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Measurement of the power consumption of set-top boxes

prepared by

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This study has been carried out on behalf of the Swiss Federal Office of Energy. All contents and conclusions are the sole responsibility of the authors.

Please refer to the following web site for additional information concerning the Swiss Federal Office of Energy "Electricity" programme:

www.energie-schweiz.ch

Contents

Summary

Digital TV will give rise to an increase in electricity consumption in the next few years, primarily because of the set-top boxes that are required for digital reception. In Switzerland, the number of set-top boxes in operation is expected to increase to around 3.4 million by 2015, or until the changeover to digital TV has been completed.

The aim of this project was to obtain more information about the power consumption of set-top boxes. For this purpose, measurements were carried out on 33 set-top boxes, the results of tests carried out by “Stiftung Warentest” were evaluated and manufacturers were asked to provide technical specifications. In this way, a total of 80 models were evaluated. The results of the measurements carried out within the scope of this project were very similar to those obtained by “Stiftung Warentest”.

Many manufacturers do not yet declare power consumption data in their specifications and manuals. Stand-by levels were only declared for 34 out of 80 set-top boxes (40%). Furthermore, details provided by manufacturers concerning consumption levels in “on” mode are often incorrect and far too high. There is clearly need for action here, both on the part of suppliers as well as at the political level.

The power consumption of efficient devices is well below the maximum levels defined in the Code of Conduct. This concerns 68% of the devices in the study. Similarly, those devices that have a high consumption level exceed the maximum levels just as clearly. This applies to 32% of the devices in the study. The average stand-by consumption of all devices in the study was 7.3 watts, compared with the mean specified threshold of 8.4 watts. The Code of Conduct thus does not appear to be very demanding, and is oriented on the market segment with higher consumption levels. The best devices are many times more efficient.

‘‘Swisscom Bluewin TV plus” is a set-top box for receiving TV via the Internet. It has an integrated hard disk for timeshift TV and recording. Its stand-by consumption is 15.4 watts. With IP reception technology, consumers need an ADSL modem in addition to a set-top box, and the modem supplied by Swisscom consumes 10.3 watts in “on” mode. Unless users switch these devices off manually, the resulting stand-by losses amount to 25.7 watts. Swisscom has given its assurance that it will work together with the manufacturers to improve the energy efficiency of these devices and thus comply with the (voluntary) Code of Conduct as soon as possible.

The importance of cable set-top boxes is expected to increase considerably. The Cablecom model that was measured in this study also has an integrated hard disk, and in addition it is equipped with a slot for a smart card. The stand-by consumption is 8.9 watts, which is also above the threshold specified in the Code of Conduct, though by no means to the same extent. In some regions, amplifiers are also installed at the cable connection to the house, and these can give rise to additional stand-by losses of around 6 watts.

On average, the stand-by consumption of satellite set-top boxes tested in this study was 7.8 watts. The levels of 70% of these devices were below the threshold specified in the Code of Conduct. If satellite receivers are used with an additional power supply, the stand-by losses increase by a few watts.

On average, terrestrial set-top boxes indicated stand-by losses of 6.5 watts, and the levels of 75% of these devices were below the threshold specified in the Code of Conduct. Many newer TV sets are supplied with integrated terrestrial receivers, and therefore do not need a separate set-top box.

Generally speaking, more sophisticated set-top boxes have higher standby losses, and this applies especially to models for high definition TV and those with an integrated hard disk.

‘‘Standby passive” mode was only implemented in one of the tested devices. The accompanying instructions were complicated and this function is therefore unlikely to be used much. There is little

point in including a clear requirement for this function in the Code of Conduct unless the operating mode in question is actually integrated into the available devices. For this reason, manufacturers should be required to integrate "standby passive" mode into their products (with automatic configuration).

In principle, switching off or unplugging set-top boxes appears to be possible with all the tested models, but some suppliers advise against this since problems can arise if the equipment is not always available for updates. In some cases there is the additional problem of loss of convenience (e.g. start-up time of several minutes with equipment supplied by Swisscom and Cablecom). This means that, in practice, most set-top boxes are never switched off.

The aim of the market overview is to provide a decision-making basis for future scenarios and strategies. The main focus is on the periodical updating of the power consumption requirements of the European Code of Conduct, a declaration requirement for suppliers, development and marketing objectives for manufacturers, decision-making aids for major buyers (providers, distributors), approval restrictions, and forecasts regarding the power consumption of set-top boxes in Europe and within Switzerland.

Abbreviations used in this study

Abbrevia-tion:	In full	Comments
ADSL	Asymmetric DSL	High-speed Internet access (via phone line)
CI module	Common interface module	Modules are inserted in a separate slot and can accept a TV card (smart card) from a provider (e.g. SF DRS). A smart card can often be directly integrated into a CI module. Some set-top boxes are equipped with two CI slots and/or two smart card slots.
DSL	Digital subscriber line	Broadband digital connection via telephone networks
DVB	Digital video broadcasting	Digital TV transmission
DVB-C	DVB cable	Digital TV transmission via cable
DVB-S	DVB satellite	Digital TV transmission via satellite
DVB-T	DVB terrestrial	Digital TV transmission via antenna
EPG	Electronic programme guide	
HDTV	High definition TV	
IPTV	Internet protocol TV	Video signals are transmitted via a broadband connection
IRD	Integrated receiver decoder	Cable or satellite set-top box
LNB, LNC	Low noise block converter, low noise converter	Receiver mounted in the focal point of a parabolic antenna for satellite reception
MPEG-2	Moving Pictures Experts Group	Compression procedure for video signals
SCART	Syndicat des Constructeurs d'Appareils Radiorécepteurs et Téléviseurs	Standard connection for audio and video equipment, especially TV sets and video recorders
STB	Set-top box	Decoder for reception of digital TV programmes
VoD	Video on Demand	Permits interactive selection of TV programmes

1. Introduction, principles

1.1 Background and objectives

In the next few years, digital television will not only be providing consumers with a comprehensive range of programmes with a stunning quality of picture and sound, it will also give rise to increased electricity consumption. This is primarily because of the set-top boxes that are required for digital reception, which could cause Switzerland's annual electricity consumption to rise by up to 0.5 percent (Swiss Federal Office of Energy media release dated 22 September 2006 concerning set-top boxes for digital TV: industry wants to cut electricity consumption).

The energy requirements of set-top boxes currently available on the market vary considerably. Studies have shown that standby consumption ranges from less than 1 watt for the most efficient devices to 18 watts for the least efficient ones (references: "Stiftung Warentest" and http.//www.ecostandby.org). In this project, measured levels ranged from 3.7 to 25.7 watts (including the necessary modem). It is therefore well worthwhile paying attention to low power consumption when buying or renting these devices. The differences in consumption will only really be of significance once digital TV has been introduced throughout the country.

To limit the maximum electricity consumption of set-top boxes in standby mode, the EU approved a Code of Conduct in November 2005, which takes the form of a voluntary agreement that was drawn up together with manufacturers and service providers from the telecommunications industry. The current target range for standby consumption is 3 to 8 watts, though the intention is to reduce this every two years, with the next review scheduled for January 2008. Switzerland is invited to participate in the ongoing improvement of the Code of Conduct, and can thus contribute its own findings and experiences. On 29 September 2006, Swiss industry representatives voluntarily undertook a commitment to observe the European Code of Conduct (as of 7 May 2007, 9 companies and organisations had signed the declaration).

With this project, the Swiss Federal Office of Energy (SFOE) set out to obtain a more detailed picture of the current situation and available products in Switzerland. The main objective of the study was to evaluate the most widely-used set-top boxes in terms of energy requirements, as well to compare the findings with data provided by the respective providers.

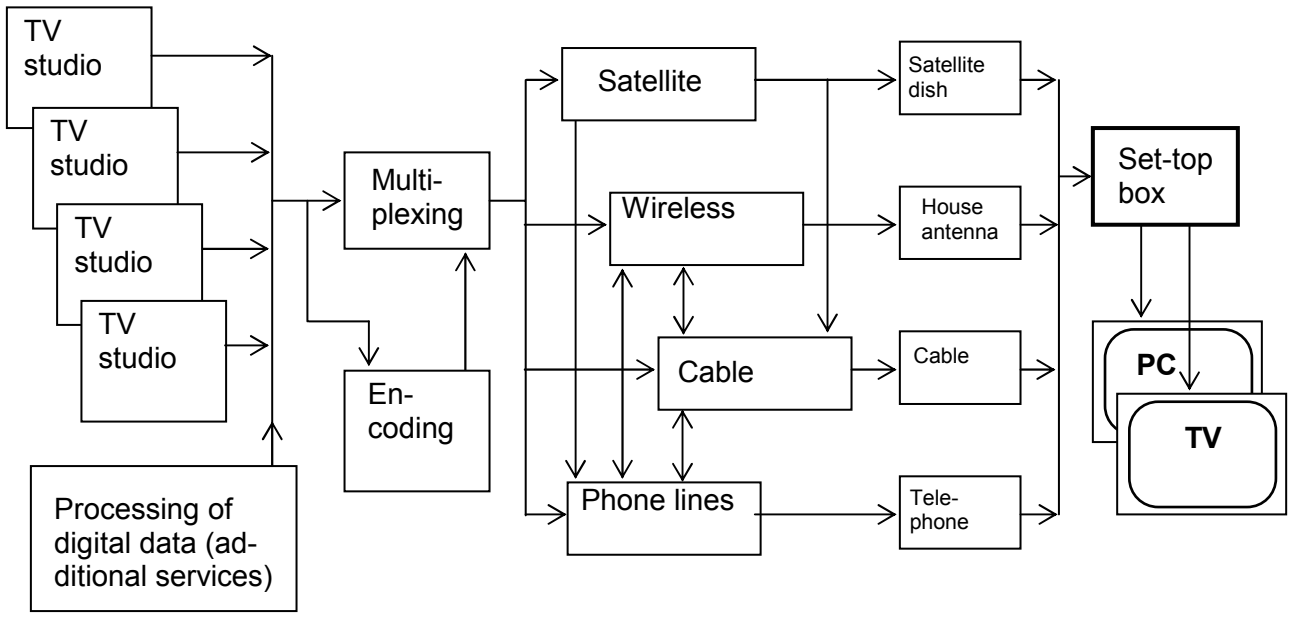
1.2 Digital TV

Digital TV represents a significant improvement on analogue television. Video and audio data are transmitted in digitised form in accordance with the applicable European standard (Digital Video Broadcast, or DVB). The goal here is to define a standard format for the various methods of transmission.

Digital TV can be broadcast via terrestrial networks, broadband cable networks, modified twin-cable copper telephone lines or via satellite. A distinction is made according to method of transmission:

- DVB-S for broadcast via satellite
- DVB-C for broadcast via cable
- DVB-T for broadcast via terrestrial transmitters and (house) antennae
- DSL for broadcast via the phone line (e.g. Bluewin TV, which is based on Microsoft's proprietary Windows Media codecs).

DVB is already in use practically all over Europe for satellite transmission (DVB-S) and in broadband cable networks (DVB-C). Testing of DVB-T commenced in 2000, and this technology was also recently introduced in Switzerland.



The diagram above depicts the transmission methods for digital TV.

The transmission route is digitised, but not (yet) the TV set. For this reason, the transmission chain has to be completed with a set-top box, which breaks down the data flows into individual programmes and passes them on to the TV set after decompressing (and for authorised used groups, decoding) them as analogue or digital video and audio signals.

Digital transmission

For television, a rapid sequence of single images has to be transmitted. Example: with the existing PAL standard with 625 lines and 25 Hz display frequency, the resulting data rate is 216 Mbits per second. Such data flows would require bandwidths that are not available. This means that the data volume needs to be reduced by means of compression, without resulting in identifiable losses of quality upon reception. For the European DVB standard, **MPEG-2** has been defined as the method for compressing data. Example: with MPEG-2, it is possible to compress PAL TV images to 4 Mbits per second without a perceptible loss of picture quality.

Technical properties of digital transmission of video signals

The digital transmission of video signals offers a variety of advantages versus analogue transmission:

- Greatly reduced data rate through compression (MPEG-2)
- Transmission in the form of MPEG-2 transport flows comprising blocks with a length of 188 bytes
- Multiplexes, i.e. groups of different programmes comprising video, audio and data

- Logical separation of channels by means of packed IDs
- Possibility of simultaneous transmission of several programmes per frequency.

Advantages of digital transmission

- Number of transmitted TV programmes per channel can be greatly increased
- Encoding procedures for pay TV can be implemented easily and securely
- Radio programmes can also be transmitted via TV channels
- Higher video and audio quality (noise-free signals)
- **Electronic programme guides** provide a detailed and individual overview of TV programmes. Programmes can be easily filtered by category or other key terms, thus making it easy for users to find the programmes of their choice. Programmes can then be recorded by simply pressing a button on the remote control.
- The number of programmes is practically unlimited. In addition to conventional TV programmes, a variety of specialised programmes will also be introduced offering a broad range of content.

IPTV

IPTV (Internet Protocol Television) is the transmission of audio and video signals to a computer in TV quality. Transmission is based on the Internet Protocol, which is also the basis of Internet access.

In addition to reception via a computer, IPTV can also be viewed on a standard television set using a suitable set-top box. For this purpose, the set-top box is connected to the router (Internet connection) and to the SCART socket on the TV set. Programmes can then be selected from a list (which usually contains numerous entries) and started at any desired time with the aid of the set-top box remote control.

The advantages of IPTV include:

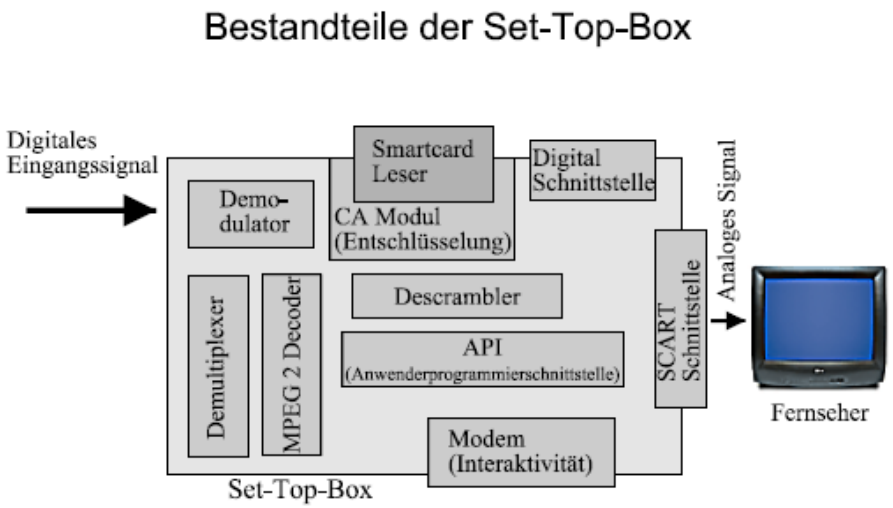
- **Interactivity**, which is made possible via the return channel. TV programmes can now also contain interactive elements in which the viewer is involved.
- **Video on Demand**, which gives viewers the option of selecting films and programmes of any category whenever they wish.
- TV programmes can be recorded on a hard disk with the aid of a digital video recorder. **Timeshifting** (time-delayed TV) is also possible.

1.3 Set-top boxes

A set-top box is required for the reception of digital video signals. This device is very similar to a satellite receiver, which is also connected to the TV set in order to permit reception. The designation “set-top box” was chosen because the device is designed to placed on top of a television set.
The main tasks of a set-top box (which is also referred to as an integrated receiver decoder, or IRD) are to decompress and decode the data flow so that a standard analogue audio/video signal is transmitted to the TV set. However, set-top boxes also contain the hardware for all other options offered by digital TV. It should also be noted here that the functions of a set-top box can also be integrated into the TV set itself, in which case it is called an integrated (digital) television set

(I[D]TV). In order to produce an analogue audio/visual (AV) signal that can be recognised by a TV set, the entire digitisation, compression and encoding process has to be reversed in the set-top box. The first step concerns the demodulation of the high-frequency signal to a digital data flow. Then the transport flow multiplex has to be broken down into its separate components in a demultiplexer. The package header, which is normally not encoded, provides the necessary information for allocation to the individual data packages. The requested audio and video signals are decompressed by the MPEG-2 decoder, or the additional services are provided. For this purpose the data flow has to be decoded, depending on whether the programme contains material subject to conditional access. Here the set-top box can be equipped with an integrated or removable conditional access module, and also contains a descrambler so that scrambling can be reversed if required. Applications are executed with the user programmable interface, which functions as middleware between the hardware and software. This is where the interactive applications are also located, which are also controlled via the set-top box. Since the introduction of digital TV has mainly been effected via private pay-TV providers who have also supplied a suitable set-top box, the devices that have been developed to date are not compatible with one another. However, thanks to efforts to establish an open market, the requirements relating to the interoperability of set-top boxes have meanwhile grown more stringent.

Through the use of non-interoperable set-top boxes it is possible for providers to prevent at least their own clientele from accessing programmes and services outside the vertically integrated distribution structure. If a proprietary set-top box secures a high share of the market, it can then fully prevent market access or else force other players to effectively enter into a dependency relationship. For other providers of set-top boxes, this in turn results in a dependency on licensing their product, which can also be equated with control over market access. The decisive components for such a procedure are the programming interface and the conditional access system of the set-top box, as well as its hardware, which can be designed to exclude services offered by other providers. The development of services to which access is blocked can be slowed down if a broad distribution of free-to-air boxes has taken place. This is not attributable to the use of proprietary standards, but rather is based on the fact that these zapping boxes do not have the facilities for decoding. If the range of freely receivable programmes and services is broad enough, there are no incentives for purchasing new and more expensive devices that are capable of decoding. This means that for the cited access-controlled services a significant group of potential customers remains untapped, and this could subsequently bring them to the limits of viability.



(Source: http://www.obs.coe.int/oea_publ/iris_special/glossardetails.pdf.de)

1.4 Network operators (providers)

In Switzerland, a variety of network operators are active on the market who use different distribution technologies that can be divided into three main categories: terrestrial, cable-based

and satellite-based. In each case, the standardised procedure for the transmission of digital content is DVB (digital video broadcasting), and in addition there is now the recently introduced IPTV (reception of TV or video streaming via Internet Protocol).

The leading network operators in Switzerland are Cablecom (cable), Telerätia (terrestrial) and Swisscom (IPTV).

1.5 Overview of the market

Set-top boxes can be divided into three categories:

- **FTA receivers** (free-to-air)
With these very basic models it is only possible to receive non-encoded programmes. They do not have any slots for subsequent expansion.

- **Receivers with a smartcard or common interface slot**
These mid-range devices are equipped with at least a smartcard slot or common access module slot and are capable of receiving encoded channels.

- **Recorders** (personal video recorders, or PVRs)
These high-end models are capable of recording programmes on an integrated hard disk, and are usually equipped with card readers for smartcards.

The range of products on the market is both broad and complex. A distinction is made between the following types of receivers:

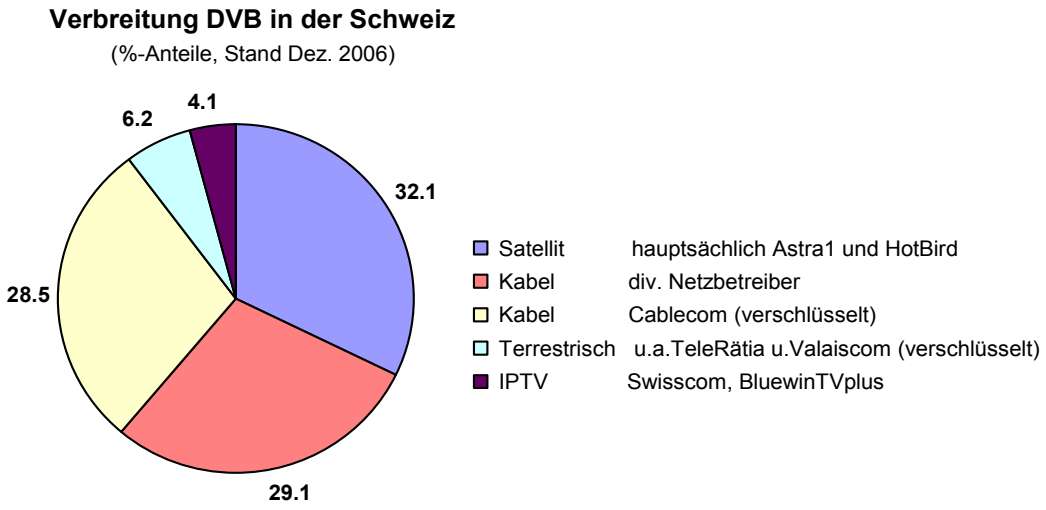
- DVB-C (cable)
- DVB-S (satellite)
- DVB-T (terrestrial)
- DSL (telephone line)

Various versions of all these types are available, according to quality and price. The main distinguishing features are twin receivers, integration of a hard disk and number of slots for smartcards.

1.6 Market shares of DVB providers

The leading network operators in Switzerland are Cablecom and Swisscom. The table below shows the respective market shares:

		Abonnente	%-Anteil	Quelle	
Satellit	hauptsächlich Astra1 und HotBird	15600	32.1	http://www.ip-	Television 2006 International Key Facts
Kabel	div. Netzbetreiber	14150	29.1	http://www.swisscable.c	Jahresbericht 2006, DVB-C total 280'000 Kunden
Kabel	Cablecom	13850	28.5	http://www.lgi.co	cablecom reports fourth quarter 2006 results
Terrestrisch	u.a.TeleRätia u.Valaiscom	30000	6.2	http://www.digitalesfernsehen.	Informaterial, Fact 01.07, Tel. Auskunft Hr. Steg
IPTV	Swisscom, BluewinTVplus	20000	4.1	http://www.swisscom.co	Medienmitteilung vom 10. Januar 2007
	Total	48600	100.0		



2 Declarations by providers

2.1 Methodology

Selection of providers

Swisscom, Cablecom and Telerätia all force their customers to use the set-top boxes supplied by the network operator. There is often only a choice between a standard and an advanced version with record function. The range of products for satellite reception is very broad. Some devices are produced by well-known manufacturers in the consumer electronics industry, though numerous others are supplied by companies that only occupy a niche in the DVB market. To receive programmes by satellite broadcast by German-Swiss station, SRG, a CI slot or smartcard reader has to be installed in the set-top box.

When the devices were selected from the list, attention was paid to the products offered by the Swiss electrical appliances sector as well as via the Internet (random sample basis). For evaluation purposes, a suitable selection was made from the large variety of available products and broad range of companies active on the market.

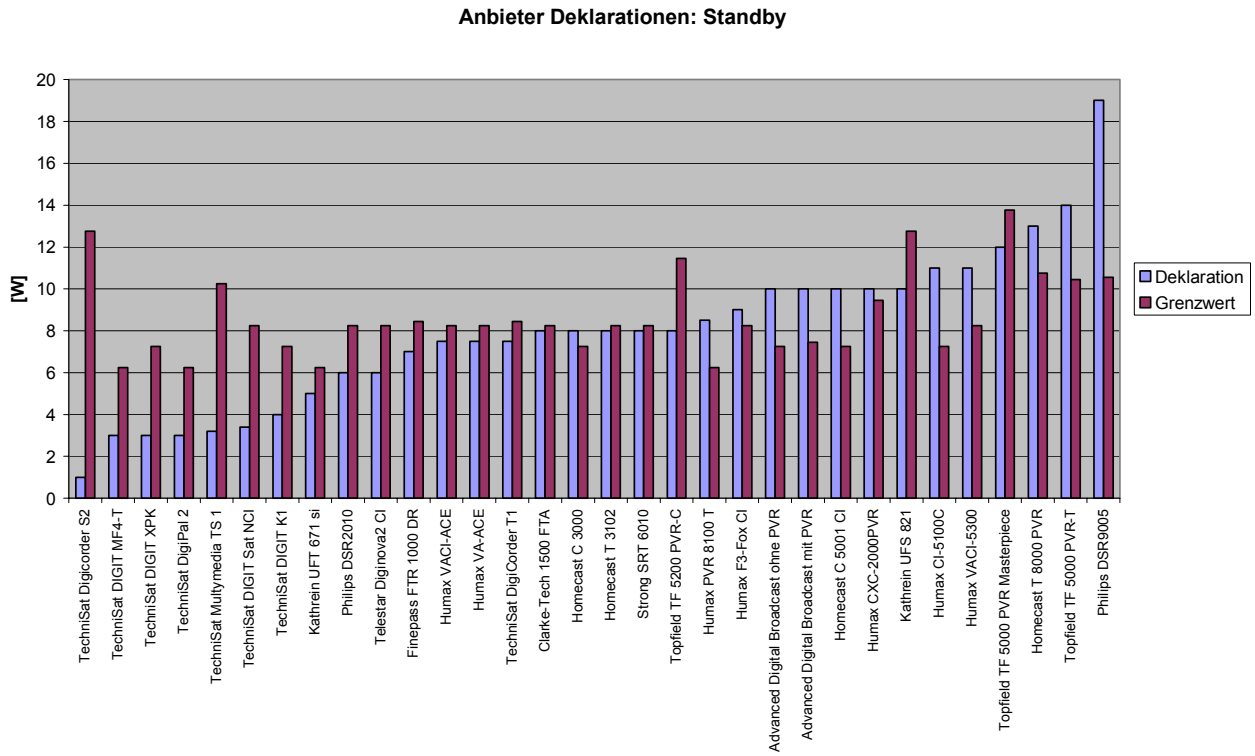
Selection of data

A search for set-top boxes from various manufacturers and suppliers was performed via the Internet. In addition to details provided in the product description, efforts were made in each case to find a user's manual or data sheet prepared by the manufacturer. It was not always possible to find such data online, and the degree of detail also varied enormously. Only a handful of manufacturers made a distinction between active standby and passive standby. We assumed that, unless a more detailed description was provided, the data referred to active standby mode.

"Stiftung Warentest"

As an addition to our own tables, we integrated two reports from "test", the magazine of consumer association "Stiftung Warentest": the report on satellite and cable receivers (issue 11/2006) and the report on DVB-T receivers (issue 3/2007). Information concerning the methodology for these two tests was not provided, but we assumed that the relevant standards were observed here.

Evaluation of declarations by providers



	Declaration [W]	Threshold [W]
Maximum	19	13.75
Mean level	8	8.70
Minimum	1	6.25

Many of the product descriptions, data sheets and user's manuals failed to include data relating to energy consumption. Out of a total of 80 tested set-top boxes, declarations by the provider concerning standby mode were only made for 32 (= 40%) of the products, and declarations concerning "on" mode were only made for 40 (= 50%) of the products.

For consumers wishing to buy a set-top box today it is not possible to obtain information about the energy consumption of the various products without going to unreasonable lengths. The necessary reliable information for making a purchase decision based on energy consumption is not available either in retail outlets or via the Internet.

3 Measurements

3.1 Methodology

We distinguished between laboratory and field measurements.

- Laboratory measurements

  In some cases we were able to borrow set-top boxes for carrying out tests. These devices were tested in the laboratory of HTW Chur in accordance with the applicable regulations (Code of Conduct on Energy Efficiency of Digital TV Service Systems), and their behaviour in operation was studied in detail. The findings thus obtained were valuable for the subsequent field measurements.

- Field measurements

  Most measurements were carried out in the sales premises of the respective providers. We were able to perform these without difficulty during off-peak business hours when very few customers were present, since the required infrastructure (antennae, monitors, power supply) was available and sufficient space was placed at our disposal for the various measurements. Two devices were tested in the homes of project staff.

3.2 Standards

The basis for carrying out the measurements was the Code of Conduct on Energy Efficiency of Digital TV Service Systems, Version 4, dated 10 March 2006.

This report distinguishes between four types of set-top box:

- STB for cable reception
- STB for satellite reception
- STB for terrestrial reception
- STB for ADSL reception

Annex C of the Code of Conduct stipulates that the energy consumption must be measured and declared in accordance with IEC 62078. For satellite devices, this means that the LNB (low noise box) current should be set at 80 mA during the test. In the field tests it was not possible to verify this requirement. In each case, the satellite dish was connected during the test, but the personnel on site were unable to provide detailed information about the system (satellite dish). During the measurements, one TV channel was active in “on” operating mode.

3.3 Operating modes

A distinction is made between four operating modes (in accordance with the Code of Conduct):

Operating mode	Definition
Off	The equipment is connected to the power supply, is not performing any functions and cannot be switched into any other operating mode with the remote control unit, an external or internal signal.
Standby passive	The appliance is connected to the power supply, is not performing its main function but can be switched into another mode with the remote control unit or an internal signal.
Standby active	The appliance is connected to the power supply, is not performing its main function but can be switched into another mode with the remote control unit or an internal signal. It can additionally be switched into another mode with an external signal, or if it receives a minimal level of data from an external source.
On	The appliance is connected to the power supply and is performing its main function, including the provision of signals to supported devices.

Operating modes and definitions

Standby is the operating mode that calls for the greatest deal of attention. This is the mode that is the most significant in terms of operating time. In accordance with manufacturers' recommendations, set-top boxes should be left permanently in standby mode when they are not in use, so that updates and information (e.g. concerning programmes) can be downloaded at any time. Whether this is really necessary, and what the disadvantages would be for users if they were to switch their set-top box off, we were unable to conclusively determine at the time of writing.

The criteria for switching from standby active to standby passive (if the latter mode is actually available) also remain unclear.

Only one of the devices in our study was equipped with passive standby, namely the DSR9005 from PHILIPS, which is not officially available in Switzerland. This model, which is intended for the German and Austrian markets (according to a statement by Philips Switzerland), was supplied to us on a loan basis for our laboratory tests (see 3.6, Results of measurements).

3.4 Power measurement

For the purpose of power measurement the following requirements must be met:

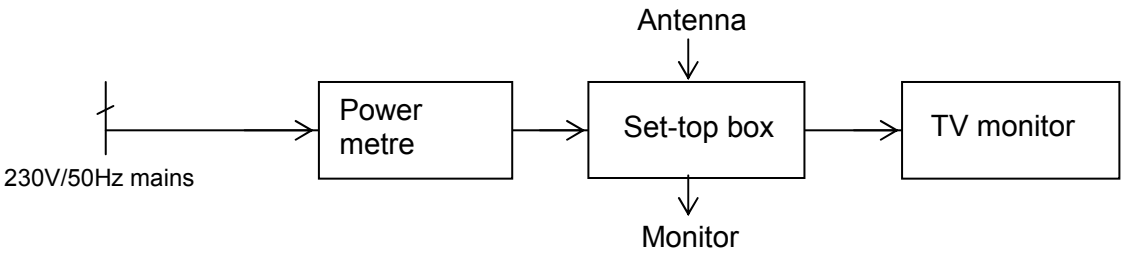
- A warm-up period of 15 minutes should be observed. During this time the device reaches its operating temperature and if necessary can download updates and the latest information. The devices tested in the laboratory of HTW Chur were switched on for a very long time (several hours) prior to measurement. For the field measurements, wherever possible a warm-up period of approximately 15 minutes was used.

- In order to create the same conditions as during normal operation, each device was connected to the TV set via a SCART cable.

- In order to reliably assess the consumption on the basis of the active output measurement, it is essential to ensure that the power intake is constant. With set-tops without a recording function, this was certainly the case, as a number of sample tests demonstrated. Among those

set-top boxes with a recording function[1], there was one in which the power intake fluctuated periodically for as yet unknown reasons (device from Cablecom with recording function / Gossen Metrawatt, Metra Hit 29S). In this case, an energy measurement or a detailed recording of power intake with subsequent averaging is required.

Test structure:



Use of operating modes:

The desired operating modes (off, standby active, standby passive, on) were used on the basis of operating instructions and familiarity with the operation of the respective set-top boxes. Most of the devices only have one standby mode.

Field measurements (photos, see Appendix):

After the warm-up period, power measurements were made using a 29S power meter from METRAHIT, and the readings were averaged over a period of 10 minutes. This permitted the calculation of active output with a precision of ±1% of the measurement range of current and voltage.
In the field tests, local circumstances also had to be taken into account. In field tests on the premises of major distributors (Media Markt, Interdiscount and Migros), only set-top boxes for digital satellite reception (DVB-S), and a small number of combination devices for DVB-S and DVB-T (terrestrial), were measured. None of the devices were equipped with recording functions (= no hard disk), which corresponds to the main market segment of satellite receivers. Measurements without a hard disk are thus sufficient over a period of 10 minutes, since no cyclical fluctuations in consumption occur (hard disk at standstill if there is no access for a certain period of time – see laboratory measurements with Cablecom set-top boxes). For measurement purposes, all set-top boxes were connected to a high-definition-ready monitor via a SCART cable. Where possible, connection was also made to a low noise box (via multiple switch) and/or a terrestrial room antenna. The CI module and smartcard slots were not used. With direct connection of a low noise box, a slightly higher power level (1.5 W) is possible if the multiple switch has its own power supply. For DVB-T, the existing TV antenna can normally continue to be used so that no additional devices need to be taken into account alongside the set-top box.

Performance of field measurements (Appendix, fig. …):

The power measurements were based on DIN EN 62087. Instead of video and audio test signals, current TV pictures (Swiss Info Channel) were used, since no influence of the transmitted image content and accompanying audio signal on the power requirement of set-top boxes was detected with the utilised power meter (PM1200).

[1] Internal hard disk for personal video recording

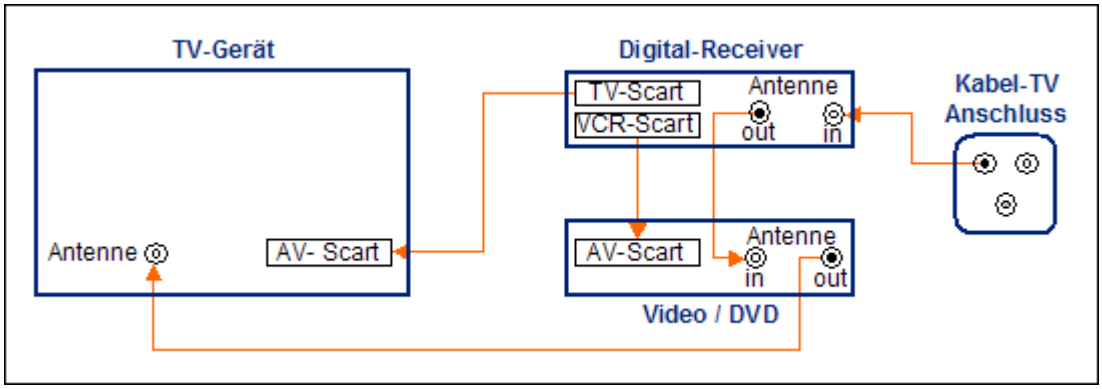
Depending on configuration, the cable connection for DVB-C (Cablecom), terrestrial antenna for DVB-T (Telerätia), DSL connection (Swisscom, Bluewin TVplus) or LNB for DVB-S systems was connected to the RF input (antenna signal) of the set-top box. In this way, measurements were carried out in “on” operating mode in close to realistic conditions with simultaneous reception of a TV programme. Furthermore, the supply of the LNB (80 to 120 mA) by the set-top box in all operating modes could also be taken into account.

Otherwise, measurements in the laboratory were carried out in accordance with the applicable regulations and with the greatest possible care and attention.

The following devices were tested in the laboratory of HTW Chur.

Cablecom:	ADB with 150 GB hard disk ADB without hard disk
Swisscom:	Bluewin TV300 with 160 GB hard disk Bluewin TVplus with hard disk
Philips:	DSR9005
Telerätia:	Techno Trend

Connection of set-top box for cable reception (digital receiver): The set-top box was operated between the cable connection and the TV set. Measurements were carried out without connecting a video recorder or DVD player.



Example of connection of a set-top box for DVB-C

The power measurements refer solely to the set-top box (digital receiver). In particular, no amplifier was included in the measurement that may have been present on the power supply side on the other side of the cable TV connection socket.

A PM1200 power meter was used for measuring the power requirement in the laboratory. With this metre it is possible to measure current, voltage, active output, reactive power and apparent output.

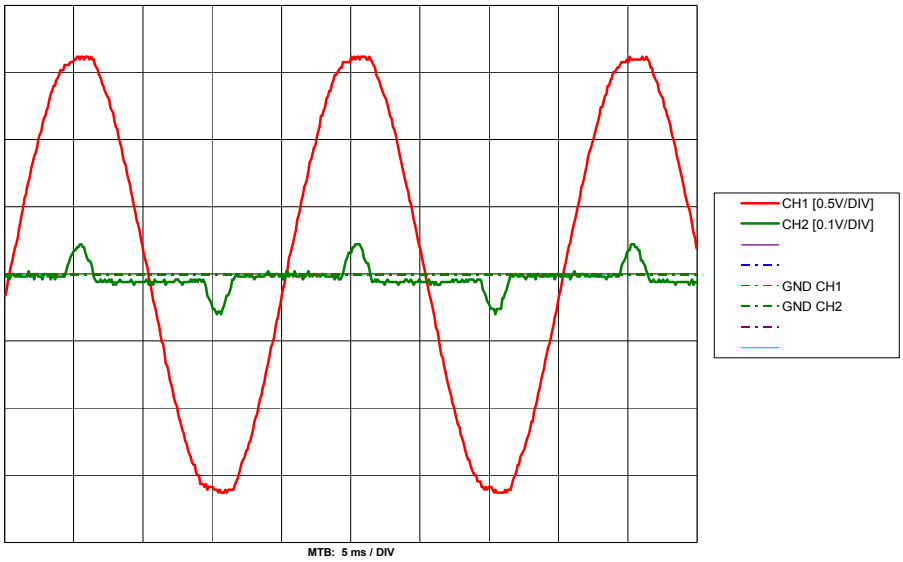
According to the specifications of the manufacturer, the degree of precision of the PM1200 with U = 230 V, I = 100 mA and power factor (PF) = 0.5 (equivalent to active power of P = 11.5 W) is **± 0.35 W**.

Reactive power is generally of the same magnitude as active power, i.e. the power factor (in “on” mode) is in the range of λ = 0.5.

With the digital TV receiver from Cablecom (device without recording function), the current and power rating were measured. The current shows the typical behaviour for a power supply unit with rectifier and subsequent smoothing by the filter capacitor.

Harmonic curve: supply voltage (100 V/div)

Curve with positive and negative peaks: current (250 mA/div)



***Cablecom** ADB without hard disk*

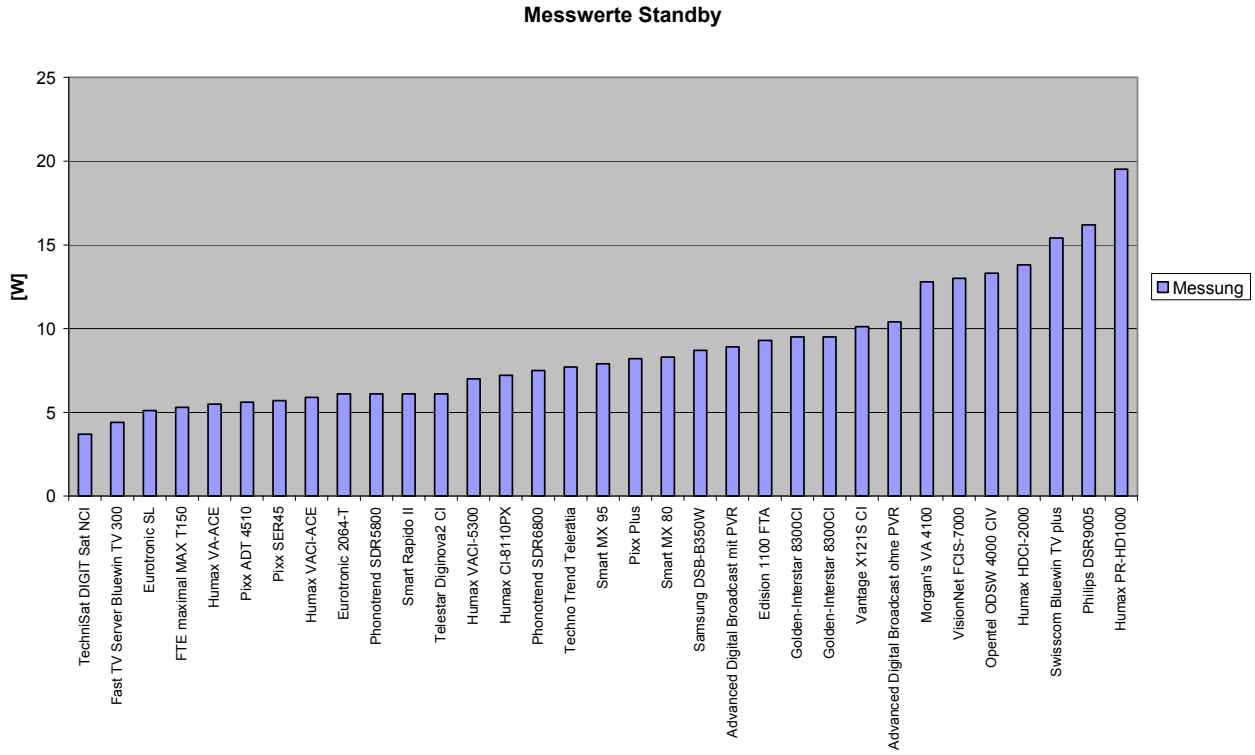
3.5 Energy measurement

At constant output, the energy requirement can be calculated from the measured power consumption: Energy (W) = P·t.

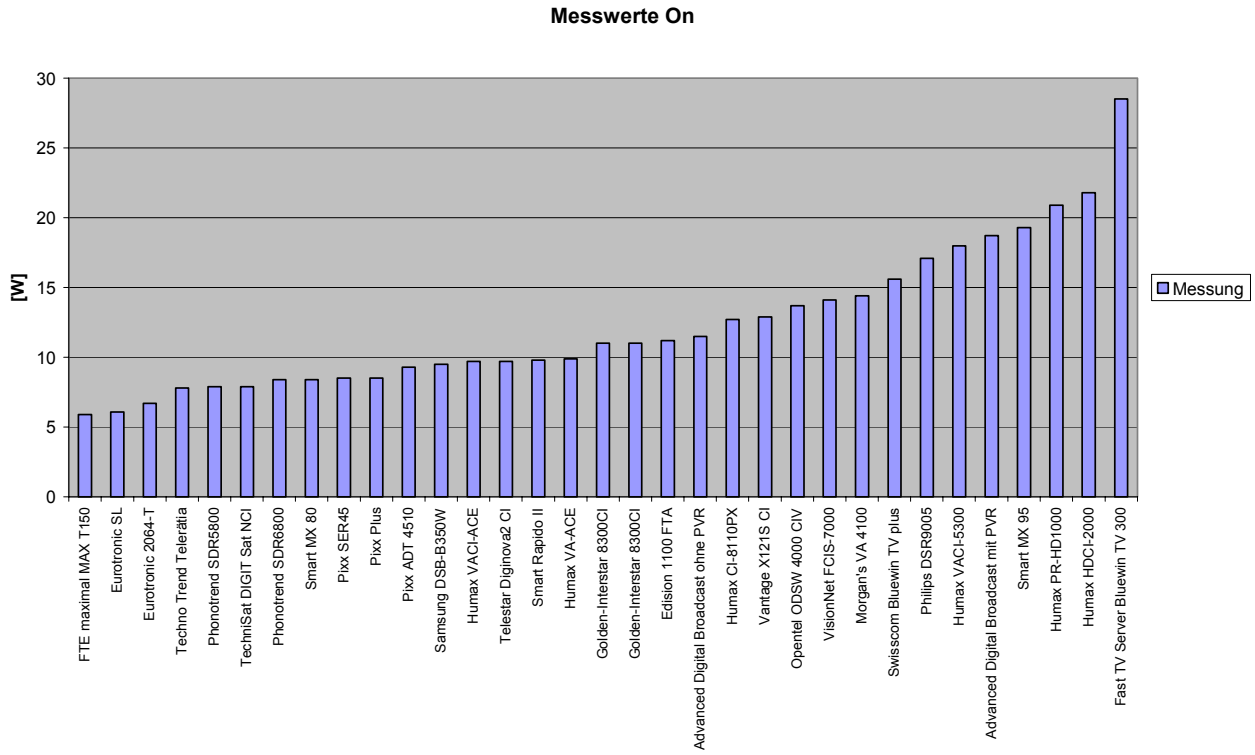
As a rule, a power measurement is sufficient for comparing the energy requirements of set-top boxes. If desired, the energy can be calculated by means of projection (multiplication with time [t]).

If output is not constant, the mean level has to be determined over a certain period of time. This can be done with the aid of an energy measurement. In the case of the Cablecom set-top box with hard disk, the energy in standby mode was measured over a period of several hours with an EMU 1.29k (class 2). The power level was then calculated by dividing the energy (W) by the time (t).

3.6 Results of measurements



	Measurement [W]
Maximum	19.5
Mean level	8.8
Minimum	3.7

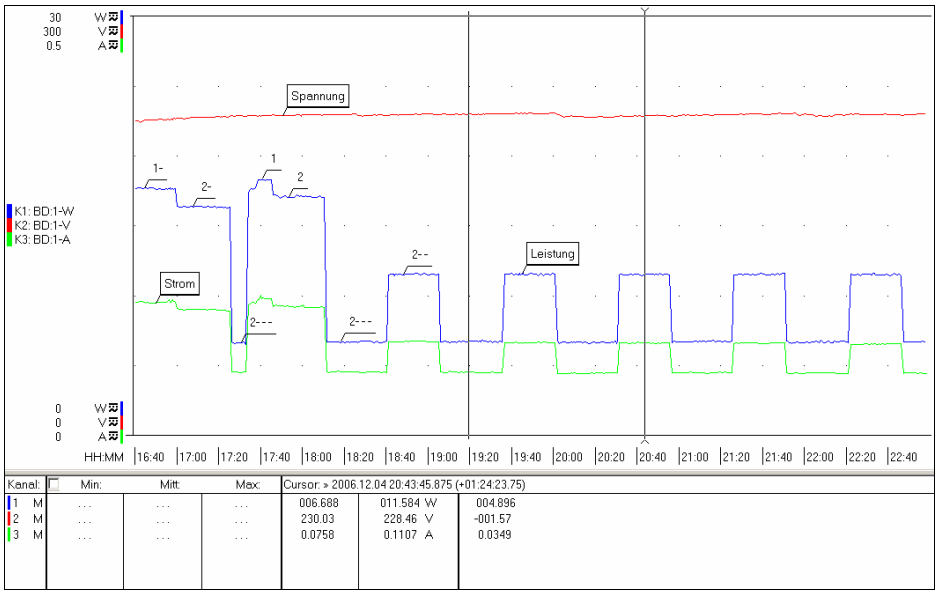


	Measurement [W]
Maximum	28.5
Mean level	12.3
Minimum	5.9

Cablecom

The device concerned is a set-top box with integrated hard disk and a slot for accommodating the Cablecom smartcard. There are currently different generations of equipment in use by Cablecom. The model used in our test was manufactured by Advanced Digital Broadcast.

The Cablecom set-top box indicated a periodical fluctuation in power requirement, though the cause of this was unknown.



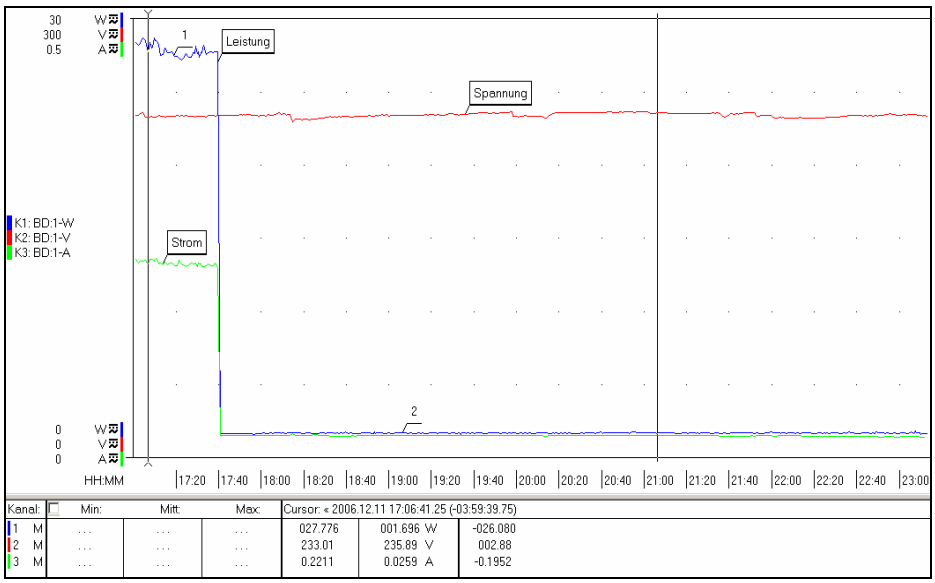
Cablecom *ADB with 150 GB hard disk*

Op. modes:	**1**	ON mode shortly after power-on or after change of op. mode	**18.3 W**
	1-	ON mode after warm-up phase, cosφ=0.49	**17.6 W**
	2	STANDBY mode shortly after power-on or after change of op. mode	**17.0 W**
	2 -	STANDBY mode after warm-up phase, cosφ=0.49	**16.4 W**
	2 - -	STANDBY (hard disk OFF), higher consumption during 25 minutes	**11.6 W**
	2 - - -	STANDBY (hard disk OFF), lower consumption during 30 minutes	**6.7 W**
		Average, calculated from **2 - - a**nd **2 - - -**	**8.9 W**

Swisscom Bluewin TV 300

The Bluewin TV 300 is a hard disk recorder for cable connection. It also requires a connection to the telephone network so that it can be programmed via the Internet or mobile phone.

The power requirement of this set-top with 160 GB hard disk is very constant. The level in “on” mode is relatively high at 28 W, but the level in standby is very low.



Swisscom Bluewin TV300 *with 160 GB hard disk*

Op. modes:	**1**	ON mode, average power during 12 minutes	**28.5 W**
	2	STANDBY, average power during 18 hours	**1.7 W**

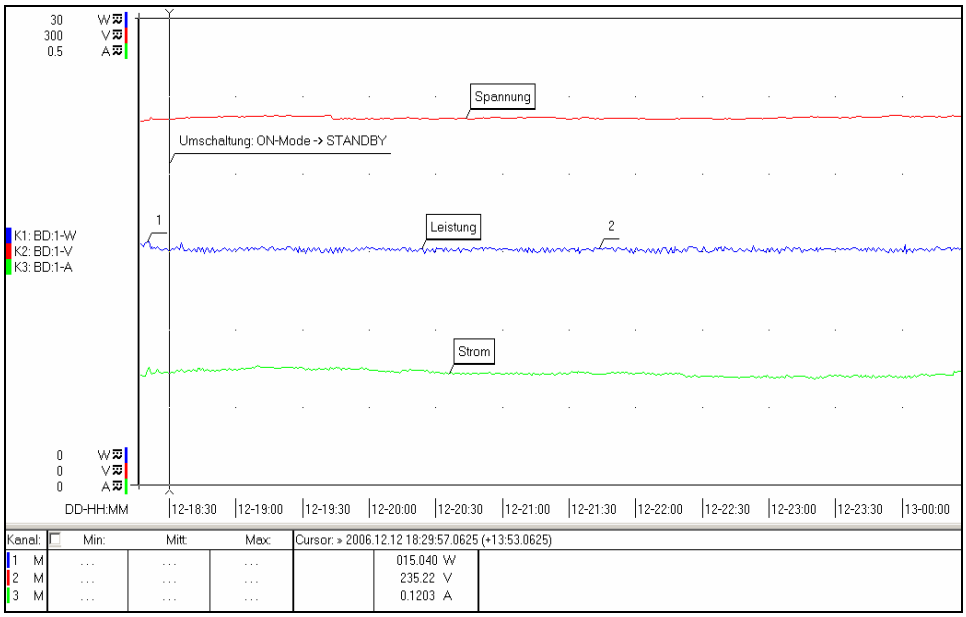
Swisscom Bluewin TV plus

Swisscom Bluewin TV plus is a set-top box for receiving TV via the Internet. It also has an integrated hard disk for timeshift television and recording.

With this model it is interesting to note that there is practically no difference between the (constant) power requirement in standby and “on” mode. Standby therefore saves virtually no energy at all.

When questioned, Swisscom confirmed this problem and stated that it is currently seeking a solution together with the manufacturer. Swisscom promised that it will comply with the Code of Conduct in the future. As an interim solution, the set-top box can be switched off. However, it then requires a start-up time of approximately 2 minutes (according to Swisscom).

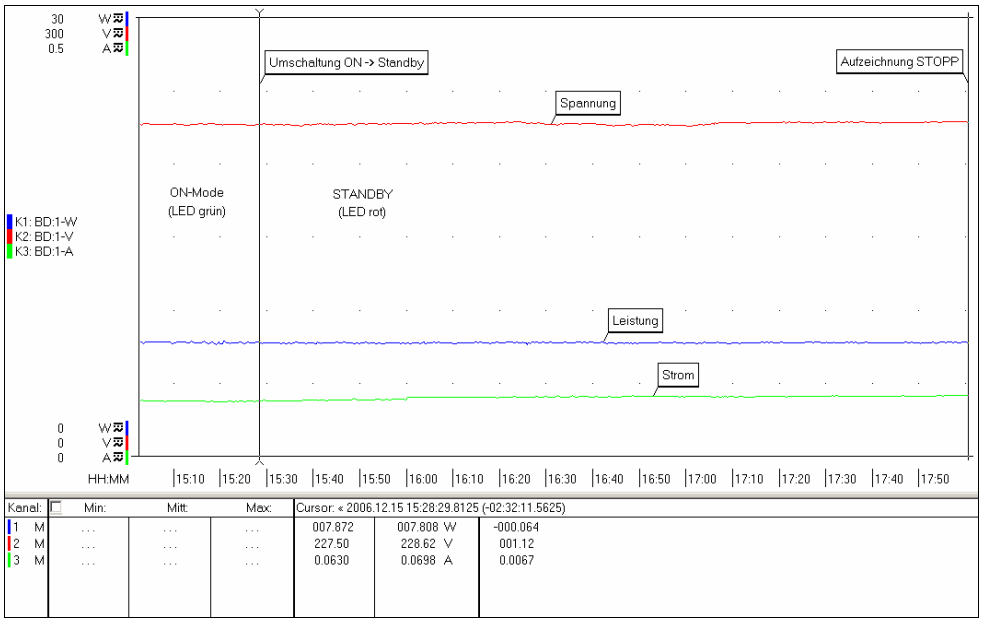
With IP reception technology, consumers need an ADSL modem in addition to a set-top box, and the modem supplied by Swisscom consumes 10.3 watts in “on” mode and 2 watts in “off” mode.



Swisscom Bluewin TVplus *with hard disk*

Op. modes:	**1**	ON mode, average power during 10 minutes	**15.6 W**
	2	STANDBY, average power during 14 hours	**15.4 W**

Telerätia TechnoTrend TT S/N: 40729644002856



Op. modes: **1** ON mode, 30 minutes wWarm-up, cosφ=0.54, $\mathbf{P_{Mean\ 20'}}$ **7.8 W**
2 STANDBY, cosφ=0.54, $\mathbf{P_{Mean\ 160'}}$ **7.7 W**

Measurement conditions:

- Measurement with SCART cable and antenna cable; connection between STB and TV set
- Measurement with improvised terrestrial antenna on STB antenna connection
- Supply of STB via external power supply unit (230 VAC / 12 VDC, 0.5 A); model DVS-1201A00FEUC 0.2 W in no-load, STB not connected
- STB does not have hard OFF (power supply switch)

Measurements

Operating mode:	**Declared level**	**Measurement with and without LNB load**		**Switch-over times** **from to**
		with [2]	**without**	
ON	20 W	17.1 W	15.1 W	passive ? ON: 30 sec.
Standby active [1]	19 W	16.2 W	14.6 W	Active ? ON: 2 sec.
Standby passive [1]	1 W	2.8 W	1.1 W	ON ? active: 2 sec. ON ? passive: 4 sec.

Measurement data for PHILIPS DSR9005

[1] Designations used by Philips: Standby active = stand-by
Standby passive = Economy mode

[2] In accordance with the Code of Conduct, based on IEC 62087: LNB current = 80 mA (for single LNB as of 1 January 2006)

Standby passive

In the course of our research and measurements, we only found one device equipped with standby passive mode. The PHILIPS DSR9005 is officially not available in Switzerland and is intended for the German and Austrian markets (according to Philips Switzerland). We were able to borrow one of these devices for testing purposes.

Operating mode:	**Declared level**	**Measurement with and without LNB load**		**Switch-over times** **from to**
		with [2)]	**without**	
ON	20 W	17.1 W	15.1 W	passive ? ON: 30 sec.
Standby active [1)]	19 W	16.2 W	14.6 W	active ? ON: 2 sec.
Standby passive [1)]	1 W	2.8 W	1.1 W	ON ? active: 2 sec. ON ? passive 4 sec.

Measurement data for PHILIPS DSR9005

[1)] Designations used by Philips: Standby active = stand-by
Standby passive = Economy mode

[2)] In accordance with the Code of Conduct, based on IEC 62087: LNB current = 80 mA (for single LNB as of 1 January 2006)

In its user's manual, Philips points out that, to save energy, the set-top box should be switched off when not in use, but in this operating mode no updates (e.g. frequency tables) can be carried out. The receiver should therefore periodically be switched to standby mode (at least once a week) so that updates can be carried out.

It was only possible to attain the standby level declared in the manual when the LNB input was not under load. With a connected LNB, the power consumption rose to 2.8 watts (see table above).

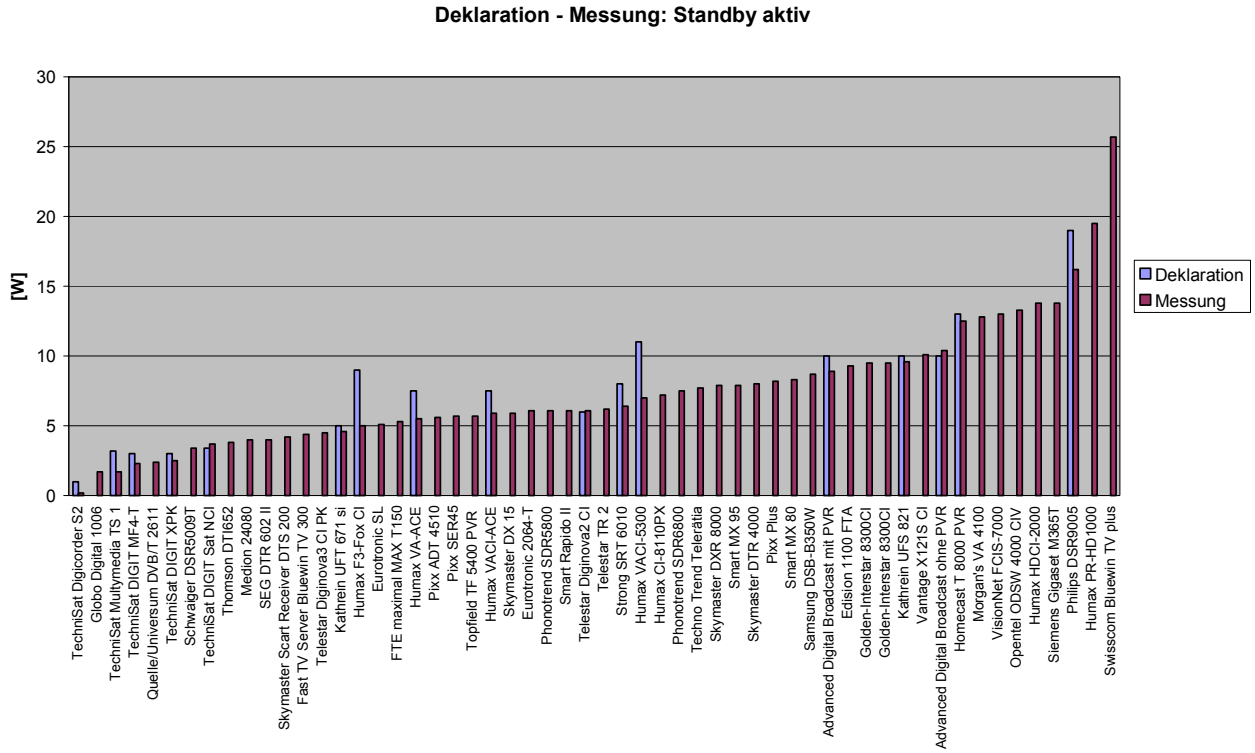
In comparison with other STB models, the measured standby passive level of the DSR9005 was lower than the standby active levels of the other devices by at least a factor of four. On the other hand, the Philips device is among those with the highest active consumption.

In order for the DSR9005 to be classified as an energy-efficient model it would have to be switched to standby passive mode when not in use. However, the waiting time of 30 seconds until the device is ready for operation in ON mode is likely to discourage users from selecting standby passive mode.

OFF mode

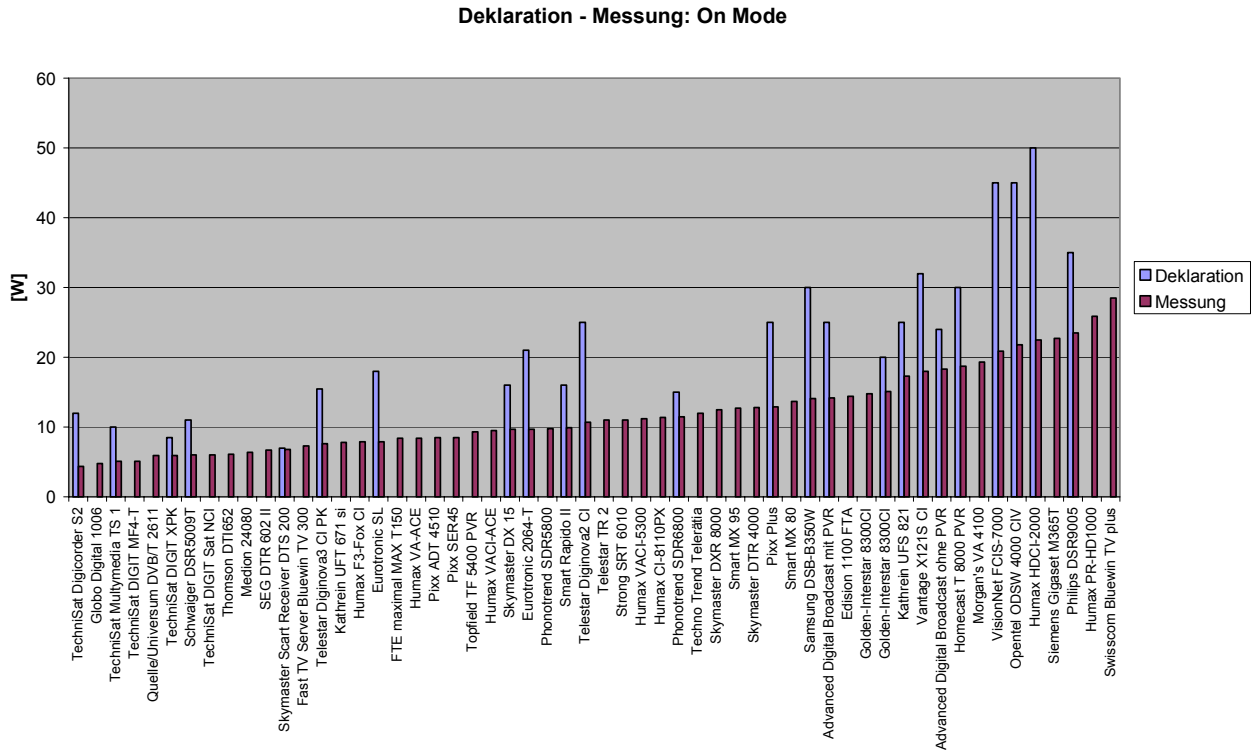
Set-top boxes can also be separated from the power supply when not in use, and some providers explicitly recommend this action. In most cases, however, they point out that this results in losses of comfort. Switching the device back on can require a certain amount of time (usually several minutes), and it may then have to first download updates for firmware or the electronic programme guide.

4. Comparison of measurement data versus declaration



	Declaration [W]	Measurement [W]
Maximum	19.0	25.7
Mean level	7.6	7.5
Minimum	1.0	0.2

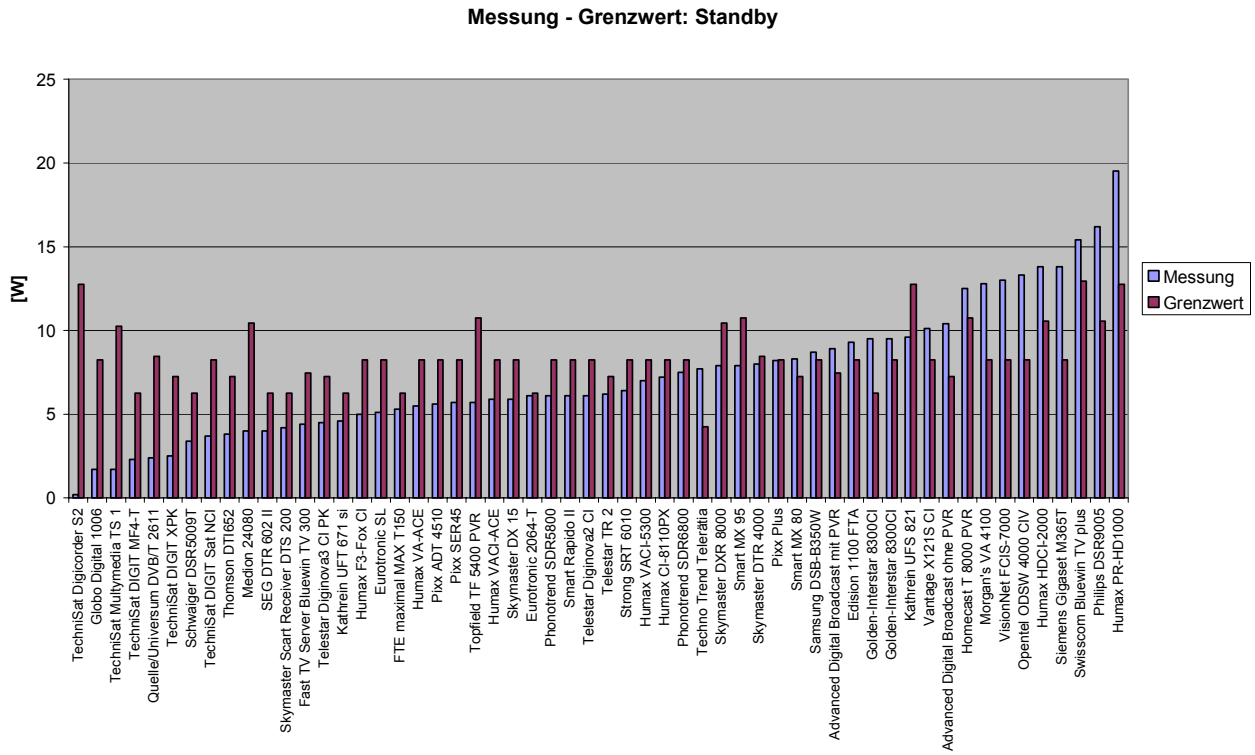
Many manufacturers do not yet declare power consumption data in their specifications and manuals. Stand-by levels were only declared for 34 out of 80 set-top boxes (40%). The levels declared by manufacturers tend to be too high.



	P_V[W]	P_V[W]
Maximum	50.0	28.5
Mean level	23.4	12.0
Minimum	7.0	4.4

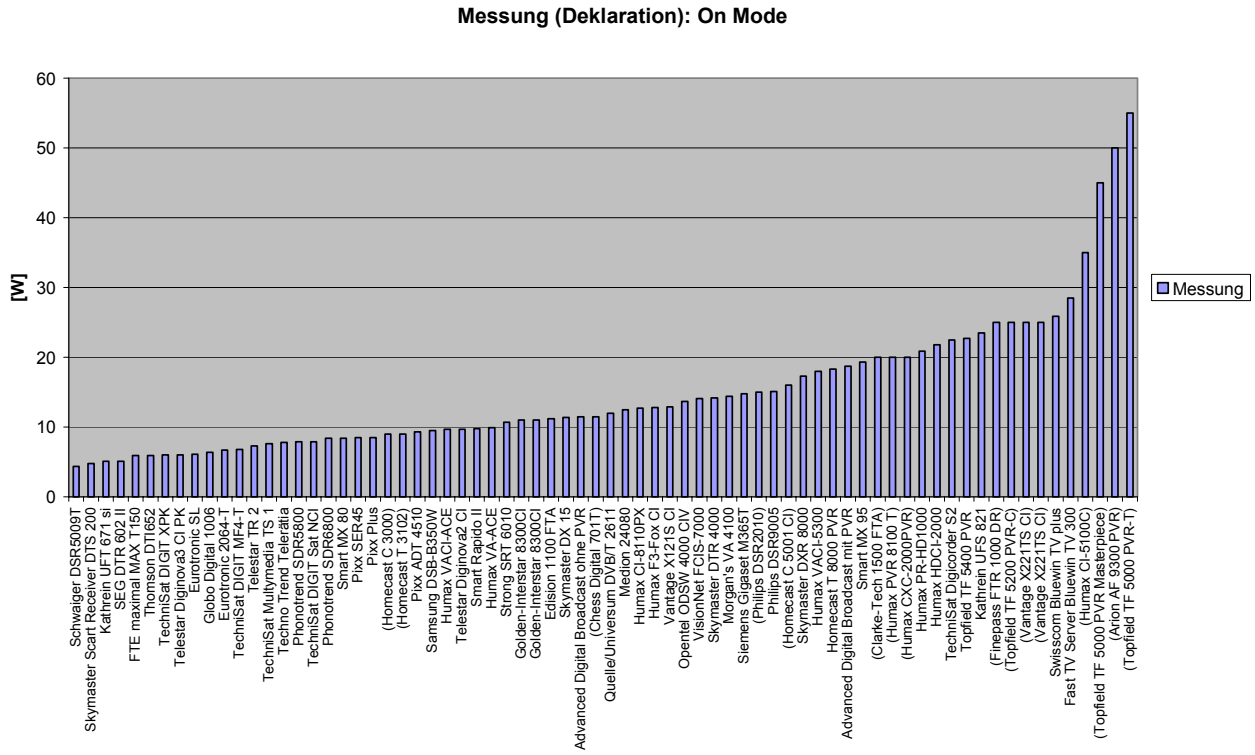
The specifications indicated by manufacturers for ON mode are often much too high. Here, half the manufacturers do not declare any levels.

5. Findings



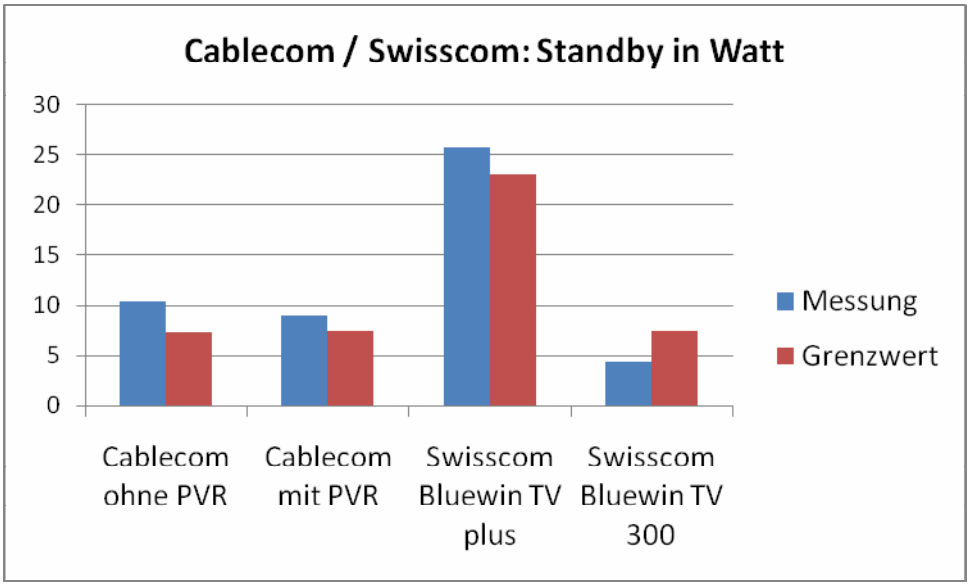
	Measurement [W]	P_V[W]
Maximum	19.5	12.95
Mean level	7.3	8.40
Minimum	0.2	4.25

The power consumption of efficient devices is well below the maximum levels defined in the Code of Conduct. This applies to 68% of the devices in the study. Similarly, those devices that have a high consumption level exceed the maximum levels just as clearly. This applies to 32% of the devices in the study. With Bluewin TV plus, the measured level includes 10.3 W ON-mode consumption by the ADSL modem.

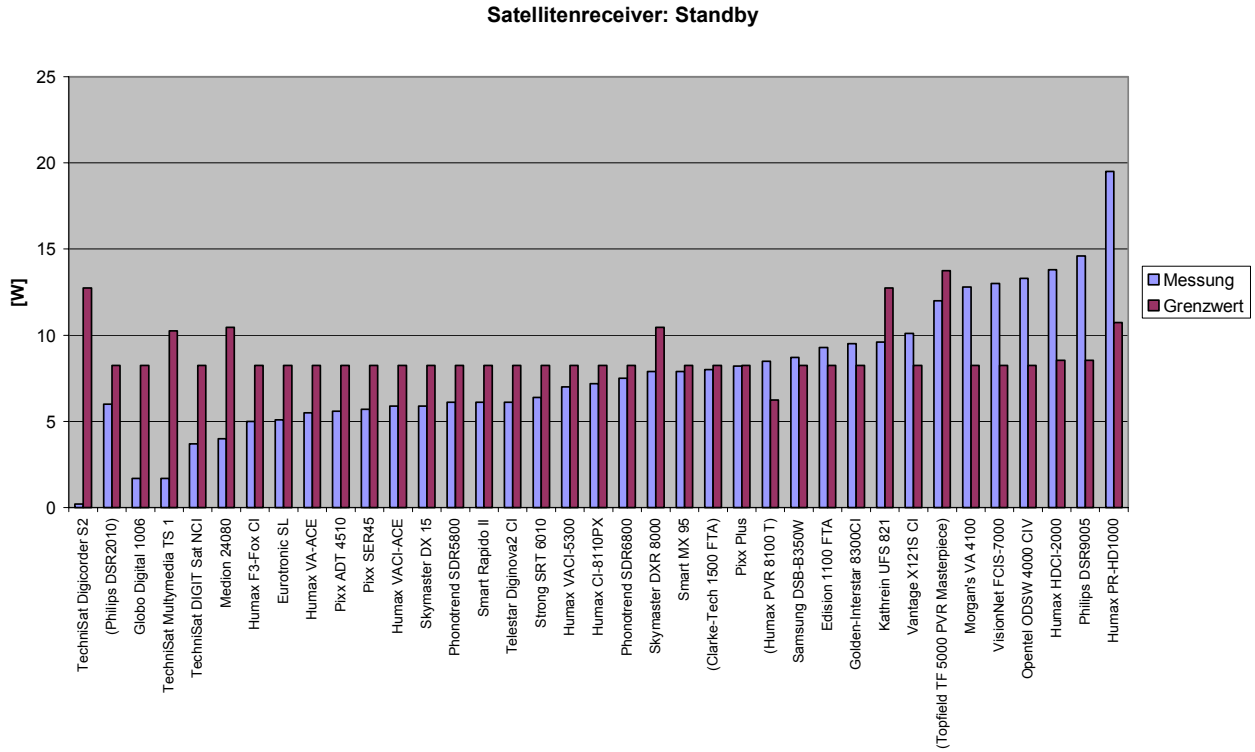


	Measurement [W]
Maximum	55
Mean level	15
Minimum	4.4

The measured levels in ON mode vary between 4.4 and 28.5 W. Manufacturers' specifications go as high as 55 W. Models indicated in parentheses mean manufacturer's specifications only (i.e. no measurement was carried out).



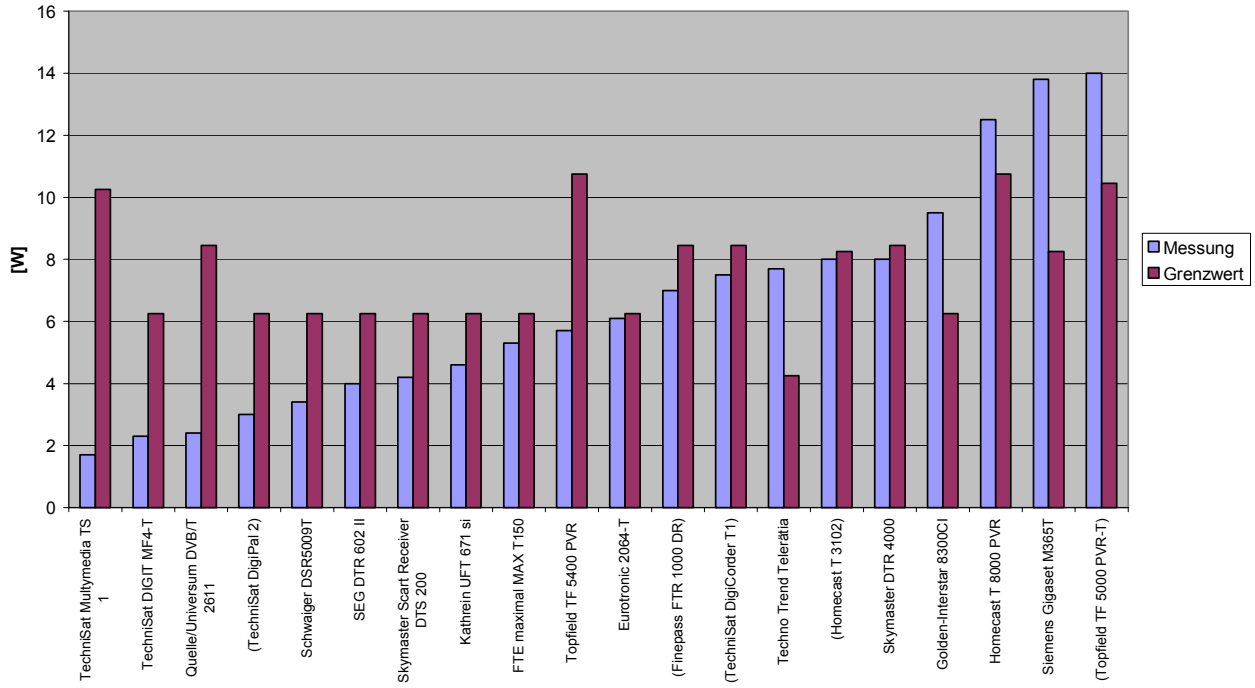
With the Bluewin TV plus set-top box, the ON mode consumption of the ADSL modem is included in the level recorded in "standby active" mode (measured level = 10.3 W, threshold = 10 W).



	P_V[W]	P_V[W]
Maximum	19.5	13.75
Mean level	7.8	8.80
Minimum	0.2	6.25

70% of satellite set-top boxes are already below the threshold specified in the Code of Conduct.

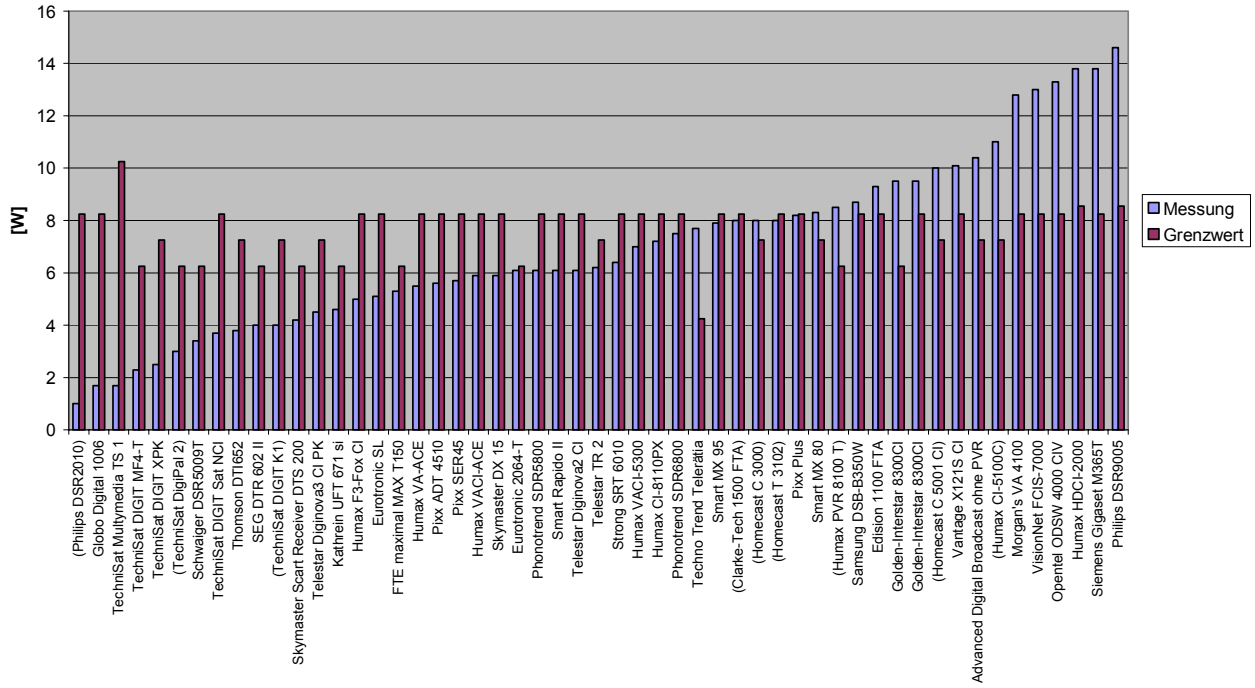
Terrestrisch: Standby



	P_V[W]	P_V[W]
Maximum	14	10.75
Mean level	6.5	7.70
Minimum	1.7	4.25

75% of set-top boxes are below the threshold specified in the Code of Conduct. Many newer TV sets are supplied with integrated terrestrial receivers, and therefore do not need a separate set-top box.

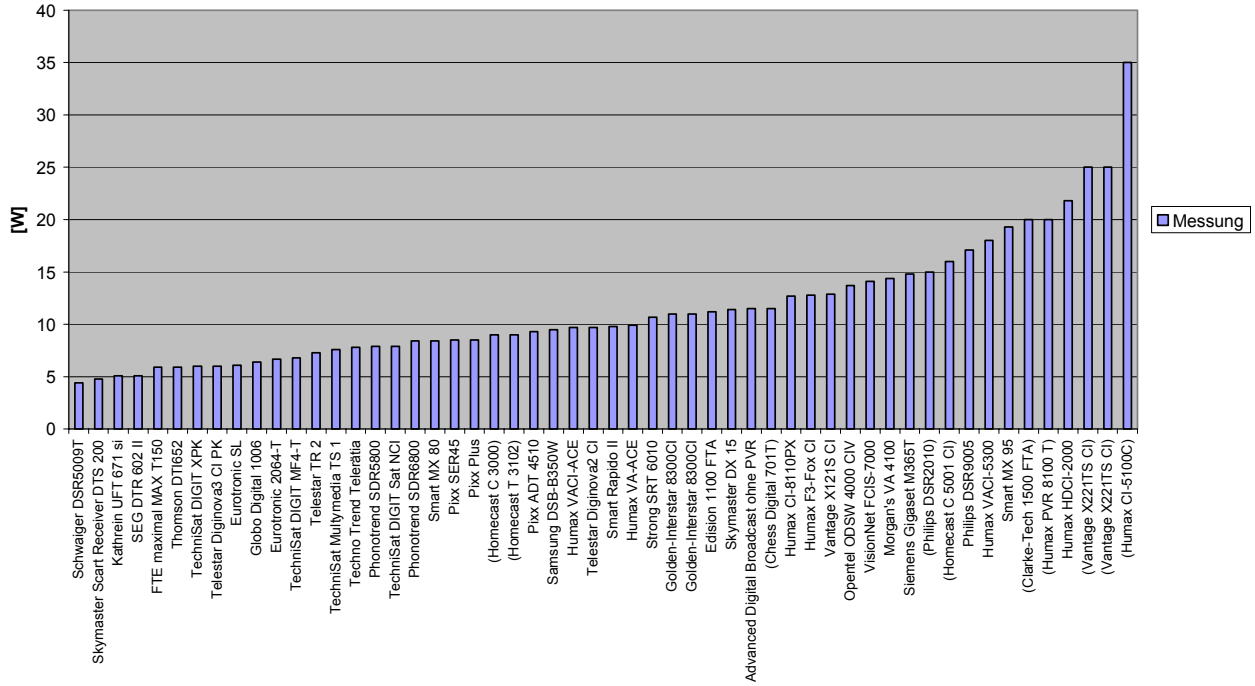
Settopboxen ohne Harddisk: Standby



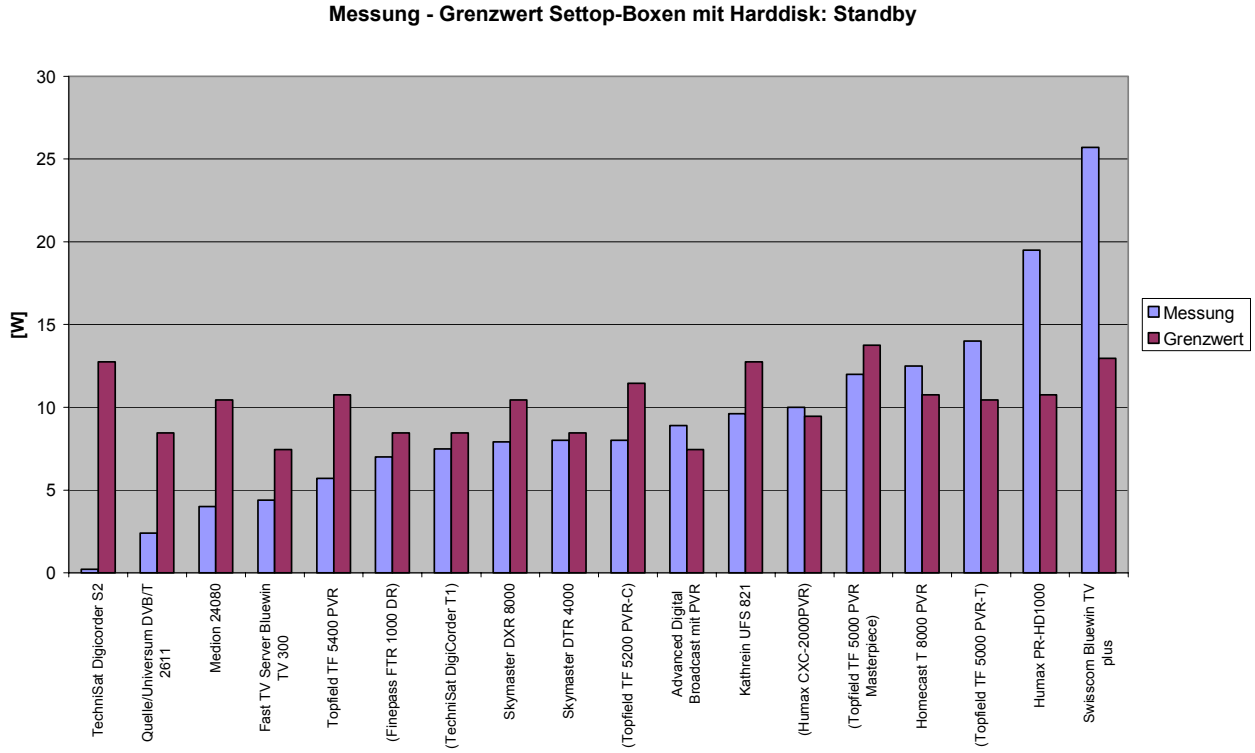
	P_V[W]	P_V[W]
Maximum	14.6	10.25
Mean level	7	7.70
Minimum	1	4.25

In the case of providers who specify the set-top box to be used, high consumption levels have a very negative impact. Here the user is forced to use the specified device.

Settop-Boxen ohne Harddisk: On Mode



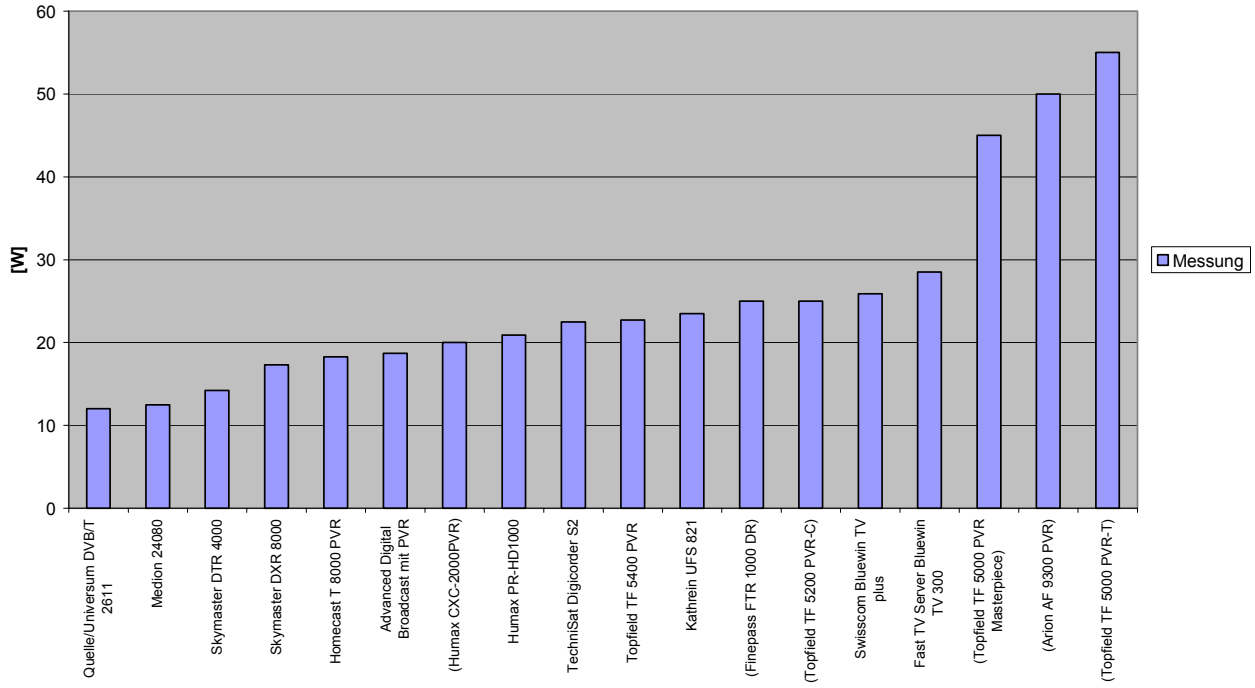
	P_V[W]
Maximum	35
Mean level	11.5
Minimum	4.4



	P_V[W]	P_V[W]
Maximum	25.7	13.75
Mean level	9.3	10.30
Minimum	0.2	7.45

In comparison with set-top boxes without a hard disk, energy consumption in standby is around 2.3 W higher on average.

Messung Settop-Boxen mit Harddisk: On Mode



	Measurement [W]
Maximum	55
Mean level	25.4
Minimum	12

With set-top boxes equipped with a hard disk, ON-mode levels are around 13.9 W higher in comparison with models without a hard disk.

7. Conclusions

In the case of DVB-S systems, in “standby passive” mode (e.g. Philips DSR9005) it would be beneficial if the LNB feed were also to be switched to inactive, since it is in any case not possible for the set-top box to process updates and other information. This would reduce consumption by approximately 2 watts (18 V, 120 mA).

In order to encourage the use of “standby passive” mode, updates should be processed in the background during normal operation (ON mode). Similarly, downloads (electronic programme guide, firmware) should take place in the background during normal operation in ON mode in order to avoid start-up delays.

In standby mode the hard disk should switch itself off.

‘‘Standby passive” mode was only available in one of the tested devices. The accompanying instructions were complicated and this function is therefore unlikely to be widely used. There is little point in including a clear requirement for this function in the Code of Conduct unless the operating mode in question is actually integrated into the available devices. For this reason, manufacturers should be required to integrate "standby passive" mode into their products. This could be accomplished by adding the following two recommendations to the Code of Conduct: 1) Standby passive mode should be integrated into all devices, and 2) the criteria (automatic or manual) governing switching between “standby active” and “standby passive” modes should be clearly defined.

8 Sources

8.1 Publications

- ***European Commission, Joint Research Centre***, Code of Conduct on Energy Efficiency of Digital TV Service Systems Version 4, October 2006
- ***European Commission, Joint Research Centre***, Code of Conduct on Energy Consumption of Broadband Equipment, July 2006
- ***Research programmes:*** www.electricity-research.ch Downloads of abstracts of detailed reports on research activities (Publications" section). Downloads of publications of the programme head.
- ***Grundlagen zur Energieeffizienz von Set-Top Boxen*** **(Principles for the energy afficiency of ste-top boxes)** Final report dated June 2004, SwissEnergy.
- ***Stiftung Warentest*** "Test", issue no. 11/2006.
- ***Stiftung Warentest*** "Test", issue no. 3/07.

8.2 Internet

- http://www.ecotelevision.org

  This site provides information on the preparatory studies for ecodesign of EuP products, lot 5 i.e. for consumer electronics: TV
- http://www.ecostandby.org

  This site provides information on the preparatory studies for ecodesign of EuP products, lot 6 i.e. for standby and off-mode losses of EuPs
- http://de.wikipedia.org/wiki/IPTV

  Definition of IPTV (Internet Protocol Television)
- http://www.iptvtoday.de/blog/iptv-grundlagen/

  Principles of IPTV
- http://www.microsoft.com/tv/IPTVEdition.mspx

  Information from Microsoft about IPTV
- http://www1.digitalfernsehen.de/katalog/stb.php

  Database with 649 set-top boxes
- www.toppreise.ch

  Overview of the market: Photo/TV → Video → Analogue / digital receivers
- www.ecoman.org

  Sensor switching: separating devices from the power supply in standby mode (ECOMAN Multi)
- www.swisscable.ch

  Swisscable, association of communications networks

9. Appendix

9.1 Photos of measurement infrastructure

Photo 1: Measurements on the premises of MediaMarkt in Chur (DVB-S and DVB-T set-top boxes)

Photo 2: Measurements in Swisscom Shop in Chur, set-top boxes for Bluewin TV300 (bottom) and Bluewin TVplus (top)

Photo 3: Measurements in the laboratory with Philips DSR9005 (DVB-S) set-top box

Photo 4: Measurements in laboratory with TeleRätia/Swisscom Broadcast (DVB-T) set-top.box

9.2 Data tables for set-top boxes

					Declara-tion	Measure-ment	Threshold	Decl.	Mess.	
Manufacturer	**Type**	**DVB technology**	**Hard disk**	**Comments**	**Stand-by mode P_v[W]**	**Stand-by mode P_v[W]**	**Stand-by mode P_v[W]**	**On [W]**	**On [W]**	
Advanced Digital Broadcast	without PVR	Cable	no	Cablecom	10	10.4	7.25	15	11.5	
Advanced Digital Broadcast	with PVR	Cable	yes	Cablecom	10	8.9	7.45	30	18.7	
Swisscom	Bluewin TV plus	IPTV	yes	Swisscom		15.4	12.95		15.6	
Fast TV Server	Bluewin TV 300	Cable	yes	Requires additional telephone connection		4.4	7.45		28.5	
Techno Trend	Telerätia	Terrestrial	no	Telerätia /Swisscom Broadcast		7.7	4.25		7.8	
Arion	AF 9300 PVR	Satellite	yes				12.75	50		
Arion	AF-9400 PV2R	Satellite	yes	for 2 TVs			12.75			
Chess	Digital 701T	Terrestrial	no				6.25	11.5		
Clarke-Tech	1500 FTA	Satellite	no		8		8.25	20		
Clarke-Tech	1500 PLUS	Satellite	no				6.25			
Coship	CDVBT 1300 A	Terrestrial	no				6.25			
Dreambox	500 C	Cable	no				9.65			
Dreambox	500 T	Terrestrial	no				8.65			
Edision	1100 FTA	Satellite	no			9.3	8.25		11.2	(1)
Eurotronic	2064-T	Terrestrial	no			6.1	6.25		6.7	(2)
Eurotronic	SL	Satellite	no			5.1	8.25		6.1	(2)
Finepass	FTR 1000 DR	Terrestrial	yes		7		8.45	25		

FTE maximal	MAX T150	Terrestrial	no			5.3	6.25		5.9	
Globo	Digital 1006	Satellite	no	Test 11/06		1.7	8.25		6.4	
Golden-Interstar	8300CI	Terrestrial	no	DVB T and S		5.3	6.25		5.9	(3)
Golden-Interstar	8300CI	Satellite	no	DVB T and S		9.5	8.25		11	(3)
Homecast	C 3000	Cable	no		8		7.25	9		
Homecast	C 5001 CI	Cable	no		10		7.25	16		
Homecast	T 3102	Terrestrial	no		8		8.25	9		
Homecast	T 8000 PVR	Terrestrial	yes	Test 03/07	13	12.5	10.75	24	18.3	

2

					Declara-tion	**Measure-ment**	**Threshold**	**Decl.**	**Meas.**	
Manufacturer	**Type**	**DVB technology**	**Hard disk**	**Comments**	**Stand-by mode P_v[W]**	**Stand-by mode P_v[W]**	**Stand-by mode P_v[W]**	**On [W]**	**On [W]**	
Humax	F3-Fox CI	Satellite	no	Test 11/06	9	5	8.25		12.8	
Humax	PR-HD1000	Satellite	yes	HDMI		19.5	12.75	45	20.9	
Humax	PVR 8100 T	Satellite	no		8.5		6.25	20		
Humax	HDCI-2000	Satellite	no	HDTV		13.8	10.55	45	21.8	(1)
Humax	VACI-ACE	Satellite	no		7.5	5.9	8.25	16	9.7	
Humax	VA-ACE	Satellite	no		7.5	5.5	8.25	16	9.9	
Humax	CI-5100C	Cable	no		11		7.25	35		
Humax	CI-8110PX	Satellite	no			7.2	8.25		12.7	
Humax	CXC-2000PVR	Cable	yes		10		9.45	20		
Humax	VACI-5300	Satellite	no		11	7	8.25	32	18	

Kathrein	UFS 821	Satellite	yes	Test 11/06	10	9.6	12.75	35	23.5	
Kathrein	UFT 671 si	Terrestrial	no	Test 03/07	5	4.6	6.25	10	5.1	
Medion	24080	Satellite	yes	Test 11/06		4	10.45		12.5	
Morgan's	VA 4100	Satellite	no			12.8	8.25		14.4	(2)
Opentel	ODSW 4000 CIV	Satellite	no			13.3	8.25		13.7	(1)
Philips	DSR2010	Satellite	no		6		8.25	15		
Philips	DSR9005	Satellite	no	HDMI	19	16.2	10.55	20	17.1	
Phonotrend	SDR5800	Satellite	no			6.1	8.25		7.9	
Phonotrend	SDR6800	Satellite	no			7.5	8.25		8.4	
Pixx	ADT 4510	Satellite	no			5.6	8.25		9.3	(3)
Pixx	SER45	Satellite	no			5.7	8.25		8.5	
Pixx	Plus	Satellite	no			8.2	8.25		8.5	
Quelle/Universum	DVB/T 2611	Terrestrial	yes	Test 03/07		2.4	8.45		12	
Samsung	DSB-B350W	Satellite	no			8.7	8.25		9.5	(2)
Schwaiger	DSR5009T	Terrestrial	no	Test 03/07		3.4	6.25	12	4.4	
SEG	DTR 602 II	Terrestrial	no	Test 03/07		4	6.25		5.1	
Siemens	Gigaset M365T	Terrestrial	no	Test 03/07		13.8	8.25		14.8	
Skymaster	DTR 4000	Terrestrial	yes	Test 03/07		8	8.45	25	14.2	
Skymaster	DX 15	Satellite	no	Test 11/06		5.9	8.25		11.4	
Skymaster	DXR 8000	Satellite	yes	Test 11/06		7.9	10.45	25	17.3	
Skymaster	Scart Receiver DTS 200	Terrestrial	no	Test 03/07		4.2	6.25		4.8	

3

					Declara-tion	Measure-ment	Threshold	Decl.	Meas.	
Manufacturer	**Type**	**DVB technology**	**Hard disk**	**Comments**	**Stand-by mode P_V[W]**	**Stand-by mode P_V[W]**	**Stand-by mode P_V[W]**	**On [W]**	**On [W]**	
Smart	MX 80	Cable	no	Not for CableCom		8.3	7.25		8.4	(2)
Smart	MX 95	Satellite	no	HDTV		7.9	10.75		19.3	(2)
Smart	Rapido II	Satellite	no			6.1	8.25		9.8	(2)
Strong	SRT 6010	Satellite	no	Test 11/06	8	6.4	8.25	25	10.7	
TechniSat	DIGIT MF4-T	Terrestrial	no	Test 03/07	3	2.3	6.25	7	6.8	
TechniSat	DIGIT K1	Cable	no		4		7.25			
TechniSat	DIGIT XPK	Cable	no		3	2.5	7.25	11	6	
TechniSat	DIGIT Sat NCI	Satellite	no		3.4	3.7	8.25	18	7.9	
TechniSat	DigiPal 2	Terrestrial	no		3		6.25			
TechniSat	DigiCorder T1	Terrestrial	yes		7.5		8.45			
TechniSat	Digicorder S2	Satellite	yes		1	0.2	12.75	50	22.5	
TechniSat	Multymedia TS 1	Satellite	no	DVB T and S/Test 11/06	3.2	1.7	10.25	15.5	7.6	
Telestar	Diginova2 CI	Satellite	no	Various models	6	6.1	8.25	21	9.7	
Telestar	Diginova3 CI PK	Cable	no	Test 11/06		4.5	7.25		6	
Telestar	TR 2	Cable	no	Test 03/07		6.2	7.25		7.3	
Thomson	DTI652	Cable	no	Test 03/07		3.8	7.25	8.5	5.9	
Topfield	TF 5000 PVR-T	Terrestrial	yes		14		10.45	55		
Topfield	TF 5200 PVR-C	Cable	yes		8		11.45	25		

Topfield	TF 5000 PVR Masterpi.	Satellite	yes		12		13.75	45		
Topfield	TF 5400 PVR	Terrestrial	yes	DVB T and S/Test 03/07		5.7	10.75		22.7	
Vantage	X121S CI	Satellite	no			10.1	8.25	25	12.9	(1)
Vantage	X221TS CI	Satellite	no				8.25	25		(1)
Vantage	X221TS CI	Terrestrial	no				6.25	25		(1)
VisionNet	FCIS-7000	Satellite	no			13	8.25	30	14.1	(1)

(1) = no (further) consumption data in manual
(2) = no data sheets/instructions online
(3) = no details in flyer, manual download not possible

Translation of figures and tables in the English version of the report

Page 9:

Components of a set-top box

Digital input signal

Demodulator
Smartcard reader
Digital interface

Demultiplexer
MPEG 2 decoder
CA module (decoding)
Descrambler
Programmable interface
Modem (interactivity)
SCART interface
Analogue signal
TV set
Set-top box

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		Subscribers
Satellite	Primarily Astra1 and HotBird	156,000
Cable	Various network operators	141,500
Cable	Cablecom (encoded)	135,800
Terrestrial	Telerätia, Valaiscom, etc, (encoded)	30,000
IPTV	Swisscom Bluewin TVplus	486,000

Market share (%)

Sources

Television 2006 International Key Facts
2006 annual report, DVB-C total 280,000 users
Cablecom reports fourth quarter 2006 results
Information material, Fact 1.7., contact Mr Steg (SRG SSR)
Media release dated 10 January 2007

Distribution in Switzerland
(market shares in %, status: December 2006)

Satellite	Primarily Astra1 and HotBird
Cable	Various network operators
Cable	Cablecom (encoded)
Terrestrial	Telerätia, Valaiscom, etc, (encoded)
IPTV	Swisscom Bluewin TVplus

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Declarations by providers: standby mode

Declaration
Threshold

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TV set

Antenna

AV SCART

Digital receiver
TV SCART
VCR SCART

Antenna
out in

AV SCART
Antenna
in out

Video / DVD

Cable TV connection

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Measurements in standby mode

Level

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Measurements in ON mode

Level

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Declaration versus measured level: “standby active” mode

Declaration
Measured level

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Declaration versus measured level: ON mode

Declaration
Measured level

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Measured level versus threshold: standby mode

Measured level
Threshold

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Measurement (declaration): ON mode

Measured level

Cablecom / Swisscom: standby in watts

Measured level
Threshold

Cablecom without PVR	Cablecom with PVR	Swisscom Bluewin TV plus	Swisscom Bluewin TV 300

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Satellite receivers: standby mode

Measured level
Threshold

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Terrestrial receivers: standby mode

Measured level
Threshold

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Set-top boxes without a hard disk: standby mode

Measured level
Threshold

Set-top boxes without a hard disk: ON mode

Measured level

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Set-top boxes with a hard disk: measured level versus threshold (standby mode)

Measured level
Threshold

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Measured levels of set-top boxes with a hard disk: ON mode

Measured level