

## Accompanying materials for “Evaluating Sustainable Interaction Design of Digital Services.”

### Data Used Directly by Model Framework

Variable Type/Name	Estimated Value	Unit	Compound Annual Growth Rate	ref date	Source
<b>Network &amp; Sever Energy Intensities</b>					
energy_intensity_core_network	1.49E-06	J / bit	-0.125	01/01/2014	Schien, D., & Preist, C. (2014). Approaches to energy intensity of the internet. IEEE Communications Magazine, 52(11)
energy_intensity_metro_network	4.87E-06	J / bit	-0.125	01/01/2015	Schien and Preist 2014 (see above)
energy_intensity_edge_network	2.70E-06	J / bit	-0.125	01/01/2015	Schien and Preist 2014 (see above)
energy_intensity_submarine	1.25E-07	J / bit	-0.125	01/01/2015	Schien and Preist 2014 (see above)
energy_intensity_cellular_3g	1.17E-03	J / bit	-0.22	01/01/2010	Andrae, Anders, and Tomas Edler. 2015. “On Global Electricity Usage of Communication Technology: Trends to 2030.” <i>Challenges</i> 6 (1): 117–57. doi:10.3390/challe6010117.
energy_intensity_cellular_4g	2.25E-04	J / bit	-0.22	01/01/2010	Andrae, Anders, and Tomas Edler. 2015. “On Global Electricity Usage of Communication Technology: Trends to 2030.” <i>Challenges</i> 6 (1): 117–57. doi:10.3390/challe6010117.
carbon_intensity_google	REDACTED (See Source)	kgCO2(e)/ kWh	0	01/01/2015	carbonfootprint.com - 2016 IEA electricity / generation World kWh electricity generation
<b>Google/YouTube Infrastructure</b>					
energy_intensity_youtube_server	2.69E-07	J / bit	0	01/07/2017	<a href="https://media.netflix.com/en/company-blog/renewable-energy-at-netflix-an-update">https://media.netflix.com/en/company-blog/renewable-energy-at-netflix-an-update</a>
GGC_hitrate	0.7		0	01/01/2015	<a href="https://peering.google.com/about/ggc.html">https://peering.google.com/about/ggc.html</a>
overhead_ggc_synch	0.1		0	01/01/2016	Expert Opinion based on knowledge of similar systems
<b>Network Traffic and Shares</b>					
household_total_data	132	GB		01/01/2016	Estimate based on UK Data due to lack of availability of global data <a href="https://www.ofcom.org.uk/_data/assets/pdf_file/0035/95876/CN-Report-2016.pdf">https://www.ofcom.org.uk/_data/assets/pdf_file/0035/95876/CN-Report-2016.pdf</a>
ww_broadband	917000000			01/01/2016	<a href="https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.18-2017-PDF-E.pdf">https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.18-2017-PDF-E.pdf</a>
share_DSL	0.44		0	01/01/2016	OECD Broadband Portal
share_Cable	0.34		0	01/01/2016	OECD Broadband Portal
share_Fibre	0.22		0	01/01/2016	OECD Broadband Portal
cell_share_4g	0.60		0.1	01/01/2016	Expert Estimate based on UK data volumes from 2016
<b>Network and Device Power Usage</b>					
Power_backhaul_Fibre	2.0	W	0	01/01/2013	K Krug, L., Shackleton, M., & Saffre, F. (2014). Understanding the environmental costs of fixed line networking. In <i>Proceedings of the 5th international</i>

					conference on Future energy systems - e-Energy '14
Power_AN_port_Fibre	3.5	W	0	01/01/2013	Krug et al 2014 (see above)
Power_CPE_Fibre	6.5	W	0	01/01/2013	<a href="https://genexis.eu/content/uploads/2016/08/DRG700_7000_Datasheet_rev8.2.pdf">https://genexis.eu/content/uploads/2016/08/DRG700_7000_Datasheet_rev8.2.pdf</a>
Power_CPE_DSL	9.7	W	0	01/01/2017	<a href="http://www.ispreview.co.uk/index.php/2017/01/energy-usage-uk-home-broadband-routers-big-isps-compared.html/3">http://www.ispreview.co.uk/index.php/2017/01/energy-usage-uk-home-broadband-routers-big-isps-compared.html/3</a>
Power_backhaul_DSL	0.8	W	0	01/01/2013	Krug et al 2014 (see above)
Power_AN_port_DSL	3.2	W	0	01/01/2013	Krug et al 2014 (see above)
Power_backhaul_Cable	3.0	W	0	01/01/2016	Virgin Media. (2016) Our carbon footprint. <a href="http://www.virginmedia.com/content/dam/virginmedia/dotcom/documents/corporate/Carbon-footprint-2016.pdf">http://www.virginmedia.com/content/dam/virginmedia/dotcom/documents/corporate/Carbon-footprint-2016.pdf</a>
Power_CPE_Cable	9.0	W	0	01/01/2016	Virgin Media. 2016 (see above)
power_smartphone	1.0	W	0	01/01/2010	<a href="https://www.usenix.org/legacy/event/usenix10/tech/full_papers/Carroll.pdf">https://www.usenix.org/legacy/event/usenix10/tech/full_papers/Carroll.pdf</a>
power_tablet	3.0	W	0	01/01/2017	<a href="https://images.apple.com/euro/environment/pdf/tf/generic/products/ipad/ipad_PER_mar2017.pdf">https://images.apple.com/euro/environment/pdf/tf/generic/products/ipad/ipad_PER_mar2017.pdf</a>
power_laptop_and_screen	32.0	W	-0.01	01/01/2015	Estimate based on Energy Star values
power_laptop	15.0	W	-0.01	01/01/2015	<a href="https://www.eu-energystar.org/calculator.htm">https://www.eu-energystar.org/calculator.htm</a>
power_screen	17.0	W	-0.01	01/01/2015	<a href="https://www.eu-energystar.org/calculator.htm">https://www.eu-energystar.org/calculator.htm</a>
power_desktop	60.0	W	-0.01	01/01/2015	<a href="https://www.eu-energystar.org/calculator.htm">https://www.eu-energystar.org/calculator.htm</a>
power_tv	37.0	W	-0.01	01/01/2015	Energy Star TV population of models + distribution of screen size from BARB
power_gamesconsole	108.5	W	-0.01	01/01/2013	Webb, a., Mayers, K., France, C., & Koomey, J. (2013). Estimating the energy use of high definition games consoles. Energy Policy, 61, 1412–1421. doi:10.1016/j.enpol.2013.05.056
power_ip_stb	3.5	W	-0.01	01/01/2015	<a href="https://ting.com/blog/the-hidden-costs-of-cable-tv/">https://ting.com/blog/the-hidden-costs-of-cable-tv/</a>
power_po_stb	21.0	W	-0.01	01/01/2015	Estimate based on mean of own measurements of Satellite and Cable STBs
<b>Media Bit Rates and Data Volume Shares (network platforms and end user devices)</b>					
audio_bitrate	0.16	Mbps	0	01/01/2016	Spotify default bit rates
video_bitrate	1.18	Mbps	0	01/01/2016	Estimated based on proportions of traffic that is YouTube and global data volumes, e.g. from Google <a href="https://youtube.googleblog.com/2017/02/you-know-whats-cool-billion-hours.html">https://youtube.googleblog.com/2017/02/you-know-whats-cool-billion-hours.html</a> and Cisco <a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf</a> and <a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html</a>
precaching_overhead	10	s	0	01/01/2016	Own experiments (the amount of video that is precached in the stream)

share_music_videos	27%		0	01/01/2016	Various including: <a href="https://blog.pex.com/state-of-the-youtube-address-an-overview-of-youtube-usage-and-growth-8d562d4b7fe">https://blog.pex.com/state-of-the-youtube-address-an-overview-of-youtube-usage-and-growth-8d562d4b7fe</a> and <a href="http://expandedramblings.com/index.php/youtube-statistics/4/">http://expandedramblings.com/index.php/youtube-statistics/4/</a>
share_mobile	0.6			01/01/2016	<a href="https://www.thinkwithgoogle.com/data/youtube-views-from-mobile/">https://www.thinkwithgoogle.com/data/youtube-views-from-mobile/</a>
share_smartphone (Of Cellular Network Traffic)	81%			01/01/2016	<a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html</a>
share_tablet_cell	20.80%			01/01/2016	Estimated based on proportions of traffic that is Cell Vs Fixed line access, e.g. Cisco <a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf</a> and <a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html</a>
share_smartphone_cell	20.80%			01/01/2016	Estimated based on proportions of traffic that is Cell Vs Fixed line access, e.g. Cisco <a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf</a> and <a href="https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html">https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html</a>
Share of non mobile devices					Coarse expert estimates based on correlation of use patterns with data from another streaming service and online reports from YouTube channel providers.
share_IP_STB	0.1			01/01/2016	
share_TV	0.1			01/01/2016	
share_gamesconsole	0.1			01/01/2016	
share_Computer	0.7			01/01/2016	
Share of computers, further broken down					Coarse expert estimates based on correlation of use patterns with data from another streaming service and online reports from YouTube channel providers.
share_Desktop	0.3			01/01/2016	
share_Laptop_Devices	0.7			01/01/2016	
in turn split between:					
share_Laptop_and_Screen	0.3			01/01/2016	
share_Laptop	0.7			01/01/2016	

### Cut Off Value Calculation for Uploaded Videos:

For 2016 we have 1 Billion hours of video viewed per day [1]. From July 2015 from speech by YouTube CEO Susan Wojcicki [2], "In total, there are 400 hours of video uploaded to YouTube every minute, which equates to 65 years of video every day". That's 576,000 hrs of video uploaded per day. If we take the 1 Billion hours from 2016 that's about 0.06% of the downloaded hours/day. Projecting to 2016 - that's likely to be about 600 to 700hrs per min [3]. Taking 700 as max likely value - that would be about 1,008,000 hrs/day or 0.1%.

[1] <https://youtube.googleblog.com/2017/02/you-know-whats-cool-billion-hours.html>

[2] <https://www.tubefilter.com/2015/07/26/youtube-400-hours-content-every-minute/>

[3] <<http://tubularinsights.com/hours-minute-uploaded-youtube/>>