Intrapology Sustainability Report

Introduction

This report summarises research conducted over the past four weeks into the sustainability of operating Intrapology's technology platform. This report dives into the current platform and two alternatives; one built on Amazon Web Services and another using a self-hosted, open-source solution. The report breaks down the main parts of the platform - from servers and databases to video streaming and user interactions - to get a clear picture of its carbon footprint and where most emissions come from.

The report doesn't just focus on what happens during live events; it also looks at emissions during idle times and testing periods. Ultimately, this report aims to help Intrapology make smart, sustainable tech choices that balance efficiency with the actual impact on the environment.

Platform Review

This document will explore the sustainability of the existing architecture alongside two alternative architectures; one using Amazon Web Services (AWS) and one using self-hosted open-source software hosted in a data centre chosen by Intrapology.

There are several key components of the platform, tabled below, that have been analysed in different potential architectures.

Component	**Existing Platform**	**Amazon Web Services**	**Self-hosted Open-Source**
Application server	Neocities	S3	Green provider blob storage
Database	Google Firebase Realtime Database	AWS Amplify Datastore	Supabase
Backend API	-	AWS Appsync	-
Video Conferencing	Zoom	Zoom	Jitsi
Video Livestream	Youtube Live	AWS IVS	Peertube

A accounting of the energy use of these components is available in the Data Collection Google Sheet. For information about how to use this sheet, see the Appendix.

The platform also has users in the form of Participants, Performers and Technicians. They use laptops or PCs to access the platform and an assessment of their impact has also been included in each platform's analysis. This is in line with the Greenhouse Gas Protocol's Scope 3 standards for "Use of Sold Products", where an entity is responsible for the energy used in the consumption of their products. The following table highlights components that have been assessed as part of this.

User	Activity	Description
Participant, Performer, Technician	Computer Use	Energy used by a computer to participate in the session
	Download Volume	Energy used sending and receiving data from the web server hosting the Intrapology platform application
	Backend API data volume, Realtime Database communication	Depending on the architecture, the energy used communicating data between a user and a backend API or Realtime database
	Video player download volume	The energy used downloading the video player, e.g. Youtube embed or other player
Performer, Technician	Data volume to video conference	The energy used by sending and receiving data from a video conference system such as Zoom, Jitsi.
Technician	Energy used running OBS	The energy used to run the Technicians PC to run OBS
	Data volume to Live Streaming service	The energy used to send the stream to a Live streaming service such as Youtube Live or Peertube

Emissions

The research set out to understand the emissions associated with the different proposed platform architectures. These emissions come from a number of sources, primarily its users and the platform itself.

The emissions have been calculated for each of the configurations in the Data Collection Google Sheet. To understand how to use the Google Sheet, refer to the Appendix.

Assumptions

The research made some assumptions for this report, however these are stored as variables in the Data Collection Google Sheet and can be altered to explore different assumptions. For this report, these assumptions have been used.

Item	**Assumption**	**Unit**
Number of Participants	30	*people*
Number of Performers	6	*people*
Length of Performance	2	*hours*
Length of Setup Time	1	*hours*
Laptop to PC ratio	70	*% Laptop users*
Bitrate for video stream from OBS	720p at 30fps	-
Video call bitrate	720p	-

Further assumptions and estimates are necessarily made in the gathering of source data for energy use and emissions of various components. These are documented in the Sources tab of the Data Collection Google Sheet.

Current Platform

The current Intrapology platform is shown abstracted in the diagram below to help understand the significant sources of emissions from the platform.

Participants

Participants connect to the platform from a computer, assumed to be a laptop or PC. They download a small application blob from the web host Neocities. This application connects to a Firebase Realtime database for content and to receive and send updates to the application state.

The application renders a Youtube Live player via an IFRAME or similar and receives a stream from Youtube Live.

Performers

Performers connect to the platform in the same way as Participants via neocities and Firebase. They are also connected to a Zoom video conference, where they send and receive video from other performers.

Technician

A Technician, assumed to be one, runs a PC running OBS. They are connected to a Zoom video conference and use OBS to transcode the incoming video call from Zoom into a livestream to Youtube Live. It is assumed that the Livestream is sent at 720p at 30 frames per second.

Youtube Live

Youtube Live transcodes the received video from OBS and broadcasts it via their platform to viewers, primarily Participants.

Neocities

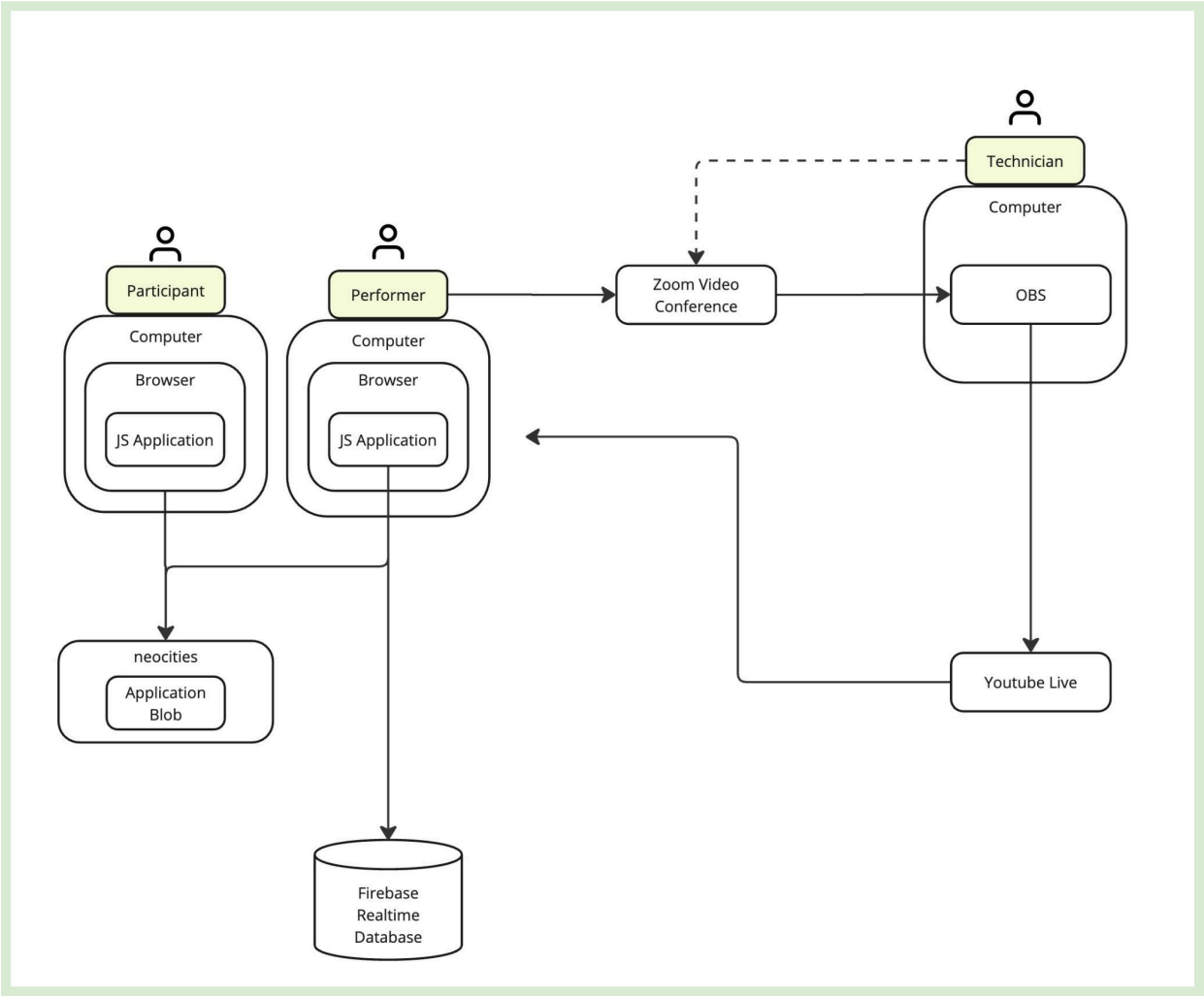
Neocities is an independent web hosting company.

Google Firebase Realtime Database

The Firebase Realtime Database is used as a datastore accessed directly by the client application running on Participants, Performer and Technician computers.

Zoom

Zoom is used as the video conferencing service and hosts Performers and the Technician and potentially other users (e.g. Moderators).



Emissions

For these assumptions the emissions of the platform for a two hour performance were found to be 21.86 kgCO_2e.

Key Contributors

The main contributors to this total are:

Participants' computer use	9.938 kgCO_2e
Youtube Livestream bandwidth	7.626 kgCO_2e

Amazon Web Services Platform

A proposed Intrapology platform running on Amazon Web Services (AWS) is shown abstracted in the diagram below to help understand the significant sources of emissions from the platform.

Participants

Participants connect to the platform from a computer, assumed to be a laptop or PC. They download a small application blob from an AWS S3 hosted website. This application connects to a backend API running on AWS Appsync for content and to receive and send updates to the application state stored in AWS Amplify Datastore.

The application renders an HTML5 video player and receives a stream from AWS Interactive Video Service (AWS IVS).

Performers

Performers connect to the platform in the same way as Participants via an S3 hosted website and AWS Appsync and Amplify. They are also connected to a Zoom video conference, where they send and receive video from other performers.

Technician

A Technician, assumed to be one, runs a PC running OBS. They are connected to a Zoom video conference and use OBS to transcode the incoming video call from Zoom into a livestream to AWS Interactive Video Service (AWS IVS). It is assumed that the Livestream is sent at 720p at 30 frames per second.

AWS Interactive Video Service

AWS Interactive Video Service (AWS IVS) transcodes the received video from OBS and broadcasts it via their platform to viewers, primarily Participants.

AWS S3

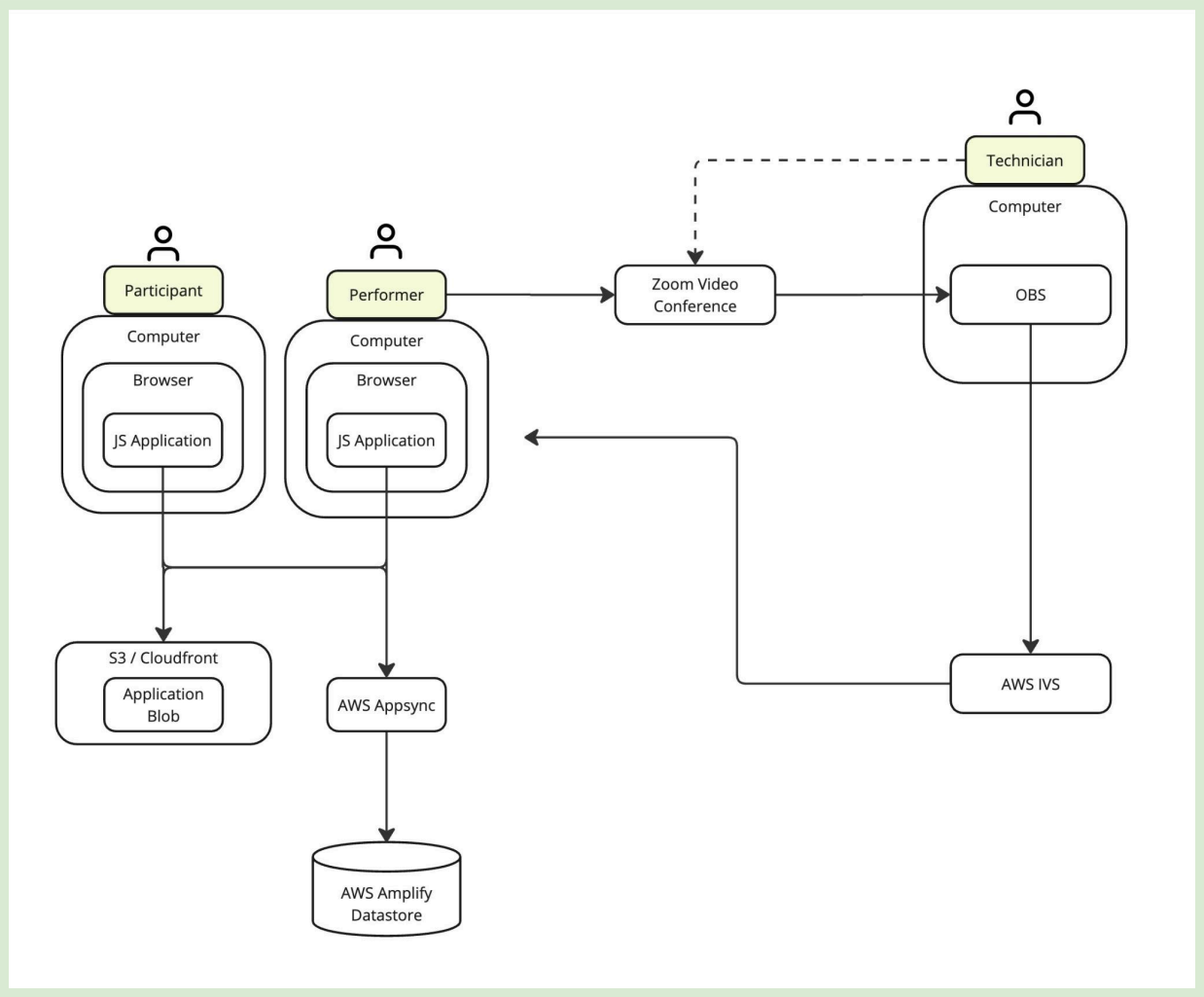
AWS S3 is a highly scalable object storage service that can be configured to host websites. It can be further augmented with AWS Cloudfront to act as a content distribution network (CDN).

AWS Appsync and AWS Amplify Datastore

These two components are AWS services that can be used to replicate the high level functionality of Firebase Realtime Database.

Zoom

Zoom is used as the video conferencing service and hosts Performers and the Technician and potentially other users (e.g. Moderators).



Emissions

For these assumptions the emissions of the platform for a two hour performance were found to be 18.63kgCO_2e.

Key Contributors

The main contributors to this total are:

Participants' computer use	9.938 kgCO_2e
AWS IVS bandwidth	4.385 kgCO_2e

Open Source Self-Hosted Platform

A proposed Intrapology platform running on open source software and self-hosted is shown abstracted in the diagram below to help understand the significant sources of emissions from the platform.

Participants

Participants connect to the platform from a computer, assumed to be a laptop or PC. They download a small application blob from a website hosted on a Green cloud service. This application connects to a database running on Supabase for content and to receive and send updates to the application state.

The application renders an HTML5 video player and receives a stream from a Peertube peer.

Performers

Performers connect to the platform in the same way as Participants via a cloud hosted website and Supabase. They are also connected to a Jitsi video conference, where they send and receive video from other performers.

Technician

A Technician, assumed to be one, runs a PC running OBS. They are connected to a Jitsi video conference and use OBS to transcode the incoming video call from Jitsi into a livestream to a Peertube server. It is assumed that the Livestream is sent at 720p at 30 frames per second.

Peertube

A Peertube server hosted in a green datacentre transcodes the received video from OBS. It sends the video to a number of peer servers, and broadcasts the stream to connected viewers, primarily Participants. The peer servers also broadcast the stream to any connected viewers.

Cloud Storage on Green Servers

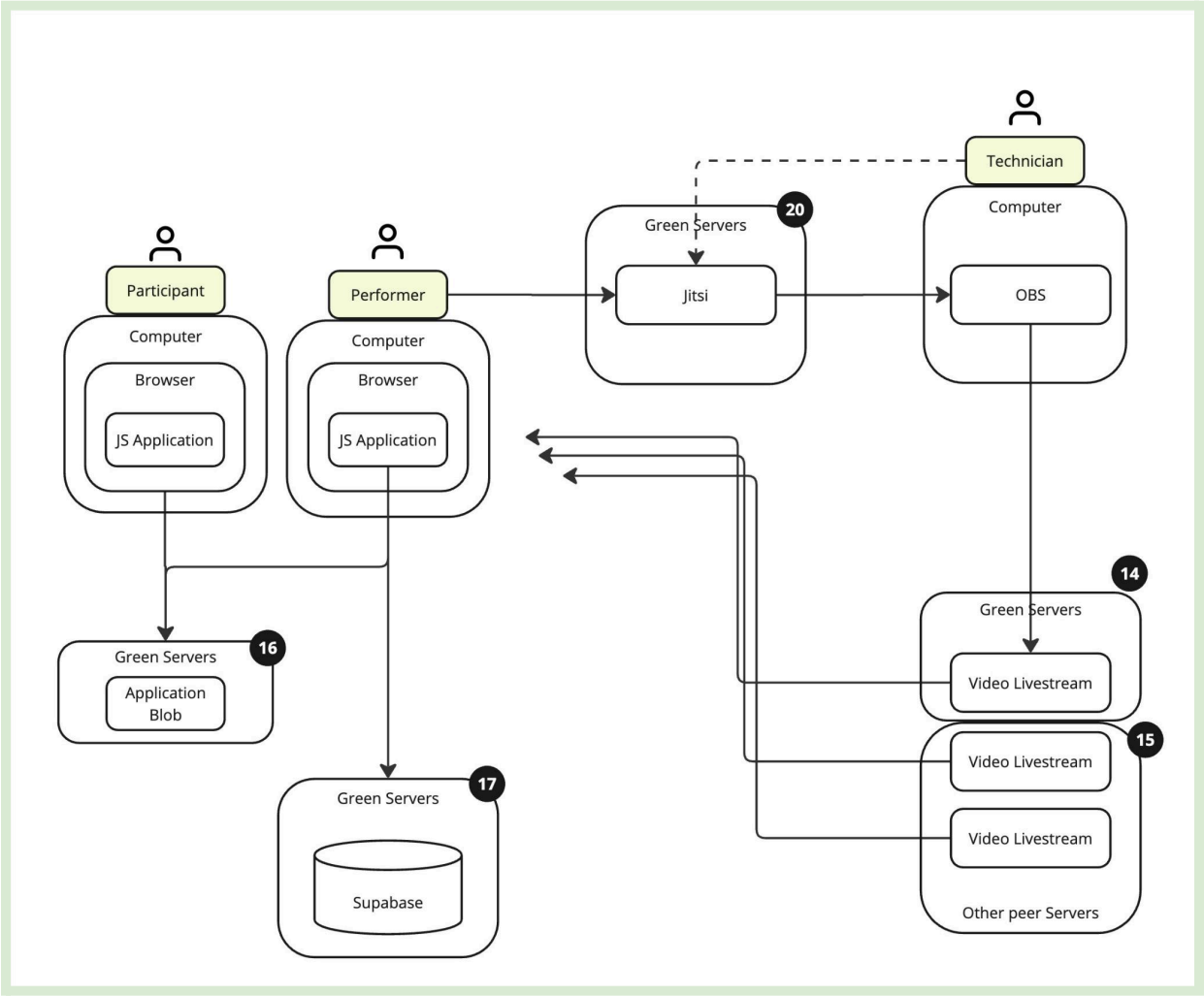
There are a number of sustainable cloud services with various options for hosting an application. See the discussion below for further information. These services will operate much the same as AWS S3 by hosting and serving data from a highly co-tenanted server or cluster of servers.

Supabase

One of a number of options that offer similar functionality to Firebase, and has been used as a specific example. Other options will likely have similar compute requirements and thus similar emissions.

Jitsi

Jitsi is used as the video conferencing service, hosted on a green server. It hosts Performers and the Technician and potentially other users (e.g. Moderators).



Emissions

For these assumptions the emissions of the platform for a two hour performance were found to be 25.90kgCO_2e.

Key Contributors

The main contributors to this total are:

Participants' computer use	9.938 kgCO_2e
Peertube Livestream bandwidth	11.438 kgCO_2e

Comparison of Emissions between Platforms

The following table shows the total emissions of the three analysed options for a performance of 2 hours, with one hour setup.

Platform	Emissions	Difference
Current Platform	21.86kgCO_2e	0
Amazon Web Services	18.63kgCO_2e	-14.7%
Open Source Self-hosted	25.90kgCO_2e	+18.5%

For each platform, the **primary emissions are from the participants' computer use and the energy to send the video stream to users**.

These findings can be viewed alongside research work in similar spaces, for example Carbon Trust's 2021 report on the carbon impact of video streaming which found that home networking equipment and energy from screens comprised the majority of emissions from streaming video.

Table 4. Breakdown of emissions and energy consumption by video streaming process component for Europe in 2020

Video streaming component stage	Emissions (gCO_2e/hour streaming)	Energy consumption (Wh/hour streaming)	% of total
Data Centres	<1	1	1%
Transmission Network	6	20	10%
Home Router	21	71	38%
TV Peripheral	3	10	5%
Screens	25	86	46%
Total	56	188	100%

Removing Computer Use from the Comparisons

If we remove participant and performer computer use from the figures the emissions comparison is:

Platform	Emissions	Difference
Current Platform	9.44kgCO_2e	0
Amazon Web Services	6.20kgCO_2e	-34.3%
Open Source Self-hosted	13.47kgCO_2e	+42.69%

The main components impacting these differences remains the *bandwidth of the resulting livestream to participants*. The calculations for bandwidth have used estimates from AWS, Youtube and Peertube documents and have assumed everyone receives the same bandwidth stream. In reality, modern streaming codecs use dynamic bitrates and the actual usage will be variable. The bitrate of the source stream - and the resulting bandwidth it uses - however is in the hands of the Intrapology team. **Higher bandwidth streams have higher carbon emissions due to their internet traffic.**

Impact of scaling participants on emissions

When we think about scaling participants to, for example, hundreds, we can run a few quick experiments using our assumptions.

Platform	**Emissions at 100 Participants**	Difference
Current Platform	59.88kgCO_2e	0
Amazon Web Services	50.34kgCO_2e	-15.93%
Open Source Self-hosted	71.34kgCO_2e	+19.14%

Platform	**Emissions at 300 Participants**	Difference
Current Platform	168.51kgCO_2e	0
Amazon Web Services	140.98kgCO_2e	-16.34%
Open Source Self-hosted	201.17kgCO_2e	+19.38%

At 100s of participants, emissions become meaningful and running several of these events a year approaches 1T of CO_2e.

Idle Emissions

Whilst the calculations have focussed on the emissions for a given performance, there are idle emissions to consider. These are the emissions from having systems and services ready to respond to user needs at any time throughout the year.

One of the benefits of cloud platforms like Zoom, AWS and Google is that they run resources on an as-needed basis. A drawback of self-hosting is that you lose the economies of scale of those vast global platforms. Thus, it's worth drawing attention to the ongoing energy use of self-hosting a Jitsi server, a Peertube server and a realtime database option like Supabase.

Using some underlying assumptions in the Sources tab of the Data Collection Google Sheet, estimates for emissions for one year of running these servers for Development are:

Application	**Emissions per year ($kgCO_2e$)**
Jitsi	19.2
Supabase	9.6
Peertube	4.8

Fine grained data for Zoom, Google Firebase Realtime Database and Youtube are not readily available. The above estimates are based on 10% utilisation of servers at recommended scale for production use, so a very broad assumption could be that an efficient cloud service would operate at less than 10% of these emissions.

Platform	**Idle emissions for 1 year**	Difference
Current Platform	$3kgCO_2e$	0
Amazon Web Services	$3kgCO_2e$	0
Open Source Self-hosted	$33.6kgCO_2e$	+1020%

Development and Testing Emissions

Intrapology doubtless wants to run rehearsals, test and develop its platforms outside of performances. Emissions for one hour of the different platform configurations with 3 participants, 3 performers and a technician are as follows:

Platform	**Rehearsal for 1 hour**	**Rehearsal for 50 hours**	Difference
Current Platform	1.94kgCO_2e	97kgCO_2e	0
Amazon Web Services	1.73kgCO_2e	86.5kgCO_2e	-10.82%
Open Source Self-hosted	2.24kgCO_2e	112kgCO_2e	+15.46%

Impact in Context

It is necessary to address three things to give these data necessary context. The size and impact of these emissions in the context of your organisation and its size, the vendors and platforms that you can use and their commitments to environmentally sustainable operations and the vendors and platforms that you can use and their social impact.

Total Emissions

The total emissions for your platform we can think of as the sum of your performance emissions, idle emissions and rehearsal emissions.

Platform	**Performances Emissions**	**Rehearsals Emissions**	**Idle Emissions**	**Total**	Difference
Current Platform	87.44kgCO_2e	23.28kgCO_2e	3kgCO_2e	**113.72kgCO_2e**	0
Amazon Web Services	74.52kgCO_2e	20.76kgCO_2e	3kgCO_2e	**98.28kgCO_2e**	-13.58%
Open Source Self-hosted	103.60kgCO_2e	26.88kgCO_2e	33.6kgCO_2e	**164.08kgCO_2e**	+44.28%

The table above is based on an assumption of four performances a year for thirty attendees and twelve rehearsals or test runs of the platform.

- The total emissions for a year range from 98 to 164 kg of CO2 equivalent emissions, if we take a rough midpoint of 130kg CO2, this is equivalent to travelling 563 miles in a medium sized petrol car, or a 714km short-haul passenger flight - approximately London to Inverness.

- We could also imagine that if Intrapology's four performances reach 120 people, the emission intensity is between 0.8 and 1.4kg per participant.

- For comparison, 1kg of CO2 emissions are equivalent to travelling about 4 miles in a medium sized petrol car.

If Intrapology scales to many more participants, the emissions also scale. At the level of 100 participants over four performances a year, the current platform would emit somewhere in the region of 266kgCO_2e, similar to a 1330km passenger flight from London to Madrid.

How Each Platform's Sustainability Approach Compares

Each vendor used to build Intrapology's platform, as well as vendors included in the options presented above take various approaches to minimise their impact on the environment. These are typically because:

- Electricity costs money and being more efficient with energy saves money
- There are legal and regulatory requirements to reduce energy use in many jurisdictions
- Customers and investors are demanding more sustainable vendors

There is a lot being done in this space, but some key things to understand about technology platforms include:

Power Usage Effectiveness

PUE (Power Usage Effectiveness) is a metric that measures a data center's energy efficiency by comparing its total power consumption to the power used by its IT equipment. An ideal PUE of 1.0 means every watt is used for computing, but in practice, values around 1.2–1.5 are considered efficient. Generally, a lower PUE indicates better efficiency.

Example published PUEs include:

- Amazon Web Services (Global): 1.15
- Amazon Web Services (Best EU): 1.04
- Hetzner Average: 1.13
- Google Cloud: 1.10

Renewable Energy

Whilst data centres nearly all use the blend of electricity available on the local grid which may be partly or entirely fossil fuel generated, many have made extensive purchases of renewable energy or fund large-scale renewables projects. These all rely on financial instruments to essentially offset the quantities of "dirty" energy consumed by the data centres.

Claims by all parties should be taken with a pinch of salt since greenwashing in this space is easy and common. The use of REGO and REC certificates, their low price, and subsequent trading has attracted some criticism, though this is by no means the only technique used to obtain renewable energy.

- AWS Renewable Energy: https://sustainability.aboutamazon.com/climate-solutions/carbon-free-energy

- Google Renewable Energy: https://datacenters.google/operating-sustainably/
- Hetzner Renewable Energy: https://docs.hetzner.com/general/others/sustainability-faqs/
- Green Geeks Renewable Energy: https://www.greengeeks.com/going-green

Transparency

We can't always rely on our providers to do the right thing so transparency is important. It allows customers to take the carbon emissions into their own hands by purchasing carbon removals, for example, or finding more efficient ways to run their platform.

Large vendors will now let customers access reports on their carbon emissions. Microsoft Azure, Amazon Web Services, Google Cloud & Google Workspace all have free dashboards. Other vendors are following suit.

Social Impact

Climate change is an intersectional challenge, disproportionately affecting marginalised communities and amplifying existing social inequalities. As environmental degradation increasingly undermines economic stability and public health, addressing climate change becomes inherently tied to social justice.

Vendors have long held social impact as both a banner for both marketing and recruitment. Large US companies publish reports detailing their social impact, including Google and Amazon. Hetzner also publishes its efforts on charitable and social impact causes and can be reviewed below:

- https://sustainability.aboutamazon.com/communities
- https://www.google.org/
- https://www.hetzner.com/unternehmen/engagement/soziales/

Despite their headline commitments, recent rollbacks of DEI (Diversity, Equity, Inclusion) goals within Amazon and Google raise concerns about the underlying commitment these organisations will have under the new US leadership and the extent to which their actions were driven by new legal mandates from the government.

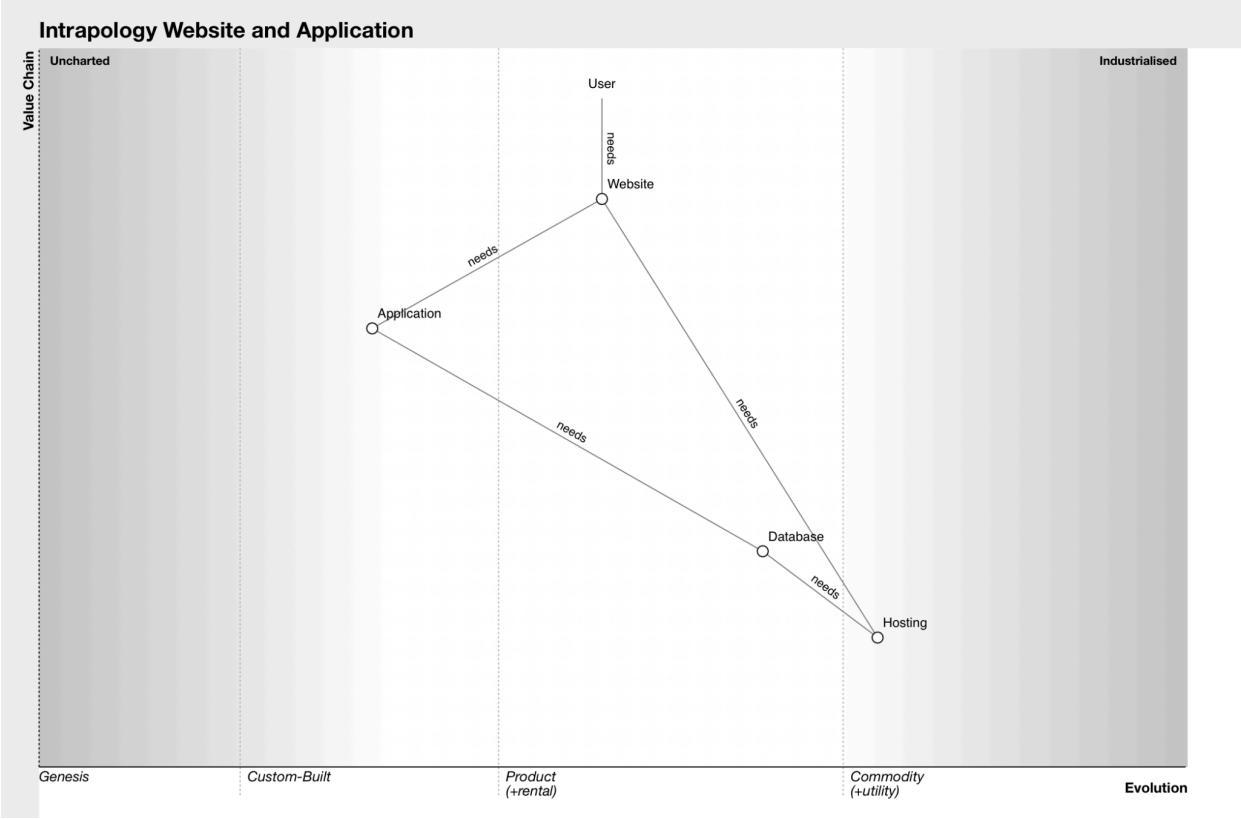
- https://www.theguardian.com/us-news/2025/feb/14/diversity-equity-inclusion-dei-us-trump-google-amazon-walmart

Ways Forward

Just about any activity we engage in as individuals, groups or organisations will necessarily emit carbon as a byproduct. To reduce our impact to zero is to cease to do anything meaningful. With sustainability practices we aim to make it such that our impact is sustainable: the things we use or deplete recover at a rate higher than we consume.

We can also consider the effort it takes to run a platform and how that is largely offset by using well-established platforms. At one end, highly abstracted platforms like Google Firebase or Zoom or Youtube are able to spend a lot of time and effort to make their systems run as efficiently as possible. To what extent can Intrapology manage that same feat? Is that worth the potential differential in social impact between something like Hetzner where you manage the underlying instances and AWS where services are abstracted to API calls.

One illuminating perspective might be to look at a Wardley Map for just the website, the application and database.



This map plots four of the components of your platform on two axes. Vertically, the closer to the top we are, the closer to the user that component is. So, the Intrapology website is right next to the user, and everything else the user interacts with is via the website.

The x-axis, from left to right, plots how evolved that component is in the market. For a very bespoke, hand-written application like Intrapology's, we can consider that to be "custom built". For "Hosting" which is a highly mature, almost utility product (like Electricity is a utility), we place it further to the right.

Since we want to be efficient and spend more time creating and doing wonderful new things, **it is best to focus on the unique aspects of Intrapology's offering** - the application, the

creativity of the experiences. We would want to avoid doing anything that brings the hosting or the database into the hands of Intrapology staff who could be contributing to custom-built, bespoke technology.

Essentially, the message is don't put yourself in a position where you are manually managing technology that other people can manage on your behalf.

You can read more about Wardley Maps, or there is an entertaining talk from the creator over on Youtube.

Suggestions

Video Conferencing

Stick with Zoom. The carbon emissions from the platform are minimal, you have very low idle-costs for using it, and the majority of emissions come from bandwidth associated with making video calls.

You can read about Zoom's own perspective on sustainability here: https://www.zoom.com/en/about/esg-fy2024-impact-report/?cms_guid=false&lang=null

Live Streaming

YouTube is another platform that is nearly zero idle cost and emissions are primarily related to bandwidth and transcoding of live video streams during performances. I would be inclined to remain with the platform.

If the social impact issues and changes to DEI policies at Google are of sufficient concern then I would explore Peertube with the caveat that the Peertube server, and associated emissions, are stopped outside of the times it is needed.

I would consider hosting this with a cloud service like Hetzner in order to maximise renewable energy use.

Website

The emissions from storage for a website are low but there is no information on how neocities co-hosts its sites. It is likely highly co-tenanted with lots of sites sharing a single physical or virtual machine.

The only places likely to be more densely co-tenanted are services like AWS S3 which comes with the benefit of Carbon Emissions reporting, but the drawback of their new stances on DEI.

Firebase Realtime Database

This is a unique service and no other cloud vendor quite adequately replicates it in a “single shot” without requiring Backend APIs to proxy queries to the vendor’s database service. The emissions are likely very low, too, given Google’s ability to co-tenant users densely.

I would not be inclined to try to move this unless there was a technical reason to, since any alternative will likely be less sustainable, more management overhead or both.

The Get Out of Jail (Nearly) Free Card

If the aim is to balance sustainability, manageability and social impact - are there any other routes forward? Can we take sustainability out of the equation and make the decision based on manageability, flexibility, price and social impact?

One option could be to address the emissions from the Intrapology platform directly. Given an annual footprint of **113.72kgCO_2e** (see Total Emissions section, above), are there avenues open to removing those emissions from the atmosphere?

Creative Options

One option could be to engage audiences to commit to helping offset your emissions through behaviour change. An example of this could be for participants to commit to a week of not eating meat. For a medium-meat eater with a 2TCO_2e annual carbon footprint from their diet, they could save nearly 12kg of CO2. And Vegetarians needn’t feel left out! Going vegan for a week could save 7.5kgCO2 over a vegetarian diet.

Of course, there are other creative options, flying less, walking and cycling instead of driving. Given the modest emissions of the performance and the ability of people to commit to change if it’s a small one and time limited, this could be a good option.

Commercial Options

The other option could be to purchase carbon removals to equate to your estimated emissions. Not to be confused with carbon offsets, carbon removals use a variety of techniques to actively remove carbon from the atmosphere. They often rely on technology and are frequently in the early stages of trying to scale. Costs range from $100/T to thousands. There are also forestry-based interventions which offer less assurance that carbon has been removed but the money contributes to vital work in reforestation and preventing deforestation worldwide and in the United Kingdom.

Appendix

How to use the Google Sheet

The Google Sheet is located at:

https://docs.google.com/spreadsheets/d/1NmmqwN3JZ4Y3qMFmaOP1KMmFe4bKo7pr9lOzhw2ZTz0/edit?gid=1719206701#gid=1719206701

Make a copy before playing with the document!

The sheet consists of three main tabs with two tabs used for scratch, disposable, analysis.

Assumptions

This tab contains a series of assumptions that will live-update the summary boxes to the right of the assumptions. If you want to see what emissions would look like with 300 participants, you can see.

Bear in mind there are no saved list of assumptions anywhere so you could take a copy before you start playing around!

Comparisons

The comparisons tab contains the data calculations for the carbon emissions of each platform. It's not intended for editing.

Sources

The sources tab contains the source data for many of the calculations. They will usually include links to source documents or tools online.

Terms Used

$kgCO_2e$

Kilograms of Carbon Dioxide Equivalent ($kgCO_2e$) is a standardized unit used to measure the impact of different greenhouse gases in terms of their global warming potential relative to carbon dioxide. It accounts for gases like methane and nitrous oxide by converting their effects into the equivalent amount of CO_2 over a given time frame, typically 100 years. This metric helps compare and assess the climate impact of various activities, products, and industries.