Channel Emissions Framework and Formulae: Linear Radio (AM/FM/Satellite/DAB) Extended Version

Phase	Step & sub-step			Physical processes involved	Formula type	Scaling factors	Expected materiality	Formulae		Expected data	Comments
CREATION	Tech Manipulation (Multivariant Creative)	Creative storage[1]		Additional server storage for multiple volumes of assets for the purpose of distribution.	Embodied emission factors	• Number and size of assets • Storage duration	• Low	$\sum_{a=0}^{A} (size_a \times time\_stored_a \times storage\_impact_a \times allocation\_factor_a)$	*a: creative asset* *A: total number of assets for the campaign* • $size_a$*: size of asset a [kB]* • $time\_stored_a$*: time stored [yr]* • $storage\_impact_a$*: carbon impact of storage of asset a [kgCO2e/kB/yr]* • $allocation\_factor_a$*: allocation factor for the campaign for asset a [%]*	-	
DISTRIBUTION	Ad Space Selection	Direct Programmatic/ Targeted/ Segmentable/ Addressable		Servers processing transmission through SSP/DSP buying process	Operational emission factors	To be adapted from digital, in future guidance work, considering usually more manual intervention and therefore less automated process.					Audio ads in linear broadcast rely more on traditional planning and scheduling, though digital audio platforms like DAX may allow for some automated placement. Manual intervention means some emissions may partially be included within corporate emissions overhead.
					Embodied emission factors						
				Networks transmission through SSP/DSP buying process	Operational emission factors						
					Embodied emission factors						
	Ad Creative Delivery	Transformation & Transfer	Linear Radio (AM/FM/ Satellite/ DAB)[2]	Data centres processing of ad delivery (broadcast) [3]	Operational emission factors	• Number of diffusions • Spot duration • Bitrate	• Low to medium	$\sum_{a=0}^{A} (number\_diffusions_a \times spot\_duration_a \times bitrate\_before\_transcoding_a) \times \sum_{i=0}^{I}\sum_{c=0}^{C} (infrastructure\_efficiency_{i,c} \times carbon\_impact\_electricity_c)$	*a: creative asset* *A: total number of assets for the campaign* *i: servers' infrastructure* *I: total number of radio servers' infrastructure involved for the campaign* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_diffusions_a$*: number of diffusions of asset a on linear radio/DAB during the campaign* • $spot\_duration_a$*: time of audio ad relative to asset a [s]* • $bitrate\_before\_transcoding_a$*: raw bitrate of asset a [kB/s]* • $infrastructure\_efficiency_{i,c}$*: energy efficiency of radio servers infrastructure i in country c, including PUE (per second of diffusion) [kWh/s]* • $carbon\_impact\_electricity_c$*: carbon intensity of electricity in country c [kgCO2e/kWh]*	-	Traditional AM/FM and DAB networks are supposed to be mobilised each type a diffusion of the spot is made (flat energy consumption, relative to time of diffusion). Satellite radio is modelized similarly to linear radio for transmission (values used can however be different, e.g. efficiency of networks), and should include rocket launches and satellite placement
					Embodied emission factors		• Low to medium	$\sum_{a=0}^{A} (number\_diffusions_a \times spot\_duration_a) \times \sum_{i=0}^{I}\sum_{c=0}^{C} (EF\_embodied\_infrastructure_{i,c})$	*a: creative asset* *A: total number of assets for the campaign* *i: servers' infrastructure* *I: total number of radio servers' infrastructure involved for the campaign* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_diffusions_a$*: number of diffusions of asset a on linear radio/DAB during the campaign* • $spot\_duration_a$*: time of audio ad relative to asset a [s]* • $EF\_embodied\_infrastructure_{i,c}$*: embodied emission factor of radio servers infrastructure i in country c (amortized relative to lifetime, per second of diffusion) [kgCO2e/s]*	-	
				Networks transmission of ad delivery (broadcast)	Operational emission factors	• Number of diffusions • Spot duration	• Low to medium	$\sum_{a=0}^{A} (number\_diffusions_a \times spot\_duration_a) \times \sum_{n=0}^{N}\sum_{c=0}^{C} (network\_efficiency_{n,c} \times carbon\_impact\_electricity_c)$	*a: creative asset* *A: total number of assets for the campaign* *n: type of network* *N: total number of networks* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_diffusions_a$*: number of diffusions of asset a on linear radio/DAB during the campaign* • $spot\_duration_a$*: time of audio ad relative to asset a [s]* • $network\_efficiency_{n,c}$*: energy efficiency network n, in country c (per second of diffusion) [kWh/s]* • $carbon\_impact\_electricity_c$*: carbon intensity of electricity in country c [kgCO2e/kWh]*	-	
					Embodied emission factors		• Low to medium	$\sum_{a=0}^{A} (number\_diffusions_a \times spot\_duration_a) \times \sum_{n=0}^{N}\sum_{c=0}^{C} (EF\_embodied\_network_{n,c})$	*a: creative asset* *A: total number of assets for the campaign* *n: type of network* *N: total number of networks* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_diffusions_a$*: number of diffusions of asset a on linear radio/DAB during the campaign* • $spot\_duration_a$*: time of audio ad relative to asset a [s]* • $EF\_embodied\_network_{n,c}$*: embodied emissions (manufacturing & end-of-life) of network type n, in country (amortized per kB of data over lifetime of infrastructure) [kgCO2e/kB]*	-	
CONSUMPTION	Device Listening	User device load		Download / stream of creative to the user device. Includes embodied emissions of devices.	Operational emission factors	• Data transferred (incl. file size) • Device type	Low	-	-	Likely low materiality, not using this formula yet but kept as theoretical placeholder.	Time to load [s] is determined by the first two parameters. Short time is expected therefore materiality is expected to be low. However, it might become more material in time with on-device advertising is also identified as having a growing impact on loading, but not modelized yet, and it also needs to be confirmed.
					Embodied emission factors		Low	-	-	Likely low materiality, not using this formula yet but kept as theoretical placeholder.	
		User device play		Play of creative on the user device. Includes embodied emissions of devices.	Operational emission factors	• Time played • Device type	High	$\sum_{d=0}^{D}\sum_{n=0}^{N}\sum_{c=0}^{C} (number\_plays_d \times time\_per\_play_d \times device\_power\_consumption_{play,d,c} \times time\_conversion\_ratio \times carbon\_impact\_electricity_c)$	*d: device type* *D: total number of device types involved in the campaign* *n: type of network* *N: total number of networks* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_d$*: number of plays (listeners) of asset(s) on device type d* • $time\_per\_play_d$*: time played per play on device type d [s]* • $device\_power\_consumption_{play,d}$*: power consumption of device type d in country c when playing audio content [W]* • $time\_conversion\_ratio$*: seconds to hours* • $carbon\_impact\_electricity_c$*: carbon intensity of electricity in country c [kgCO2e/kWh]*	Use full device power in the formula.	Smart speakers & car radios to be included in the approach, will require specific guidance and data sources to be identified. Background listening should require specific guidance and modelling.
					Embodied emission factors		High	$\sum_{d=0}^{D}\sum_{n=0}^{N}\sum_{c=0}^{C} (number\_plays_d \times time\_per\_play_d \times EF\_embodied\_device_{play,d,c})$	*d: device type* *D: total number of device types involved in the campaign* *n: type of network* *N: total number of networks* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_d$*: number of plays (listeners) of asset(s) on device type d* • $time\_per\_play_d$*: time played per play on device type d amortised: embodied emissions of device type d in country c (amortized per s over lifetime of device), share of play [kgCO2e/s]*	Use full device EF in the formula. Total active used time over lifetime by device type is the result of daily use x lifetime in years.	
ALL	Corporate emissions overhead			Allocated organisational emissions attributed to the specific campaign across ALL entities in the campaign value chain.	Corporate overhead	Campaign revenue	Low	-		-	Every organisation in the value chain should be reporting their verified enterprise GHG emissions inventory annually to ensure reasonable data quality at the enterprise level. More guidance will follow on this in the next update of the GMSF.

Key

- = Not yet applicable or to be investigated further

∑ = The mathematical sign for a sum

Footnotes for Channel Emissions Framework Linear Radio (AM/FM/Satellite/ DAB)

Creative storage

[1] Although relevant in theory, unlike video transmission, transcoding was considered negligible in the case of Audio channel, since audio files are small files and generally include little / no manipulation. More generally, given this small size of files resulting in probable low materiality, the Creative Storage topic will be to discuss in future guidance work to decide if the data required for the calculation is worth tracking down.

Digital listening of traditional radio stations

[2] Digital listening of linear broadcast radio, is categorised for now as On Demand Audio as this is consumed via internet connected devices. To be explored further in Audio Data Guidance.

Datacentres processing

[3] Datacentres handle multiple operations, therefore future guidance work will be conducted on allocation of emissions, capitalising on work already completed on the Digital channel.

AD NET ZERO
ALL FOR NONE

Channel Emissions Framework and Formulae: Audio On Demand Extended Version

Phase	Step & sub-step		Physical processes involved	Formula type	Scaling factors	Expected materiality	Formulae		Expected data hacks	Comments
CREATION	Tech Manipulation (Multivariant Creative)	Creative storage[1]	Additional server storage for multiple volumes of assets for the purpose of distribution.	Embodied emission factors	• Number and size of assets • Storage duration	• Low	$\sum_{a=0}^{A} (size_a \times time\_stored_a \times storage\_impact_a \times allocation\_factor_a)$	*a: creative asset* *A: total number of assets for the campaign* • $size_a$: *size of asset a [kB]* • $time\_stored_a$: *time stored [yr]* • $storage\_impact_a$: *carbon impact of storage of asset a [kgCO2e/kB/yr]* • $allocation\_factor_a$: *allocation factor for the campaign for asset a [%]*	-	
DISTRIBUTION	Ad Space Selection	Direct Programmatic/ Targeted/ Segmentable/ Addressable	Servers processing transmission through SSP/DSP buying process	Operational emission factors	To be adapted from digital, in future guidance work, considering usually more manual intervention and therefore less automated process.					Audio ads in linear broadcast rely more on traditional planning and scheduling, though digital audio platforms like DAX may allow for some automated placement. Manual intervention means some emissions may partially be included within corporate emissions overhead.
				Embodied emission factors						
			Networks transmission through SSP/DSP buying process	Operational emission factors						
				Embodied emission factors						
	Ad Creative Delivery	Transformation & Transfer	Data centres processing of ad delivery (unicast)[3]	Operational emission factors	• Data transferred [kB] • Location	Medium to high	$\sum_{a=0}^{A} (number\_plays_a \times server\_output\_per\_play_a) \times \sum_{i=0}^{I}\sum_{c=0}^{C} (breakdown\_infrastructure_{i,c} \times infrastructure\_efficiency_{i,c} \times carbon\_impact\_electricity_c)$	*a: creative asset* *A: total number of assets for the campaign* *i: servers' infrastructure* *I: total number of radio servers' infrastructure involved for the campaign* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_a$: *number of plays (listeners) for asset a on radio on demand* • $server\_output\_per\_play_a$: *total server output data per play of asset a [kB]* • $breakdown\_infrastructure_{i,c}$: *breakdown of total content delivered by infrastructure i in country c (e.g. from ad servers or edge nodes) [%]* • $infrastructure\_efficiency_{i,c}$: *energy efficiency of radio servers infrastructure i in country c, including PUE (amortized per kB of data over lifetime of infrastructure) [kWh/kB]* • $carbon\_impact\_electricity_c$: *carbon intensity of electricity in country c [kgCO2e/kWh]*	• Total server output data per impression / Total data transferred on network per impression: For audio format: portion of file size loaded (incl. buffer) + payload overhead of additional assets	Conventional network model for digital networks, especially valid for digital radio but with to be investigated for digital radio broadcasted via multiplexes, where spare capacity adds complexity. Content Delivery Networks (CDNs) are not used for audio in this context.
				Embodied emission factors	• Data transferred [kB]	• Medium to high	$\sum_{a=0}^{A} (number\_plays_a \times server\_output\_per\_play_a) \times \sum_{i=0}^{I}\sum_{c=0}^{C} (breakdown\_infrastructure_{i,c} \times EF\_embodied\_infrastructure_{i,c})$	*a: creative asset* *A: total number of assets for the campaign* *i: servers' infrastructure* *I: total number of radio servers' infrastructure involved for the campaign* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_a$: *number of plays (listeners) for asset a on radio on demand* • $server\_output\_per\_play_a$: *total server output data per play of asset a [kB]* • $breakdown\_infrastructure_{i,c}$: *breakdown of total content delivered by infrastructure i in country c (e.g. from ad servers or edge nodes) [%]* • $EF\_embodied\_infrastructure_{i,c}$: *embodied emissions of radio servers infrastructure i in country c (amortized per kB of data over lifetime of infrastructure) [kgCO2e/kB]*		
			Networks transmission of ad delivery (unicast)	Operational emission factors	• Data transferred [kB] • Location	Medium to high	$\sum_{a=0}^{A} (number\_plays_a \times network\_transfer\_per\_play_a) \times \sum_{n=0}^{N}\sum_{i=0}^{I}\sum_{c=0}^{C} (breakdown\_network_{n,i} \times network\_efficiency_{n,i} \times carbon\_impact\_electricity_i + breakdown\_network_{n,c} \times network\_efficiency_{n,c} \times carbon\_impact\_electricity_c)$	*a: creative asset* *A: total number of assets for the campaign* *n: type of network* *N: total number of networks* *i: servers' infrastructure* *I: total number of radio servers' infrastructure involved for the campaign* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_a$: *number of plays (listeners) for asset a on radio on demand* • $network\_transfer\_per\_play_a$: *total data transferred on network per play of asset a [kB]* • $breakdown\_network_{n,i}$: *breakdown of total content having transited on network n in country of infrastructure i [%]* • $network\_efficiency_{n,i}$: *energy efficiency network n, in country of infrastructure i (per kB of data) [kWh/kB]* • $carbon\_impact\_electricity_i$: *carbon intensity of electricity in country of infrastructure i [kgCO2e/kWh]* • $breakdown\_network_{n,c}$: *breakdown of total content having transited on network n in country of user c [%]* • $network\_efficiency_{n,c}$ *energy efficiency network n, in country of user c (per kB of data) [kWh/kB]* • $carbon\_impact\_electricity_c$: *carbon intensity of electricity in country of user c [kgCO2e/kWh]*		
				Embodied emission factors	• Data transferred [kB]	• Medium to high	$\sum_{a=0}^{A} (number\_plays_a \times network\_transfer\_per\_play_a) \times \sum_{n=0}^{N}\sum_{i=0}^{I}\sum_{c=0}^{C} (breakdown\_network_{n,i} \times EF\_embodied\_network_{n,i} + breakdown\_network_{n,c} \times EF\_embodied\_network_{n,c})$	*a: creative asset* *A: total number of assets for the campaign* *n: type of network* *N: total number of networks* *i: servers' infrastructure* *I: total number of radio servers' infrastructure involved for the campaign* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_a$: *number of plays (listeners) for asset a on radio on demand* •$network\_transfer\_per\_play_a$: *total data transferred on network per play of asset a [kB]* •$breakdown\_network_{n,i}$: *breakdown of total content having transited on network n in country of inframortisede i [%]* •$EF\_embodied\_network_{n,i}$: *embodied emissions (manufacturing & end-of-life) of network type n, in country of infrastructure i (amortized per kB of data) [kgCO2e/kB]* •$breakdown\_network_{n,c}$: *breakdown of total content having transited on network n in country of user c [%]* •$EF\_embodied\_network_{n,c}$: *embodied emissions (manufacturing & end-of-life) of network type n, in country of user c (amortized per kB of data over lifetime of infrastructure) [kgCO2e/kB]*		
CONSUMPTION	Device Listening[4]	User device load	Download / stream of creative to the user device. Includes embodied emissions of devices.	Operational emission factors	• Data transferred (incl. file size) • Device type	Low	-	-	Likely low materiality, not using this formula yet but kept as theoretical placeholder.	Time to load [s] is determined by the first two parameters. Short time is expected therefore materiality is expected to be low. However, it might become more material in time with on-device advertising, and is also identified as having a growing impact on loading, but this is to be confirmed.
				Embodied emission factors		Low	-	-	Likely low materiality, not using this formula yet but kept as theoretical placeholder.	
		User device play	Play of creative on the user device. Includes embodied emissions of devices.	Operational emission factors	• Time played • Device type[5]	High	$\sum_{d=0}^{D}\sum_{n=0}^{N}\sum_{c=0}^{C} (number\_plays_d \times time\_per\_play_d \times device\_power\_consumption_{play,d,c} \times time\_conversion\_ratio \times carbon\_impact\_electricity_c)$	*d: device type* *D: total number of device types involved in the campaign* *n: type of network* *N: total number of networks* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_d$: *number of plays (listeners) of asset(s) on device type d* •$time\_per\_play_d$: *time played per play on device type d [s]* •$device\_power\_consumption_{play,d}$: *power consumption of device type d in country c when playing audio content [W]* •$time\_conversion\_ratio$: *seconds to hours* •$carbon\_impact\_electricity_c$: *carbon intensity of electricity in country c [kgCO2e/kWh]*	Use full device power in the formula.	Smart speakers & car radios to be included in the approach, will require specific guidance and data sources to be identified. Background listening should require specific guidance and modelling.
				Embodied emission factors		High	$\sum_{d=0}^{D}\sum_{n=0}^{N}\sum_{c=0}^{C} (number\_plays_d \times time\_per\_play_d \times EF\_embodied\_device_{play,d,c})$	*d: device type* *D: total number of device types involved in the campaign* *n: type of network* *N: total number of networks* *c: country of final user* *C: total number of countries involved for the campaign* • $number\_plays_d$: *number of plays (listeners) of asset(s) on device type d* •$time\_per\_play_d$: *time played per play on device type d amortised: embodied emissions of device type d in country c (amortized per s over lifetime of device), share of play [kgCO2e/s]*	Use full device EF in the formula. Total active used time over lifetime by device type is the result of daily use x lifetime in years.	
ALL	Corporate emissions overhead		Allocated organisational emissions attributed to the specific campaign across ALL entities in the campaign value chain.	Corporate overhead	Campaign revenue	High	-		-	Every organisation in the value chain should be reporting their verified enterprise GHG emissions inventory annually to ensure reasonable data quality at the enterprise level. More guidance will follow on this in the next update of the GMSF.

Key

- = Not yet applicable or to be investigated further

∑ = The mathematical sign for a sum

Footnotes for Channel Emissions Framework Audio On Demand[2]

Creative storage
[1] Although relevant in theory, unlike video transmission, transcoding was considered negligible in the case of Audio channel, since audio files are small files and generally include little / no manipulation. More generally, given this small size of files resulting in probable low materiality, the Creative Storage topic will be discussed in future guidance work to decide if the data required for the calculation is worth tracking down.

Audio on demand
[2] Covering any type of audio on demand, including podcasts.

Datacentres processing
[3] Datacentres handle multiple operations, therefore future guidance work will be conducted on allocation of emissions, capitalising on work already completed on the Digital channel.

Host-read ad
[4] Specific host-read audio ad formats, which are not standalone files that can easily be isolated and measured, will be the subject of future guidance work to assess the materiality and complexity of data gathering and assessment.

Devices types
[5] Any internet enabled devices are considered included in the case of digital radio: laptop, mobile, tablets, but also smart speakers, TV's... Future guidance work will address specific device list and reference emission factors, capitalising on work already completed on the Digital channel.