not really relevant. Table 5.9. demonstrate it.

	ON MODE (W)	STANDBY (W)
SD	9,04	2,9
HD	11,55	0,82
TOTAL	2,51	- 2,08

Table 5.9. SDTV Vs. HDTV power consumption consumption in On and standby modes.

Looking at the table 5.9. is important to stress that the standby power is lower in HD than in SD. This is due that no new device (according to the latest Energy Star Labels) can consume more than 1W in standby mode. Most of the new devices are HD so the thresholds are tighter.

Considering that most 2010 sold TV include a STB, also is a included feature in the new HD televisions, the consumption of the STB will be included with the television, so the research is going to avoid that consumption for separate.

5.2. PRODUCTION

This chart is a study based on data recorded in the previous chapter, grouped according to the encoding format. One can notice that the MPEG-4 AVC is the one that consumes more logical because its compression is much higher and requires the use of more specific and advanced techniques that require more powerful processors, which implies a higher energy consumption .
MPEG-2 needs a bigger file size so that implies bigger bandwidth.

Referring to high-definition encoders is possible to see that the difference in consumption is more depending on the type of encoder used. While currently the most modern codecs MPEG-4 AVC have dramatically decreased their consumption small differences still exist.

The table 5.10. shows the average difference between SD and HD. The fact is that doing this study, HDTV is more recent than SDTV so the power consumption was an important point in the designers. In SDTV the ones that consumes most, are the oldest ones. Nowadays, main encoders can compress into SD and HD, so the manufacturers do not design only a SD encoder.

HD	114,67
SD	72,7
TOTAL	41,97

Table 5.10. Average power consumption difference of SD and HD encoders.

This measure is not well accurate. Is the difference between the results found searching in internet for the encoders and power consumption.
At this point, is necessary to decide about which compression format is going to be used. Nowadays in most European countries the compression format is still MPEG-2 for both definitions, SDTV and HDTV. For SDTV via IP and for HDTV the final compression format is the MPEG-4 AVC but the transcoder will convert the MPEG-2 digital format to H.264.

Chart 5.11. calculates the new SDTV encoder average.

POWER CONSUMPTION (W)
67,67

Table 5.11. SDTV encoder new average with MPEG-2 compression format.

Before calculating the HDTV average, is preferable to analyse the results in the previous chapter. First of all is important to highlight that the consumption depending on the coding format is really different. Chart 5.12. exposes the average consumption depending on the compression format.

FORMAT	POWER CONSUMPTION (W)
MPEG-2	60
MPEG-4 AVC	156,57
BOTH	50

Table 5.12. Power consumption average grouped by compression format.

MPEG-4 AVC format consumes a high quantity of energy compared to the other formats and also is strange that encoders with both technology there are the less consumer devices.

The first reason is because the encoders with MPEG-2 and AVC formats are the most recent encoders, with new technology and tighter with the environmental requirements, but is important to check the main features in order to know which features are relevant for the energy consumption.

So for that reason, it is going to be analysed the technical characteristics of them, and do they differ with respect to the foregoing. First is decided to evaluate the technical specifications, which values are more relevant than others. The one which is not possible to compare between them is the brand. Depending on the brand the power consumption will be slightly different.

For this reason, there are analysed two HD encoders Fujitsu brand. Compared models (both high-definition) are IP-9500 and IP-900E:

		IP-9500	**IP-900E**
Power Consumption		60 W	38 W
Video	**Coding**	MPEG-4 AVC (H.264)	
	Profile	HP@L4, MP@L4, CSC422	HP@L4, MP@L4
	Resolution	1920/1440/960 x 1080i 1280/960/640 x 720p	
	Bit rate	3-27 Mbps	1-27 Mbps
	CBR/VBR	CBR	CBR/VBR
Audio Encoding		MPEG-1 Layer-2 MPEG-2 AAC Dolby-E pass thru Uncompressed	MPEG-1 Layer-2 MPEG-2 AAC
System		MPEG-2 TS (ASI) MPEG-2 TS/TTS (IP)	MPEG-2 TS/TTS (IP)
Latency	**IP**	Standard (~1.56s) Low Latency (~500ms)	Standard (~1.56s) Low Latency (~400ms)
	ASI	Standard (~1.38s) Low Latency(~300ms)	

Table 5.13. Relevant encoder features using a comparison between Fujitsu IP-9500 and Fujitsu IP-900E.

The first thing that should be analysed is that the Fujitsu IP-9500 is an encoder for IP and TV, IP-900E contrary to this is only an encoder for IPTV.

Another thing that sets them apart are the audio codecs they support. While the first can encode audio as MPEG-1 and MPEG-2 also allows audio encoded with Dolby E. The main features of Dolby E are:

- Help distribute surround and multichannel audio throughout the broadcast chain prior to transmission.

- Allows distribution of up to 8 channels of audio, metadata and timecode through existing dual-channel structures..

- Help switching, editing, encoding, decoding and audio/video synchronization in a manageable way.

- Allows access to the Dolby E Partner Program which help the user to plan the product purchase and system design decisions such as create a clear path in the facilities in order to realize the benefits of Dolby E technology.

More audio channels implies more energy and power consumption, so audio encoding is another important characteristic.

For example looking at the previous encoders, on the one hand there is the Fujitsu IP-920E with a consumption of 38W without Dolby E technology and is designed for high definition IPTV, while on the other hand the Digicast DMB- 8800 with a consumption of 40W without even having Dolby E technology however can encode to HD television and not only for IP.

Another important aspect that unfortunately is difficult to compare is the method of compression. For instance, there are encoders that allows up to 4 GOP levels, but not all of them allows it. Few of the encoders manufacturers gives that information. Staring at the profile and level combination, both can use the three GOP frames, but is difficult to know how many hierarchical GOP levels are used to compress the file.

Chroma is also an important variable. Depending on the number of chroma samples the quality will be different, and also the compression will be stronger or lower. For that reason there are not only 4:2:0 encoders but also encoders able to use both of the chroma systems 4:2:0 and 4:2:2.

The chart 5.14. shows MPEG-4 AVC encoders for the HDTV. The brands that are taken were Fujitsu and Cisco. Cisco is one of the most important companies related with the network.

The selected encoders in the chart are because they can use at least HDTV and not only IPTV.

BRAND MODEL	COMPRESS FORMAT	MAX. RESOLUTION	FREQUENCY OF SCANNING	PROFILES	POWER CONSUMPTION (W)
Tandberg EN5990	*H.264 / MPEG-4 AVC*	*1080i, 720p*	*720p60 1080i30*	*MP, HP @ L4*	*150*
Fujitsu IP-920E	H.264 / MPEG-4 AVC	1080i, 720p	720p59,94 1080i59,94	HP@L4; MP@L4	38
Fujitsu IP-9500	H.264 / MPEG-4 AVC	1080i, 720p	720p60 1080i60	HP@L4; MP@L4; 422CSC	60
Cisco D9054	*H.264 / MPEG-4 AVC*	*1080i, 720p*	*720p59,94 1080i29,97*	*MP @ L4*	*≤ 500*
Cisco D9094	H.264 / MPEG-4 AVC	1080i, 720p	720p60 1080i60	MP, HP @ L4	60

Table 5.14. HDTV encoders with MPEG-4 AVC encoding format

Most of them have a higher consumption than Standard Definition, also notes that none of them can offer superior quality than 720p or 1080i format, 1920x1080 with progressive scan can not be offered . It is important to emphasize important two aspects when calculating the consumer:

1. PIP (Picture in Picture) : Format in which an image is displayed full screen with sound while at the same time in a small window is displayed another channel, very useful for advertisements or to wait for until a desired program starts. This format is only available at the Cisco D9054. It is the largest consumer model but is the only one who has this feature. From our point of view, is a very useful feature, but is not strictly necessary and a feature that consumes significantly

related with the utility. There are also studies related with the decrease about the number of broadcasted channels. Instead of broadcasting all of the HD channels, only distribute the favourite ones and small number of non important for the customer.

2. Resolution. Today, many HDTV allows the use of 1080p. Consumption when using the 1080p format is higher because it uses more amount of information, which implies an increased need for bandwidth. Most encoders use MPEG-4 AVC at a resolution of 1080i or 720p, so do not arrive at such a high level. It is opted for the MPEG-4 transmission, because although the MPEG-2 there are more encoders able to provide a progressive scan of 1080, MPEG-4 AVC bandwidth is much narrower, occupy less and more quality related with the bandwidth, and furthermore, these encoders have a frequency of 50Hz at least, so that human perception will not be able to view these errors. Finally nowadays most channels use MPEG-4 due to limited bandwidth benefits and the fact that in households most devices that use the 1080p are the consoles with Blu-ray or HD DVD players.

3. Frequency: The frequency of scanning is important because it requires a quick update on the screen so that consumers may not perceive the defects. That's why it will require at least a frequency of 59.97 Hz at both 720p and 1080i.

The following calculated average excludes the Cisco D9054 model because uses the PIP system not strictly necessary, because otherwise the consumption will vary considerably. The Tandberg also is deleted due to the fact that the encoder does not comply the minimum requirements, at least a 1080i 59.94 Hz . The mean of the coders then, is:

POWER CONSUMPTION (W)
52,66

Table 5.15. Final average of MPEG-4 AVC HD encoders

The last average is lower than the MPEG-2 format average. As it was mentioned before, most European countries still encodes in MPEG-2 so is at this point is necessary to analyse the MPEG-2 HD encoders. Nowadays in most of the countries is broadcasted in MPEG-2 format. The transcoder is the one charged of converting the digital signal from MPEG-2 to AVC format in the national/regional headend due to the limited bandwidth range in the countries. Based on it, the election will be the MPEG-2 format, but is worth to think in the future and in the following years UltraHD with higher resolution and bandwidth requirements and 3DTV will need different encoding formats than MPEG-2 so, instead of only taking the MPEG-2 format encoders, the final option is an encoder with both compression formats. Finally, the consumption of the encoder part will be:

POWER CONSUMPTION (W)
50

Table 5.15. Final average of HD encoders. In that case with both compression formats.

The last decision is that since 2009 there is the new DVB-T2 broadcasting, the future digital terrestrial television, which is going to use the AVC compression format, for that reason most of televisions sold in 2010 are able to decode MPEG-4 AVC HD signal, so in the broadcast part, the transcoder will be needed to convert the signal from MPEG-2 to MPEG-4 part 10 for the final user according to that new technology.
At the end of this chapter there will be a comparison with an hypothetical scenario of a HD/SD transmission using both compression formats.

The next step is to go to the multiplexer. The various signals created in the encoder (Audio, Video, Data) will be multiplexed into one turning this into Transport Stream to carry this signal to the modulator and to the transmitting antennas.

5.3. BROADCAST

5.3.1. MULTIPLEXER

First of all is important to calculate the difference between the average to see how distant is the consumption in SD and HD.

HD	108,50 W
SD	36,43 W
DIFFERENCE	73,07 W

Table 5.16. Average difference between HD and SD encoders based on the results obtained in the third chapter.

As is possible to see in the table 5.16. the consumption differs relevantly. To accurate more the results, probably it should be useful to take a look again to the Spanish channels separating the SD multiplexers to the HD.

A Spanish television (TV3) is broadcasting the following TV channels: TV3, Canal 33, Super 3/3XL, 3/24, Esport 3 and TV3 HD. Also two radio channels: Catalunya Radio and Catalunya informació. Esport 3 and TV3HD are multiplexed in the multiplexor number 44 although the rest are in the multiplexer number 61. Furthermore, TV3 also offers 4 interactive channels multiplexed in the number 61. In the number 44 apart from that list broadcasts 5 more channels: 2 TV channels and 3 radio channels. All the TV channels, except TV3HD emitted in HD, are diffused in 16:9 format.
Is the most important channel in Catalunya and one of the most regional channels in the country, so that is the reason of broadcasting 17 channels. In Spain there are now 106 broadcasted channels divided in television, radio or interactive, and 14 multiplexers, 5 of those video channels are in HD.

The 5 HD channels are in 5 different HD multiplexers. All of this multiplexers contain 12 SD channels, 5 HD channels and 8 radio channels.

Each HD channel needs a bit rate around 20Mbps so 100Mbps in total. The SD requires 4Mbps for a total of 64Mbps. Finally every radio channel needs 256Kbps so 2Mbps for the 8 audio channels. Additionally each HD channel needs 5 HD dual audio entrances with a 384Kbps each for a total of 3.950Mbps and 12 more standard audio channels at 256Mbps each, 4 with dual audio in total are 4Mbps.

Treating all that information is possible to determine that the average channels for each multiplexer is 1 HD channels, 2 HD audio channels, 2,4 SD channels, 3,2 SD audio

channels and 1,6 radio channels, so 10 inputs per MUX. So, selecting the MUX from the table 3.7 that meet the requirements, the HD average power consumption is finally exposed in the table 5.17.

POWER CONSUMPTION (W)
83,33

Table 5.17. Final HDTV MUX average.

The number of inputs is the most significant point for the consumption. The energy required is higher according to the quantity of information processed into MPEG-TS streams. The number of channels per multiplexor also depends on the quality of the diffusion. For example multiplexors with HD channels broadcast 7 channels in the same multiplexor maximum, due to the quantity of information that an HD channel needs.

COMPANY	MULTIPLEXER NUMBER	NUMBER OF TV CHANNELS	NUMBER OF RADIO CHANNELS
TV3	44	4 (one in HD)	3
Telecinco	27	4 (one in HD)	1
TV3	31	2 (one in HD)	2
Antena 3	34	4 (one in HD)	2
La Sexta	47	3 (one in HD)	0

Table 5.18. Spanish TV companies with HD channels grouped by MUX, Number of channels per MUX, video and radio.

On the other hand, There are 35 SD video channels, 22 radio or interactive channels distributed along the 9 SD multiplexers. That implies 92 inputs spread in 9 multiplexers, with an average of 10 inputs per device.

Regarding to the chart 4.6 and selecting the correct devices, the power consumption is:

POWER

CONSUMPTION (W)
68,33

Table 5.19. SD multiplexers power consumption average.

Through this comparison is noted to be that the most influential point for the power consumption, related with the multiplexer, is the number of inputs, i.e., the number of channels being multiplexed. An SD MUX consumes less power consumption than HD and does not have an HD input, but according to the DVB-T distribution channels nowadays, the companies uses more channels per SD MUX than in an HD MUX due to the higher bit rate required for the HD channels. Normally each multiplexer supports all of the bit rate, but not the necessary quantity of inputs, and SD MUX with more inputs consume more energy than the others.

This example helps to note that with a daily example, the consumption difference between SD and HD is less than the first impression, cause is reduced to 19,17 W.

HD	87,5
SD	68,33
TOTAL	19,17

Table 5.16. Power consumption difference between SD and HD encoders.

5.3.2. MODULATOR

Modulator is one of the devices that is independent of the quality. But one important requirement is a wide bandwidth because is required for the HD transmissions due to the higher file size and also we suppose that the frequency is important for the number of channels, that in the following years the channel numbers are increasing up to 700 in HDTV.

MODEL	FREQUENCY	BANDWIDTH	MODULATION	POWER CONSUMPTION (W)
Cisco D9630	45 – 870 MHz	6, 7, 8 MHz	64QAM, 256QAM	< 50
Cisco D9634 D9638	45 – 870 MHz	6, 7, 8 MHz	64QAM, 256QAM	< 50
Digicast DMB-2018	170 ~ 860 MHz	5, 6, 7, 8 MHz	QPSK, 16QAM,	40

			64QAM	
Digicast DMB-2028	30 ~ 1000 MHz	5, 6, 7, 8 MHz	QPSK, 16QAM, 64QAM	40
Pro Television Technologies PT2080	30 ~ 1000 MHz	5, 6, 7, 8 MHz	QPSK, 16QAM, 64QAM	75
Pro Television Technologies PT2082	30 ~ 1000 MHz	1.7, 5, 6, 7, 8 MHz	QPSK, 16QAM, 64QAM, 256QAM	75

Table 5.17. List of preferable modulators according to the features overmentioned.

In Spain the modulation is in 64QAM constellations, so using this feature and a frequency of 860MHz due to the higher increasing number of TV channels now and in the future, the power consumption is calculated using the devices in the table 4.17.

POWER CONSUMPTION (W)
55

Table 5.18. Power consumption modulator average.

5.3.3. RECEIVER

The receiver is a device which takes place in the physical layer, so they are independent of the quality of the broadcasting. The average of that devices is:

POWER CONSUMPTION (W)
18,41

Table 5.19. Power consumption average for the receiver.

5.3.4. TRANSCODER

As it was explained on the second chapter, the transcoder requirements will be the same than the encoder.

Normally in the transmissions the function of the encoder is to convert from MPEG-2 to MPEG-4 AVC.

One important variable to keep in mind about this device is the convert format. The power consumption is bigger if the conversion is from MPEG-2 to H.264 than vice versa. In DVB-T HD transmissions the digital signal to the used is broadcasted in MPEG-2 but emitted in AVC so the necessary conversion will be from MPEG-2 to MPEG-4 AVC. In SD the transcoder is used to convert the signal to MPEG-4 for the transmission via IP after the headend.
In DVB-T2 the transcoder is not required, because the standard of compression is AVC for HDTV.

The average of that devices for this type of transcoding is really high due that first is necessary to decompress the input format to an intermediate for later on compress again to the desired format. But also a transcoder can be used for transcoding content, ie, changing the bit rate to meet the bandwidth requirements of the network and also for transcoding resolution, downgrading from HD resolution to SD or lower.

The averages of the transcoder are:

HD	251,2
SD	42,53
TOTAL	208,67

Table 5.20. Power consumption difference between SD and HD transcoders.

So the difference is really important. This is because an HD encoder needs more functionalities, not just to convert from MPEG-2 to MPEG-4. There are many regions with a limited bandwidth or not able to see HD and the transcoder should change de resolution or the bit rate. This changes needs energy supply and are complex so the power consumption is strictly bigger.

5.3.5. UPCONVERTER

The Upconverter is totally independent about the transmission. The mission of this device is to convert to VHF and UHF the signal received from the modulator and send the signal to the antennas and satellites for being distributed.

Normally this device is placed in the end of the headend after the modulator. Based on it sometimes there is a device that modulates and converts the signal by itself. The power consumption for that devices is a little bit higher.

BRAND / MODEL	POWER CONSUMPTION (W)
DVEO UCM 4540	80
Cisco Quantum RF Modulator / Up converter	< 30
DrawCom Modulator-Upconverter	30
Hangzhou DMB-5000	30
AVERAGE	42,5

Table 5.21. List of Modulator-Upconverter devices with its power consumption.

The average of this devices is higher than the normal upconverter logically, remember that the median was 13,03 according to the table 4.12, but is lower than the combination between modulator and upconverter for separate.

MODULATOR	55 W
UPCONVERTER	13,03 W
MODULATOR-UPCONVERTER	42,5 W
TOTAL	25,53 W

Table 5.22. Average difference between Modulator and Upconverter for separate and Modulator-Upconverter.

There is a energy save of 25,53 W of average so for a installation, depending on the requirements and the bandwidth of it, should be useful.

5.4. DVB-T SCENARIO

Assuming that a TV Channel called UPCTV (Universitat Politècnica de Catalunya TV) plans to broadcast 4 TV channels, one of them in HD through the network:

- UPC news (HD)
- 24/7 weather
- UPC activities.
- Faculties reports.

For that channels 4 encoders will be needed. One in HD and three in SD. For the SD encoder the election is the Grass Valley Model with a consumption of 17W. For the HD the preferable device is Ambrado HCE1604; 4:2:2 chroma format, lower power consumption are the important features for the election. Furthermore that device provides a scanning mode from 1080p so this is also an important point to improve the image quality. Fujitsu IP-920E has lower consumption but this consumption is not really real because there are options like dual audio channel which are not included in the standard product, and the consumption is measured based on the standard.

CHANNEL	CONSUMPTION (W)
UPC news	40
24/7 weather	17
UGENT activities	17
Faculties reports	17
TOTAL	91

Table 5.23. List of channels with the relative power consumption for each.

Next step is to choose the multiplexor. The multiplexor will need 9 inputs. 1 HD video, 2 HD audio, 3 SD video and 3 SD audio.
The choice is the Continuum D9616 because supports up to 16 inputs and the consumption is 50W.

POWER CONSUMPTION (W)
50

Table 5.24. Power consumption for the multiplexer option.

For the modulator and the upconverter is required a high output frequency in order to

select the channel frequency, a 64QAM modulator because is the required for the Spanish DVB-T transmission. So the choice is the Cisco Quantum RF Modulator / Up converter.

POWER CONSUMPTION (W)
30

Table 5.25. Power consumption for the modulator-upconverter option.

Then the signal will be diffused via antenna until the national headend receiver device. This point is necessary to check that we will calculate the power consumption for the national headend for one house DVB-T distribution.

The receiver choice will depend on the IF range. The Titan DVB-receiver has a wide range of frequencies so is the device elected.

POWER CONSUMPTION (W)
30

Table 5.26. Power consumption for the receiver option.

Then the transcoder will decompress the signal. 4 transcoders will be necessary. One HD transcoder converting from MPEG-2 to H.264 the signal. For HD transcoder the election will be Cisco D9901, due to the low consumption, the brand and the requirements.

1 x Cisco D9901	190 W
TOTAL	190 W

Table 5.27. Power consumption for the transcoder option.

Again is turn to the multiplexer to create the MPEG-TS signal, later modulator-upconverter to modulate the frequency and convert it to RF signals (VHF or UHF) to

finally be broadcasted via antenna again.

For the customer we will assume that there is a house with 2 televisions. The requirements is to use a HD television in order to view the HD channel broadcasted. The STB are integrated in the television so the consumption will be the TV consumption.

One television will be placed in the living room with around 50 inches, so the choice is Sony KDL-55EX713 with LED technology for the lower consumption. The second TV will be situated in the room, so the screen size will be around 32 inches. With that screen size is not worth to buy a LED TV because the price is higher and with a small screen size the power consumption savings are not significant. The election is Sony KDL-32NX503.

Sony KDL-55EX713	101 W
Sony KDL-32NX503	66 W
TOTAL	167 W

Table 5.28. Power consumption for the transcoder option.

Summarizing,

DEVICE	POWER CONSUMPTION (W)
ENCODERS	91
MULTIPLEXER	50
MODULATOR-UPCONVERTER	30
RECEIVER	30
TRANSCODERS	190
MULTIPLEXER	50
MODULATOR-UPCONVERTER	30
TELEVISION + STB INTEGRATED	167
TOTAL	638

Table 5.29. Power consumption for the whole HDTV with DVB-T transmission.

For the SD transmission the consumption will change in the encoders, transcoders, the TV, the STB and the multiplexer.

Concerning about the encoders the election will be the same than the SD devices in the HD previous transmission. The transcoder is not going to be used in this case.

Considering that the UPC news is an SD channel the multiplexer will need 8 inputs: 4 for SD channels and 4 for SD audio. The preference is Digital-ST DST 9110 for the high bit rate and the low consumption of 25W.

The STB option is the one with lower power consumption considering the On Mode and the Standby Mode, the Philips DTR230 model meets this requirement with 5W in on mode and 1W in standby mode. The Standard definition TV is the Haier HTR20 with a 85W of energy waste.

DEVICE	POWER CONSUMPTION (W)
ENCODERS	68
MULTIPLEXER	25
MODULATOR-UPCONVERTER	30
RECEIVER	30
MULTIPLEXER	25
MODULATOR-UPCONVERTER	30
STB	5
TELEVISION	85
TOTAL	323
HD – SD DIFFERENCE	315

Table 5.30. Power consumption for the whole SDTV transmission with the difference between HDTV broadcasting.

The difference between the two transmissions is 315W. But as is shown in that research every year the manufacturers are decreasing the power consumption so in few years the difference will be significantly smaller.

According to the difference between the transmissions, is important to say that the difference is still important.

5.5. DVB-T2 HD SCENARIO

In this case there will be the same scenario but with a DVB-T2 technology, so the first important step is the use of MPEG-4 AVC for the HD transmission.

The involved devices are the encoder and the transcoder. In that case the HD encoder cannot be the same used in the previous scenario, because the combination of profiles and levels for H.264 is BP@L4 for the Ambrado device, not enough for a high quality of image, so in that case the encoder used is NTT Electronics HVE9100 with a consumption of 60W.

The transcoder in that case is not necessary for the reason that there is no conversion needed.

CHANNEL	CONSUMPTION (W)
UPC news	60
24/7 weather	17
UGENT activities	17
Faculties reports	17
TOTAL	111

Table 5.31. List of channels with the relative power consumption for each.

According to that information, table 5.31. shows the consumption of DVB-T2 scenario.

DEVICE	POWER CONSUMPTION (W)
ENCODERS	111
MULTIPLEXER	50
MODULATOR-UPCONVERTER	30

RECEIVER	30
TRANSCODERS	*0*
MULTIPLEXER	50
MODULATOR-UPCONVERTER	30
TELEVISION + STB INTEGRATED	167
TOTAL	468
HD DVB-T2 Vs. HD DVB-T1 save	170
HD DVB-T2 Vs. SD	145

Table 5.32. Power consumption for the whole HDTV transmission with DVB-T2 standard compared with SDTV and HDTV previous scenario.

In the DVB-T2 hypothetical case the savings for the HD technology are important, so it is proved that the new DVB standard is going to decrease the power consumption significantly.

5.6. VARIABLES

According to that chapter, the variables that affect directly to the power consumption grouped by distribution chain step are:

DEVICE	VARIABLE
ENCODERS	Compression format, Inputs, Audio encoding, Chroma, Video resolution, Bit rate, aspect ratio.
MULTIPLEXER	Number of inputs, output bit rate
MODULATOR-UPCONVERTER	Constellations, Frequency range, Bandwidth.
RECEIVER	Frequency range input
TRANSCODERS	Input/output format
TELEVISION + STB INTEGRATED	Type of screen, screen size, ecological savings, aspect ratio, refresh

	frequency, scanning mode, image settings, dimension, luminosity, contrast, use, type.

5.33. Summary with the most important features and variables in the distribution chain.

These are the main important variables to keep in mind not only to reduce the power consumption but also to do a better choice of the devices. Note that most of the devices variables must be matched, for instance the frequency, if the frequency in the modulator-upconverter is large, in the receiver must be large also. The compression format and transcoding must be selected according to the final customer definition, H.264 for HD and MPEG-2 for SD.

Nowadays all the manufacturers are aware about the importance of being respectful with the environment but also is important for the users to know that when they buy a product, not only the technical features are relevant, there is something more which not only consumes less for the environment; also helps the user to save money.

6. CONCLUSIONS

This thesis studied the power consumption of the main devices involved in a DVB-T transmission, both HD and SD technologies comparing the consumption and the most important variables.

The HD transmission is a technology without a established nomenclature. Although there is a DVB-T2 recent standard, main of the TV channels still broadcasts in MPEG-2 and a transcoder is the device used to convert to MPEG-4 AVC the signal for the final distribution.

According to that non constituted nomenclature, in countries such Spain most of the HDTV channels still broadcasts in MPEG-2 but with an eye in the DVB-T2 version. For that reason in Chapter 4 the HD transmission was used using both standards.

Associating that information with the power consumption organizations such as Energy Star or Greenpeace are implanting new ecological standards. Energy Star started with the 3.0 version but it was not really strict so the following versions are tighter and, with Energy Star 5.0 version , in 2012 the restrictions will be really stringent, so that involves the manufacturers to reduce the energy emissions of their HD devices.

If one thing was wanted to make clear in this thesis is the increase in level of consciousness, always have a eye on the environment. In the aforementioned example of the video distribution there were selected leading brands for the devices such as Cisco or Sony. Sony is in the Top-5 of Greenpeace list of most environmental respectful electronic brands and Cisco made collaborations in projects with Greenpeace in underdeveloped countries. Furthermore is one of the most valued brands by Greenpeace because in the last 5 years, Cisco reduced into a 25% the aggressiveness with the environment.

It is clear that the HDTV consumption is planned to increase. Considering the DVB-T2 versions, the broadcasting standard codification is MPEG-4 AVC for the HDTV. According to that, the use of a transcoder is avoided so that implies a 25-26% reduction of power consumption in comparison with DVB-T1.

In the final studied scenario, apart from comparing the consumption and note that the consumption is reduced with DVB-T2, it was discovered the most important variable the encoding format. Also more than the encoding format, the main point is to use the same coding standard during the entire distribution chain, based on it, transcoders will not be necessary, and, as it was shown, are the devices which consumes most.

In the customer level it was exposed that, due to the previously mentioned ecological organizations, there were developed new techniques to decrease ostensibly the consumption using the same technology and creating new STB able to receive and decode the signal with MPEG-4 AVC format. Manufacturers of the used devices in their private laboratories investigate and design chips, processors and strategies to reduce the necessary energy for the distribution chain of HDTV and the process will be followed in the future.

SDTV and HDTV transmissions with the DVB-T1 standard are still differentiated referring to the consumption of each, but it was seen that with the DVB-T2 nomenclature, the energy equalization is closer in time.

For future technologies such as 3DTV or UltraHD it is unknown if that features will be enough for an ecological consumption, but regarding to the HD television, if the evolution is following in the same way, always with an environmental consciousness, not only in a user level but also in designer, programmer and manufacturer status, the HDTV future is insured.

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