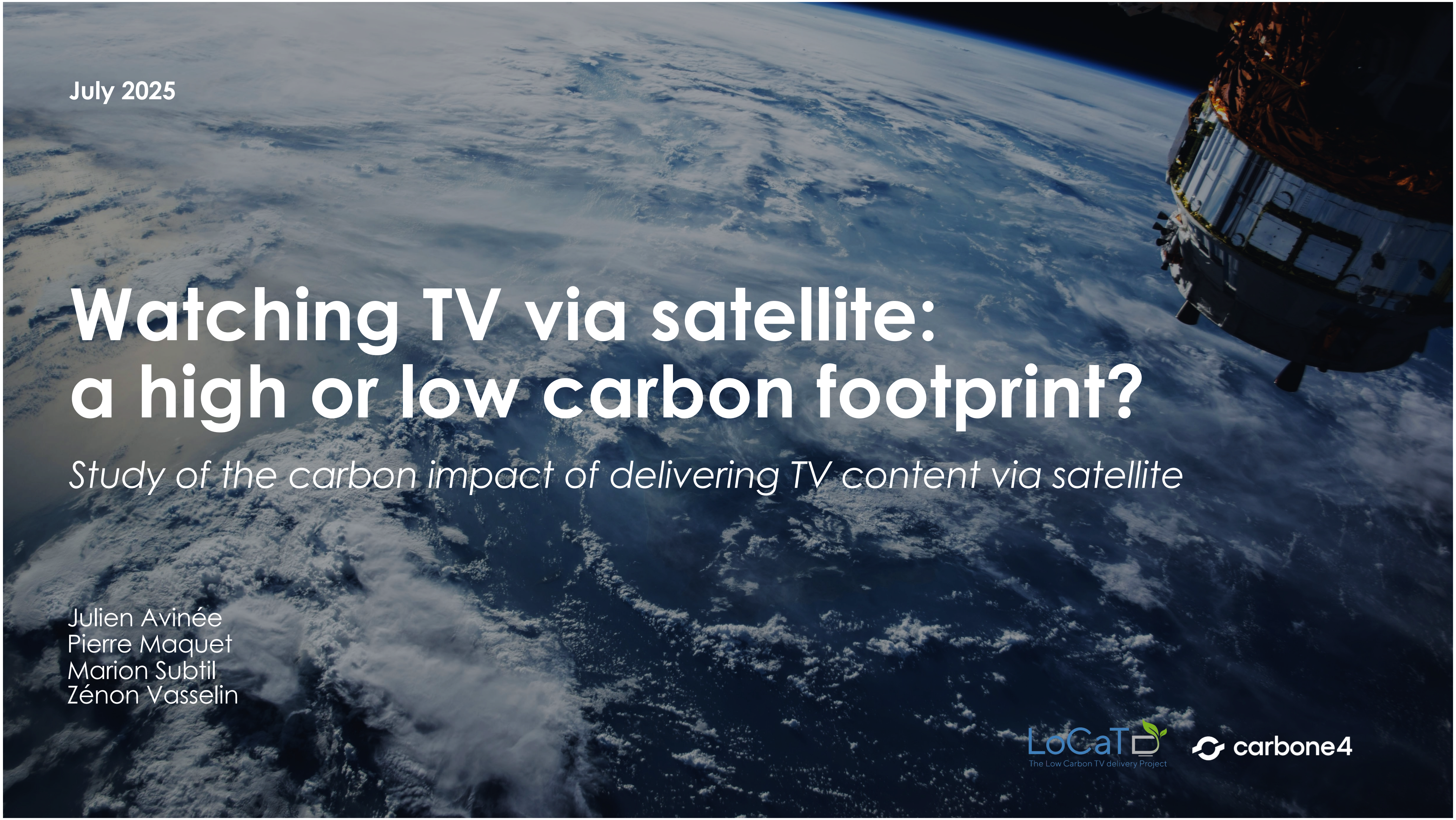

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Watching TV via satellite: a high or low carbon footprint?

Study of the carbon impact of delivering TV content via satellite

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LoCaT
The Low Carbon TV delivery Project

carbone4

Executive summary

The *LoCaT-Sat* study is an extension of the LoCaT original study completed in 2021 ("LoCaT-Original"[1]) launched to assess the energy consumption and carbon footprint of TV content delivery, for one hour of viewing. Following the initial study, which encompassed DTT[2], OTT[3], and IPTV[4] distribution, this new phase aims to analyze the carbon impact of satellite TV delivery, known as DTH[5], using the same scope, assumptions, and scenarios to ensure comparable results.

The study includes the entire DTH transmission chain: from uplink sites, to satellites, and finally consumers' in-home reception equipment (excluding the TV set itself). As with the LoCaT original study, this analysis focuses specifically on the energy consumption during the use phase, excluding energy consumption and emissions related to the manufacturing and end-of-life of infrastructure. It is worth noting that satellite launch energy consumption is included in this study.

The results indicate that DTH, in spite of the high energy consumption during the launch, has a low emission intensity per viewer hour, in the same order of magnitude when compared to DTT and significantly lower than IPTV or OTT. It is worth underlining that most greenhouse gas emissions are associated with the energy consumption of home reception equipment, including antennas, set-top boxes and amplifiers. Although comparing TV delivery modes is relevant, it should be noted that DTH infrastructure generally complements terrestrial networks already widely deployed to support a range of digital services.

This report outlines the results of the study, as well as the approach taken to model DTH delivery.

[1] https://thelocatproject.org/
[2] DTT: Digital Terrestrial Television (transmission of television content using ground-based transmitters and received via a standard UHF antenna)
[3] OTT: Over-The-Top (delivery of video and audio content over the Internet)
[4] Internet Protocol Television (delivery of television content over managed IP networks)
[5] DTH: Direct-To-Home (satellite television distribution method that delivers broadcast content directly from the satellite to the viewer's home, bypassing terrestrial networks)

About LoCaT-Sat Study

The LoCaT-Sat study has been conducted a collaborative project under the LoCaT umbrella, coordinated by BMV Consulting on behalf of a consortium of leading European TV stakeholders. With its recognized expertise in carbon assessment and sustainable strategy, Carbone 4 was commissioned to support BMV Consulting and the consortium in conducting this study, ensuring a robust, data-driven approach to quantify the environmental performance of DTH distribution. The Project Sponsors are:

- **Eutelsat Group**: the world's first GEO-LEO satellite operator
- **Intelsat, now part of SES**: a global network operator
- **Hispasat**: a Spain based satellite operator and service provider, leader in content distribution across Spanish and Portuguese speaking countries
- **Inverto**: a Luxembourg based developer and marketeer of broadcast reception equipment, video streaming solutions and end-to-end content delivery platforms based on DVB-NIP
- **ST Engineering iDirect**: a subsidiary of ST Engineering and a global leader in satellite communications (satcom) providing technology and solutions that enable its customers to expand their business, differentiate their services and optimize their satcom networks
- **Tivù**: an Italia based DTH platform provider

The Project Sponsors contributed both primary and secondary data for the analysis and facilitated interviews with experts from their organisations to fill gaps in knowledge.

Sponsor inputs were validated by Carbone 4, who also sourced data independently where there were gaps in data available from Sponsors. Assistance to the Sponsors for project initial set up and during the execution phase was provided by Blue Maple Ventures (BMV).

About Carbone 4

Carbone 4 is the first independent consultancy specialised in low carbon strategy and adaptation to climate change. Constantly on the lookout for low amplitude signals, we deploy a systemic view of the energy climate issue and put all our rigour and creativity to work to transform our clients into leaders in the climate challenge.

This report was authored by Julien Avinée, Marion Subtil and Zénon Vasselin.

Content

1. Introduction

1.1 Study objectives

The aim of this study is to quantify the energy consumption and carbon footprint associated with one hour of DTH viewing, and to compare these results with those of other distribution methods, as estimated in the original LoCaT study from 2021(“LoCaT-O”).

1.2 Previous studies

LoCaT-Sat is an incremental extension of the original LoCaT study from 2021 (“LoCaT-O”)[1]. To ensure the comparability of results, this extension retains the same assumptions, methodology, and scope as used in the original LoCaT study, without reassessment or modification.

[1] https://thelocatproject.org/

2. General approach

2.1 Methodology

To estimate the energy consumption and greenhouse gas (GHG) emissions associated with the DTH delivery method, the same approach as in the LoCaT original study was used:

1. Developing a detailed system map of the DTH[1] delivery method considered in the study, to identify the components that consume energy during the use phase.
2. Collecting data from sponsors on system variables and parameters that govern each component of the system, to conduct quantitative modeling.
3. Using viewership data to determine the overall emissions per device hour of DTH[1] TV content.
4. Using this model to explore and compare the energy consumption and carbon impacts under different conditions based on a set of plausible scenarios. These scenarios (A, B, C and D) are those of the LoCaT original study and are based on various model parameters (e.g., viewership, delivery method penetration).

2.2 Functional unit

To compare the GHG emissions associated with DTH[1] delivery with the other delivery methods from LoCaT original study, a common unit is required. Hence, in LoCaT studies, GHG emissions are measured based on one device hour of television viewing.

This is aligned with the functional unit used in other studies and media publications, such as the BBC White Paper, Netflix's public disclosures on streaming emissions, and various other studies estimating the emissions of TV content.

For the scenario analysis, this functional unit is supplemented with estimates of total annual energy consumption and GHG emissions per country.

[1] DTH: Direct-To-Home (satellite television distribution method that delivers broadcast content directly from the satellite to the viewer's home, bypassing terrestrial networks)

2.3 Data sources

The DTH distribution chain is structured into three segments: uplink sites, satellites, and in-home equipment. Carbon footprint calculations draw on two main data sources: confidential LCA[1] reports for the satellite segment, and actual energy consumption data for uplink sites and in-home equipment, provided directly by the LoCaT-Sat project sponsors. These sponsors also supplied detailed information on the number and capacity of DTH channels (SD[2], HD[3], UHD[4], etc.).

To assess the impact of DTH services in North and Latin America, which were not covered by the original LoCaT study, complementary external data sources were used. These include:

- Electricity emission factors and decarbonization pathways from the IEA's 2020 *Stated Policies Scenario*;
- Average household size from Pew Research Center;
- Average daily TV viewing time per person in North America from RTL Ad Alliance;
- TV ownership rates from Nielsen's *National Television Penetration Trends for* North America and the *OECD Telecommunication and Broadcasting Review of Brazil 2020* for Latin America;
- DTH household estimates from S&P Global for Latin America;
- The proportion of individual households derived from national census data of key Latin American countries.

All other assumptions and inputs were taken from LoCaT original study. Only aggregated results are published.

[1] Life Cycle Assessment
[2] SD: Standard Definition
[3] HD: High Definition
[4] UHD: Ultra High Definition

2.4 Study boundaries and limitations

2.4.1 Geographical

This study focused on European countries, North America and Latin America. Data from regional studies were used, supplemented by detailed national data where available. Countries for which extensive data could be gathered, either through Project Sponsors or public sources, included: France, Germany, Italy, Spain and the United Kingdom.

The countries chosen also vary in terms of prevalent delivery methods, geographical region and size, population, and viewership behavior. As such, they provide a sound subset to confirm that the modelling was applicable for different scenarios. By convention, we designate by EU28 the European Union (27 countries) and the UK. North America includes Canada and the United States of America. Latin America includes Mexico and the countries of Central America, South America and the Caribbean.

2.3.2 Scope of the study

The energy and carbon impacts of transport from the play-out to satellite uplink sites, also known as backhaul or contribution, were not included for comparison purposes. This phase is common to all TV delivery methods and is not specific to DTH. Including it would have led to an overestimation of emissions attributed to DTH delivery compared to other distribution methods. Its greenhouse gas (GHG) assessment, which was also excluded from the LoCaT original study for the same reason, remains an area for potential improvement in future research.

While the satellite launch phase is included via LCAs-based estimates, other potential impacts of launches (such as high-altitude emissions) are not included due to the current lack of scientific understanding, which likely leads to an underestimation of the total climate impact.[1].

Furthermore, the analysis excludes GHG emissions from manufacturing and end-of-life processes for all infrastructure and devices, focusing only on use-phase emissions.

These scope choices align with LoCaT original study and ensure consistent system boundaries across all TV distribution methods. However, they also imply that the carbon footprints and energy consumptions reported here apply to a specific scope and should be interpreted with that context in mind.

Finaly, while comparing TV delivery methods is relevant, they often overlap, each adding infrastructures and energy consumption to the overall TV delivery system. No method should be seen as a standalone alternative, as growing complexity and redundancy between methods may jeopardize global TV delivery decarbonization efforts. For instance, since most users already rely on the Internet (used for OTT and IPTV) for a wide range of digital services, future decisions on TV delivery should consider marginal use and threshold effect. Further research should develop a "target scenario" for 2035, describing what a sustainable, efficient and resilient TV system could be and setting out the transition pathways to achieve it.

2.4.3 GHG emissions data

As mentioned in the LoCaT original study, emission factors are a key variable in infrastructure modeling, as they largely explain differences across geographies due to national variations in electricity generation mixes.

To ensure consistency with the original analysis, LoCaT-Sat relies on the same

[1] Miraux, L. (2021). Environmental limits to the space sector's growth. Science of The Total Environment

emission factors - based on 2020 data - and applies the same electricity mix decarbonization pathways. It is therefore an incremental extension of LoCaT-Original, without reassessing or modifying its assumptions, methodology, calculations, nor results.

Only the decarbonization of national electricity mixes have been considered, as it represents a significant and well-documented factor. No decarbonization trajectory have been considered for launcher-related energy consumption, which remains a limitation of this analysis.

2.4.4 Scenario framework

This study is built on the four scenarios developed in the LoCaT original study (A, B, C and D) to ensure consistency and comparability. These scenarios were designed to isolate the impact of changes in TV delivery method penetration, while keeping other variables constant across scenarios.

Key scenario parameters include population growth, electricity decarbonization, TV viewing trends, delivery method shares[1] (DTH, DTT, IPTV, OTT), and technological developments in distribution networks. Full details of the scenario assumptions are in the LoCaT report.

The total capacities required for DTH delivery in Europe, North America and Latin America (in Mbps) were estimated based on the number of channels and their respective formats (SD, HD, UHD). No changes were assumed in the number of channels or their formats over time. This static capacity assumption is a simplification that ignores potential evolution in broadcasting demand or technology (e.g., future growth in channel count or shifts toward higher-bitrate formats). It ensures a controlled comparison over time but may underestimate future capacity-related emissions if content offerings expand or video quality increases.

Under a hypothetical assumption in which all satellite channels are broadcast in UHD (stress test) the carbon impact results for DTH in Europe would be increased by approximately 0.6% in 2020, 0.7% in 2025, 0.7% in 2030 and 0,8% in 2035 per viewing hour.

The increase is minor and driven by higher energy consumption of uplink sites and satellites: UHD channels require more data, which in turn demand more energy for uplink. Meanwhile, the energy consumption of in-home equipment remains unchanged as quality improves, explaining why the overall trend does not result in a significant increase in total energy use and emissions.

Likewise, aside from the projected decarbonization of national electricity grids, the scenario does not factor in additional efficiency gains or decarbonization measures for satellite technology and launch operations. This conservative stance (i.e., assuming no improvement in satellite energy efficiency or cleaner launch processes) likely overstates long-term satellite emissions if such innovations occur, but it provides a consistent baseline for comparison.

Regarding in-home equipment, the study assumes a continued decline in the use of set-top boxes, with their share dropping from 71% in 2020 (market data) to 29% by 2035, while embedded decoders are expected to rise from 29% to 71% over the same period. This reversal in usage trends is based on several key market dynamics : all new TVs now include embedded decoders, allowing viewers to access content without the need for external set-top box (market data form TV manufacturers). Free-to-air providers, representing roughly 50% of

[1] The evolution of TV viewing by delivery methods in scenarios A, B, C and D is described in the appendix.

the market, are expected to transition entirely to embedded decoders by 2035, as they do not require strict operator control. Pay TV operators, accounting for the other 50%, are more conservative due their preference for maintaining control via external devices; nonetheless, around 50% of them are expected to adopt embedded decoders by 2035. The energy consumption of these integrated TVs falls outside the scope of this study.

In Latin and North America, the adoption of embedded decoders follows a different trajectory, reflecting distinct market trends confirmed by expert input. The share of embedded decoders in these regions is assumed to grow from 0% in 2020 to 30% in Latin America and 50% in North America by 2035, respectively. These differences are due to different operator strategies and consumer behavior across the regions.

3 Description of DTH distribution

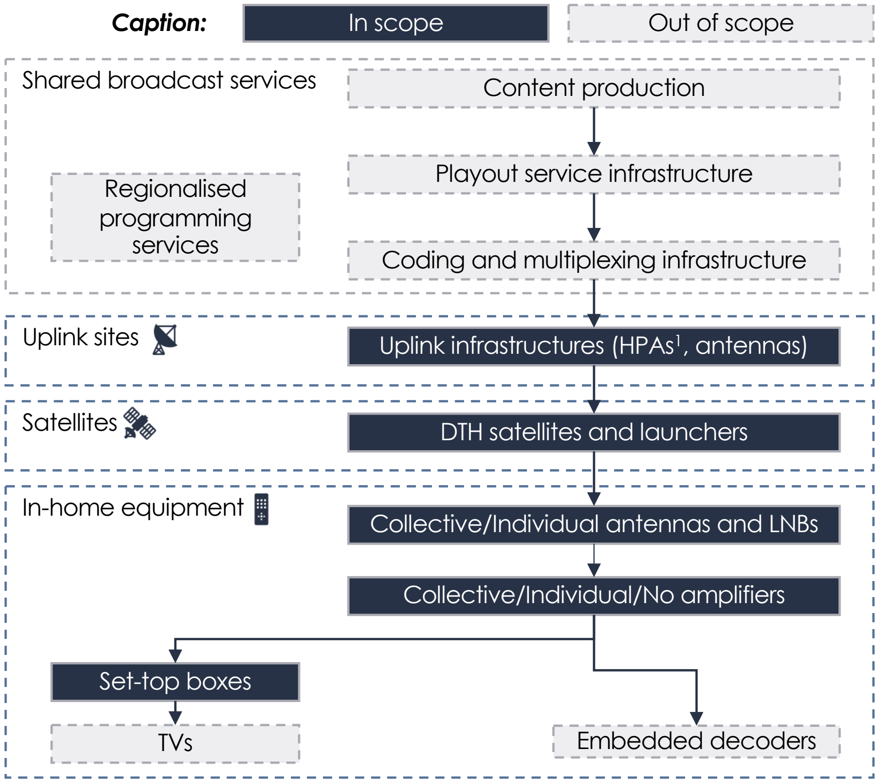

Figure B - satellite television reference architecture model

[1] HPA: High Power Amplifier

3.1 Uplink sites

Television channels are first aggregated, encoded, and modulated at uplink facilities, also known as teleports. These sites transmit the broadcast signal via powerful antennas to geostationary satellites orbiting at approximately 36,000 kilometers above Earth. High Power Amplifiers (HPAs) are used to ensure the signal strength is sufficient for satellite reception. Each teleport can manage multiple channels and transponders simultaneously (transponders being the satellite components that receive, amplify, and retransmit signals back to Earth on a specific frequency band). This stage involves significant energy consumption, primarily from RF[1] equipment and signal processing systems.

3.2 Satellites

Once received, the satellite retransmits the signal back to Earth over a wide geographical coverage area, known as the satellite footprint. Each satellite operates using multiple transponders, each assigned to a specific frequency band and signal. Geostationary satellites maintain a fixed position relative to the Earth's surface, enabling reception of the broadcasting signals with a fixed satellite dish. While energy consumption in orbit is relatively stable and autonomous - mainly generated through the solar panels on the satellite, the launch phase represents a notable portion of the satellite's carbon footprint, especially due to rocket propulsion systems.

[1] Radio Frequency (RF equipment includes all components that generate, transmit, receive, amplify, or convert radio-frequency signals in a DTH distribution system)

3.2 In-home equipment – reception by end users

At the household level, consumers receive the satellite signal via a satellite dish, equipped with a Low-Noise Block downconverter (LNB). The LNB captures the weak microwave signals transmitted by satellites, amplifies them, and downconverts them to a lower frequency band suitable for transmission through coaxial cables. These signals are then transmitted to a set-top box or directly to a TV with an embedded satellite decoder. This equipment demodulates and decodes the signal for display on a TV.

Electricity consumption is directly related to viewing time and the number of devices switched on. In multi-dwelling buildings, the use of shared DTH reception infrastructure (e.g., communal dishes, distribution amplifiers, centralized LNB arrays) can significantly influence the per-household energy consumption profile.

4 Calculation approach

4.1 Estimating viewership

For Europe, DTH viewing hours for 2020 were estimated using data from the European Audiovisual Observatory Yearbook 2020 (TV households and average daily viewing time per country) and Eurostat (average household size per country). The average viewing hours were multiplied by the number of TV households in each country. To convert these individual-based figures into device viewing hours, an adjustment was made to account for shared viewership within households. The multiple viewers per device assumption was based on the LoCaT original study methodology and aligned with the BBC White Paper approach: 1.0 viewer per device for one-person households, 1.5 viewers per device for two-person households, 2.0 viewers per device for households of three or more people. Average household size per country (from Eurostat) was used to apply the appropriate viewer-per-device ratio.

For North and Latin America, DTH viewing hours for 2020 were estimated using a consistent calculation approach. For North America: a population of 377.6 million (UN), 96% TV household penetration rate (Nielsen), average household size of 2.6 (Pew Research), and 2:40 hours of daily TV viewing per person (RTL Ad Alliance). For Latin America: a population of 646.7 million (UN), 94% TV household penetration (OECD), average household size of 4.6 (Pew Research), and 4:57 hours of daily viewing per person (calculated from confidential data).

Projections for 2020-2035 are based on LoCaT original study assumptions regarding the evolution of the number of TV households, the evolution of average viewing hours and the evolution of DTH market share according to the different scenarios (A, B, C, D). All underlying assumptions are recalled in the annex of the LoCaT original study.

4.2 Uplink sites

The estimation of GHG emissions associated with DTH uplink sites was based on a technical modeling of a representative teleport used for DTH. The methodology involved the following steps:

1. **Representative uplink teleport electricity consumption per transponder**
   The energy consumption model for uplink facilities was based on representative DTH broadcasting teleports in Europe and South America. Annual electricity consumption per transponder was calculated based on measured power data from HPAs and antenna allocation profiles, based on discussions with industry experts. Additional electricity consumption from ancillary systems (video processing, modulation, RF processing) was included to reflect the full operational requirements per transponder.
2. **Estimation of the total uplink electricity consumption**
   The total number of transponders used for DTH broadcasting in Europe, North America and Latin America was estimated based on the required transmission capacity in each region (in Mbps), enabling the extrapolation of total uplink electricity consumption per region.
3. **Distribution of the electricity consumption by country**
   Electricity use was distributed by country, assuming channels are uplinked from their country of origin (e.g. Sky UK channels from the UK).
4. **Emission calculation**
   Country-level GHG emissions were calculated using national electricity emission factors. It should be noted that this extrapolation approach assumes all uplink sites operate with similar efficiency and energy requirements as the representative teleport modeled.

5. **Normalization per viewing hour**
   Results were normalized by dividing total emissions by the number of TV viewing hours in each scenario.

4.3 Satellites

The emissions associated with geostationary satellites used for DTH broadcasting were estimated based on confidential life cycle assessments (LCAs) of satellite and launcher operations. The steps followed were:

1. **Emission-to-mass ratio derivation**
   An emission-per-mass ratio was derived for satellite operational energy consumption, based on confidential LCAs data.
2. **Application to one typical satellite**
   This ratio was applied to the launch mass of a representative DTH satellite to determine average operational emissions per satellite.
3. **European and American fleet scaling**
   The total number of satellites required to deliver DTH services in Europe, North America and Latin America was estimated based on total capacity needs (in Mbps), allowing regional-level aggregation of emissions. It should be noted that this extrapolation assumes all DTH satellites operate with similar transponder efficiency as the representative satellite modeled.
4. **Normalization per viewing hour**
   Total emissions were then normalized by the total number of TV viewing hours per scenario.

4.4 In-home equipment

This category covers the energy use of consumer equipment required to receive satellite television, such as set-top boxes, satellite decoders, and associated reception devices.

1. **Average power consumption by equipment type**
   Average annual electricity consumption per device type was estimated using representative consumption data. The following power were used: 3.6 W for set-top boxes, 0.8 W for individual amplifiers, 11 W for collective amplifiers, 5 W for collective LNBs, and 2 W for individual LNBs. Use-time assumptions were applied, assuming that 50% set-top boxes and individual LNBs are switched off when not used, while other equipment types are considered to run continuously. A share of the consumption of collective equipment has been allocated to DTT distribution and therefore excluded from the scope, proportionally to the DTT/SAT split and for half of the collective building equipment in Europe.
2. **Estimation of equipment stock in Europe, North America and Latin America**
   The number of active devices in Europe, North America, Latin America and selected countries (e.g., France, Germany, Spain) was estimated based on household data and DTH penetration rates.
3. **Annual electricity consumption per country**
   Annual electricity consumption for TV viewing via DTH was then calculated per country, by combining consumption per unit with national equipment stocks.
4. **Emission calculation**
   Emissions were assessed using country-specific electricity emission factors.

5. **Normalization per viewing hour**
   Total emissions were normalized per scenario by dividing by the number of DTH viewing hours.

Note: This methodological framework also included minor refinements compared to the original LoCaT study, notably the inclusion of signal repeaters where applicable.

A key modelling assumption concerns the sharing of reception infrastructure in multi-dwelling. In such cases, the energy consumption of equipment such as shared antennas, Low-Noise Block downconverters (LNBs), and centralized amplifiers can be distributed across multiple households watching DTH TV. In Europe, since nearly half of households live in multi-dwelling buildings, this parameter has a significant influence on overall results. This is less true in North and Latin America, where multi-dwelling buildings are estimated to represent only 10% and 20% of the housing stock, respectively.

However, the actual number of households using DTH within a given building, and thus sharing the same reception infrastructure, varies widely depending on the type of building and the country, and is difficult to estimate precisely. In this study, it is assumed that antennas and LNBs are shared on average by four households, reflecting the conservative assumption that not all residents in a multi-dwelling building access DTH.

In addition, the study assumes a continued decline in the use of set-top boxes in Europe, with their share dropping from 71% in 2020 (market data) to 29% by 2035, while embedded decoders are expected to rise from 29% to 71% over the same period (see 2.4.4.). In Latin and North America, the number of embedded decoders is assumed to grow from 0% in 2020 to 30% and 50%, respectively.

5 Results

5.1 Results for Europe

Overall emissions from DTH distribution are largely driven by in-home equipment

The emissions associated with the energy consumption of uplink sites and satellites (including launch) are ultimately relatively low when compared to the energy consumption of in-home reception equipment. This is primarily because DTH infrastructure emissions are amortized over a very large number of viewing hours.

In contrast, in-home equipment consumption is nearly directly proportional to viewing time. While some equipment, such as satellite antennas in multi-dwelling units, may be shared among several households, most in-home devices (e.g., set-top boxes or TVs) contribute linearly to energy use on a per-hour basis.

Uplink sites	0.03
Satellites	0.02
In-home equipment	4.65
Total	**4.70**

Table A - Carbon footprint of DTH for use-phase in Europe (2020 – gCO_2eq per device viewing hour) – excluding manufacturing and end-of-life of equipment

As a result, overall emissions from DTH distribution are largely driven by in-home equipment. Consequently, the results are highly sensitive to the underlying data and assumptions, particularly those related to household typologies.

In particular, the average number of households per residential building (e.g., single-family vs. multi-family housing) plays a significant role in shaping the final carbon footprint.

Watching TV via DTH is slightly more emissive than DTT in Europe

DTT is the most carbon-efficient TV delivery method across Europe, showing the lowest emissions per device viewing hour. DTH consistently ranks second, with slightly higher emissions than DTT but far lower than OTT and managed IPTV.

At the European level and considering that antennas and LNBs are shared on average by four households in multi-dwelling buildings, **DTH emits 4.7 gCO_2e per device hour**, compared to 3.3 gCO_2e for DTT, but five times less than OTT (26.2 gCO_2e) and nearly eight times less than managed IPTV (37.0 gCO_2e).

This ranking is maintained in France and the UK, confirming DTH's relatively low carbon footprint among TV delivery systems.

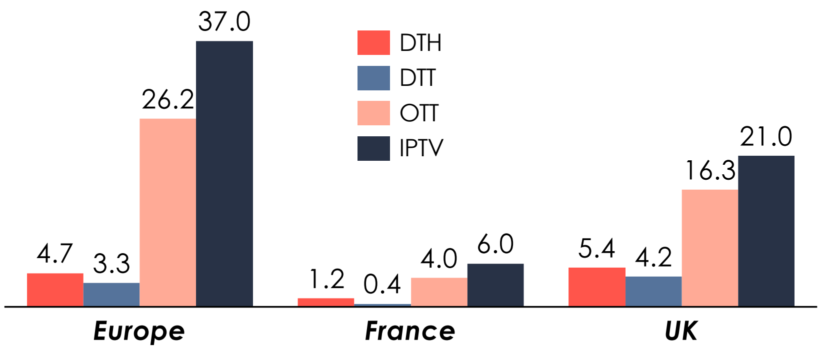

Figure B - Carbon footprint per delivery methods for use-phase (2020 – gCO_2eq per device viewing hour) - excluding manufacturing and end-of-life of equipment

The majority of electricity use in DTH delivery occurs at the end-user level

It's important to note a key limitation in the analysis: not all energy consumption sources are fully accounted for. Launch-related energy consumption, primarily from fuel combustion, is excluded from the electricity figures. Although LCA data enables an estimate of the GHG emissions linked to the launch phase, it does not provide a reliable measure of the associated energy use in kWh. As a result, this potentially significant component is omitted from the energy consumption totals presented here.

Focusing solely on electricity consumption during the use phase, the vast majority, 19.4 Wh out of a total 19.5 Wh per device viewing hour, is attributable to in-home equipment. Uplink site consumption is minimal (0.10 Wh), and satellites in orbit are considered to consume no grid electricity, as they are powered primarily by solar energy. Any additional operational energy needs managed from the ground are already included in the uplink site category.

This underscores that the energy impact of DTH, in terms of electricity use, is overwhelmingly concentrated in user-end equipment.

Uplink sites	0.10
Satellites	/
In-home equipment	19.41
Total	**19.51**

Table C – Electricity consumption of DTH in Europe (2020 – Wh per device viewing hour) – excluding TV sets

Electricity consumption per device viewing hour varies significantly between delivery methods and across countries. As shown, DTH remains among the most energy-efficient options, particularly when compared to OTT and IPTV.

Differences across countries (Europe, France, UK) can be explained by the number of DTH households in each country and the volume of uplink performed domestically, as uplink consumption is attributed to the country where the uplink is done.

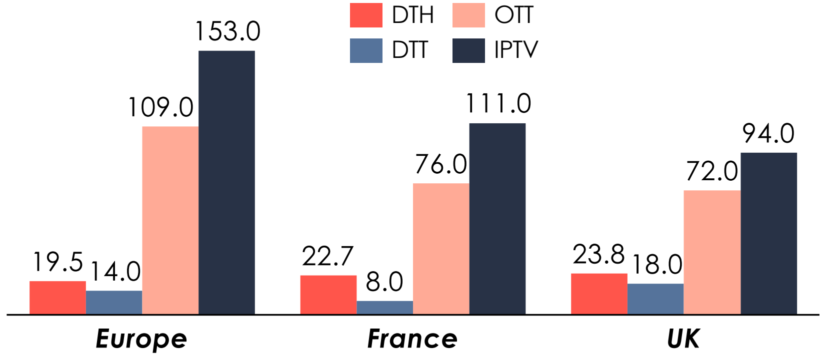

Figure D – Electricity consumption per delivery methods (2020 – Wh per device viewing hour) – excluding TV sets

Note: Differences in results between countries are mainly due to varying viewing habits, which affect how the energy consumption of reception equipment is spread over the number of viewing hours.

With Europe's electricity mix set to decarbonize, DTH transmission emissions are expected to drop sharply

The carbon footprint steadily declines between 2020 and 2035, primarily due to the projected decarbonization of electricity grids across Europe, with the gradual phase-out of set-top boxes providing a slight additional reduction. The trajectory of the electricity grid emission factor in Europe, used in LoCaT-O and defined by the European Environment Agency in 2019, is applied (0.24 $kgCO_2e$ /kWh in 2020 to 0.16 in 2025, 0.09 in 2030, and 0.06 $kgCO_2e$/kWh by 2035).

In Scenario D (Figure H), however, the carbon footprint per device viewing hour is slightly higher than in Scenarios A, B, and C (Figure G). This difference does not stem from electricity consumption, which remains relatively stable across all scenarios. Instead, it reflects a lower volume of DTH viewing hours in Scenario D, due to DTH's reduced share in the overall TV distribution mix.

As a result, fixed emissions from shared infrastructure, particularly satellites and uplink stations, are spread over fewer viewing hours, increasing the carbon intensity per device hour.

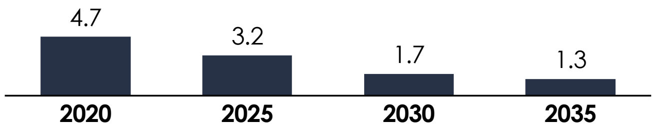

Figure E - Carbon footprint of DTH for use-phase in Europe in scenarios A, B, C (2020 to 2035 – gCO_2eq per device viewing hour)

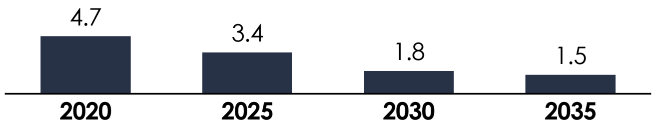

Figure F - Carbon footprint of DTH for use phase in Europe in scenario D(2020 to 2035 – gCO_2eq per device viewing hour)

The electricity consumption is not expected to change significantly

The electricity per device viewing hour slightly increases over time in scenarios A, B, C and D (Figures I and J). This is because the total electricity consumption of in-home equipment decreases less than the total number of device viewing hours.

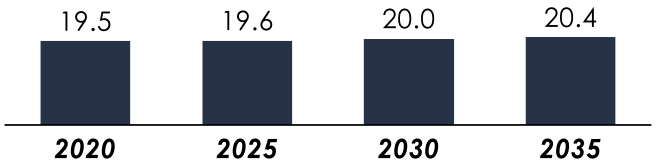

Figure G – Electricity consumption of DTH in Europe in scenarios A, B, C (2020 to 2035 – Wh per device viewing hour)

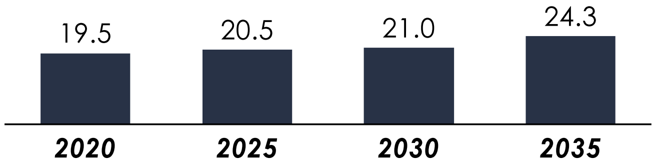

Figure H - Electricity consumption of DTH in Europe in scenario D (2020 to 2035 – Wh per device viewing hour)

5.2 Results for North America and Latin America

Compared to Europe, DTH use-phase emissions are higher in North America and are expected to remain so, while they are currently lower in Latin America - but this situation is likely to reverse over time.

Emissions during the use phase of DTH services are currently higher in North America than in Europe. This is largely driven by a more carbon-intensive electricity mix in the U.S., coupled with lower amortization of energy consumption per hour of viewing. This trend is expected to remain consistent across all future scenarios.

Conversely, Latin America currently shows lower emissions and electricity consumption during DTH use, thanks to better amortization per viewing hour. This is despite a higher carbon intensity in the electricity mix and a lower share of embedded decoders (0% in the Latin America vs. 29% in Europe). Looking ahead, this trend is likely to reverse by 2035, Europe is expected to significantly reduce electricity consumption per hour of DTH viewing, driven in part by a growing share of embedded decoders (71% in Europe, 30% in Latin America).

	Europe	North America	Latin America
Uplink sites	0.03	0.21	0.01
Satellites	0.02	0.09	0.03
In-home equipment	4.65	7.69	4.22
Total	**4.70**	**7.99**	**4.25**

Table I – Carbon footprint of DTH for use-phase by region (2020 – gCO_2eq per device viewing hour) – excluding manufacturing and end-of-life of equipment

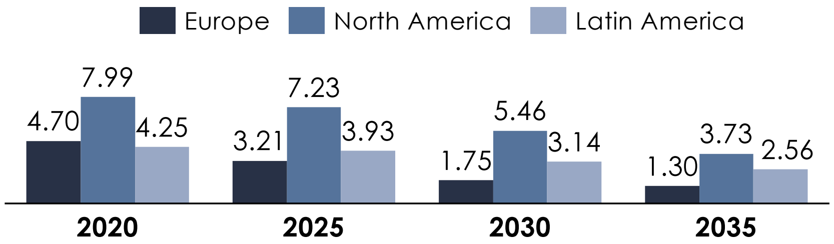

Figure J - Carbon footprint of DTH for use-phase by region in scenarios A, B, C (2020 to 2035 – gCO_2eq per device viewing hour)

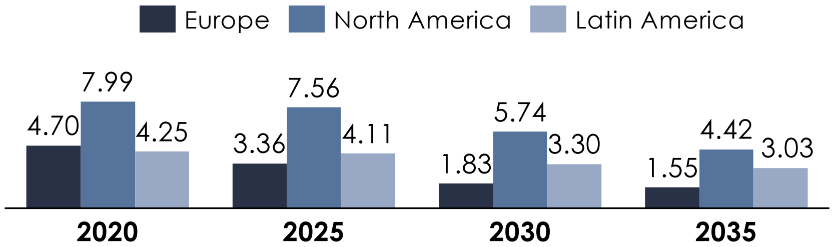

Figure K - Carbon footprint of DTH for use phase by region in scenario D(2020 to 2035 – gCO_2eq per device viewing hour)

	Europe	North America	Latin America
Uplink sites	0.10	0.55	0.01
Satellites	/	/	/
In-home equipment	19.41	18.59	10.50
Total	**19.51**	**19.14**	**10.51**

Table L – Electricity consumption of DTH for use-phase by region (2020 – gCO_2eq per device viewing hour) – excluding manufacturing and end-of-life of equipment

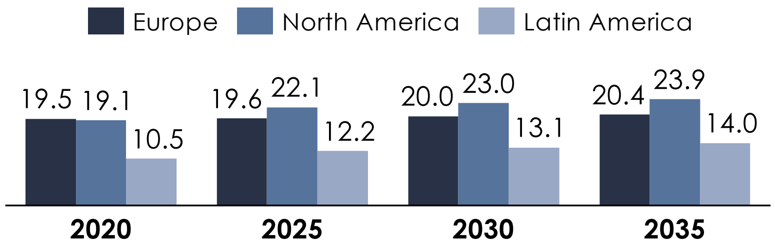

Figure M – Electricity consumption of DTH by region in scenarios A, B, C (2020 to 2035 – Wh per device viewing hour)

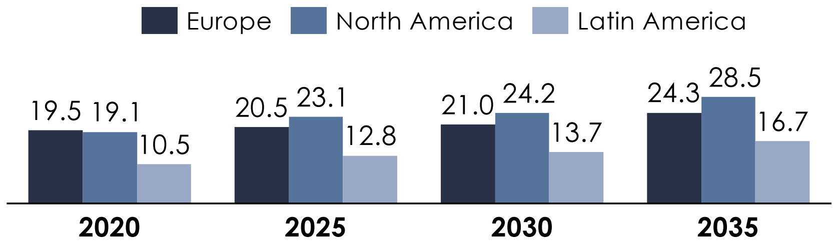

Figure N - Electricity consumption of DTH by region in scenario D (2020 to 2035 – Wh per device viewing hour)

6 Conclusions

When comparing the use phase of different TV delivery methods, DTH emerges as one of the most carbon-efficient options per device viewing hour, second only to DTT, and is significantly less carbon-intensive than OTT or IPTV. This efficiency is particularly evident when DTH infrastructure serves large audiences, as the emissions from satellite and uplink operations are amortized over a high number of viewers.

While these findings highlight the carbon efficiency of DTH during the use phase, several limitations must be considered to put the results into perspective.

- The comparison focuses solely on the use phase and does not account for full life-cycle emissions (e.g., manufacturing, end-of-life) of the infrastructure. A full life-cycle perspective would offer a more complete view, especially since some delivery infrastructures serve multiple purposes. For example, fibre-optic networks used by IPTV and OTT also support internet services, while satellite and uplink systems are primarily dedicated to TV broadcasting. These differences in infrastructure scope may affect the comparability of absolute carbon footprints, particularly in regions where IPTV or OTT networks are already widely deployed.
- Moreover, while DTH systems have a relatively low operational carbon footprint, they are typically deployed alongside terrestrial networks, not instead of them. Fiber and mobile infrastructure are widely rolled out for diverse services beyond TV delivery applications. Therefore, DTH should be seen as an additional layer in an already extensive digital ecosystem, not a standalone low-carbon alternative.
- In-home equipment remains the dominant source of energy-related emissions, underscoring the importance of device efficiency and user behavior in shaping environmental performance.
- The number of DTH households sharing reception equipment in multi-dwelling buildings represents a key modeling uncertainty. This parameter varies significantly by country and building type, and can significantly affect the results per device hour.
- Finally, while launch-phase emissions were partially accounted for through life-cycle estimates, the broader climate impact of satellite launches remains poorly understood. In particular, the radiative forcing effects of emissions in the upper atmosphere (stratosphere and mesosphere) are not yet well quantified, and scientific consensus on their long-term warming potential is still emerging.

Glossary

LCA: Life Cycle Assessment

DTH: Direct-To-Home (satellite television distribution method that delivers broadcast content directly from the satellite to the viewer’s home, bypassing terrestrial networks)

DTT: Digital Terrestrial Television

HPA: High Power Amplifier

HD: High Definition

IPTV: Internet Protocol Television (streaming of television content over managed IP networks)

LNB: Low-Noise Block Downconverter (device mounted on the satellite dish at the receiver's end)

OTT: Over-The-Top (delivery of video and audio content over the Internet)

RF: Radio Frequency (RF equipment includes all components that generate, transmit, receive, amplify, or convert radio-frequency signals in a DTH distribution system)

SD: Standard Definition

TV: television

UHD: Ultra High Definition

Appendix: Summary of 2020 results

Unit energy and GHG impacts of TV delivery, by country (excluding TV sets) for 2020

Country	Total annual device hours (billions)	Annual GHG emissions (ktCO2e)	GHG emissions (gCO2e / device hour)	Electricity consumption – excluding satellite (GWh)	Electricity consumption – excluding satellite (Wh/device hour)
France	8.40	10	1.20	191	22.72
Germany	29.21	215	7.35	634	21.71
Italy	21.18	85	4.00	362	17.09
Spain	2.18	9	4.03	42	19.41
United Kingdom	18.65	101	5.44	444	23.79
Europe	**123.42**	**580**	**4.70**	**2 408**	**19.51**
Canada	2.38	7	3.33	48	20.28
United States of America	34.09	284	8.32	650	19.06
North America	**36.48**	**291**	**7.99**	**698**	**19.14**
Latin America	**74.93**	**318**	**4.25**	**788**	**10.51**

Appendix: Overview of the LoCaT original study's scenarios[1]

TV viewing per delivery method	2020	2025	2030	2035
Scenario A	**Baseline IPTV growth based on current trends. IPTV and OTT increase steadily. DTT, CAB, and DTH decline gradually.**			
DTT	40%	35%	30%	25%
OTT	0%	2%	6%	10%
IPTV	13%	21%	26%	32%
DTH	**25%**	**23%**	**21%**	**19%**
CAB[2]	22%	19%	17%	14%
Scenario B	**Accelerated IPTV growth. IPTV grows rapidly, replacing DTT, which declines significantly. DTH declines gradually.**			
DTT	40%	30%	20%	10%
OTT	0%	5%	10%	15%
IPTV	13%	23%	32%	42%
DTH	**25%**	**23%**	**21%**	**19%**
CAB[2]	22%	19%	17%	14%
Scenario C	**IPTV plateau and DTT regrowth. IPTV stagnates post-2025; DTT regains viewership. DTH declines gradually.**			
DTT	40%	40%	40%	42%
OTT	0%	2%	5%	7%
IPTV	13%	16%	18%	18%
DTH	**25%**	**23%**	**21%**	**19%**
CAB[2]	22%	19%	17%	14%
Scenario D	**DTT home caching for VOD. DTT remains stable due to off-peak caching; IPTV and OTT grow slower. DTH declines gradually more.**			
DTT	40%	37%	35%	37%
OTT	0%	2%	6%	8%
IPTV	13%	20%	25%	27%
DTH	**25%**	**22%**	**20%**	**16%**
CAB[2]	22%	19%	15%	12%

[1] https://thelocatproject.org/
[2] CAB : Cable (delivery of television content via coaxial or fiber-optic cables directly to homes, typically through a subscription service provided by cable operators - the LoCat original study and LoCaT-Sat do not consider a detailed analysis of cable)

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