



On1ign

EXP

How might we shape the future
of a greener Internet?

Lu Ye
2020



Royal College of Art

IDE
INNOVATION
DESIGN
ENGINEERING

**Imperial College
London**

EXECUTIVE SUMMARY

Onlign is an experimental project on addressing the issue of the environmental impact of the Internet, specifically from an end user point of view. Facing the urgency of climate change, this unexpectedly emission-intense and fast growing sector should be taken seriously from now. The nature of the Internet has made its sustainability aspect both challenging and transformable. On one hand, it's even less tangible and visible than other form of consumption like lighting and heating. On the other hand, the value, perception and need for the Internet can be very flexible.

During my research, I sought to discover opportunities to leverage user behaviours and the flexible nature of the Internet usage to minimise the environmental impact. I examined the roles that different parties are playing in the current Internet system. From the weak signals and inspiration from inside and outside the industry, I defined the goal of impact to be minimal carbon footprint or carbon-aware usage of the Internet. This is becoming meaningful as more Internet infrastructure is pushed to adopt more renewable energy. The work then focused on understanding how end users could align their behaviours according to the availability of the intermittent renewable energy.

There are two final outcomes by the end of the project. The first outcome evolved from an advanced experiment and went through user validation: a near-to-today proof of concept in the form of a browser extension. The second outcome is design speculation as a result of further applying the insights from the exploration process and POC to various Internet usage scenarios. It takes the form of an operating system that demonstrates a minimal viable carbon-aware everyday Internet experience. With the design speculation I aim for visualising a preferable future and presenting an invitation to designing internet applications that lead to thoughtful consumption and minimal carbon footprint.

CONTENT

ACKNOWLEDGEMENT	04
STATEMENT OF ORIGINALITY	04
INTRODUCTION	05
RESEARCH FRAMEWORK	07
Project Ethos	
Understanding the system and state of art	
EXPLORATION	13
Prblem Framing	
EXP	
Manifesto	
EMBODIMENT	24
Delivery Strategy	
Proof of Concpet	
Design Speculation	
CONCLUSION	38
REFERENCE	39

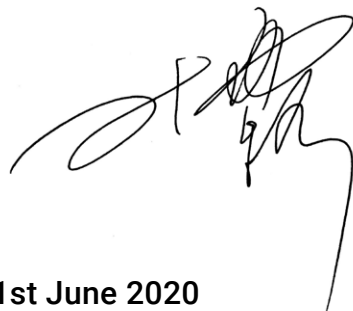
ACKNOWLEDGEMENT

I would like to thank my IDE peers, tutors and alumni who helped me in experiments and accompanied me in this difficult time and experts who offered valuable feedback and suggestions.

STATEMENT OF ORIGINALITY

I confirm that except where otherwise indicated in the text, all other parts are my own original work.

Lu Ye



1st June 2020

INTRODUCTION

“When the Despacito music video reached a record-breaking five billion views on YouTube in April 2018, it also burned the same amount of energy as 40,000 US homes in a year.”¹

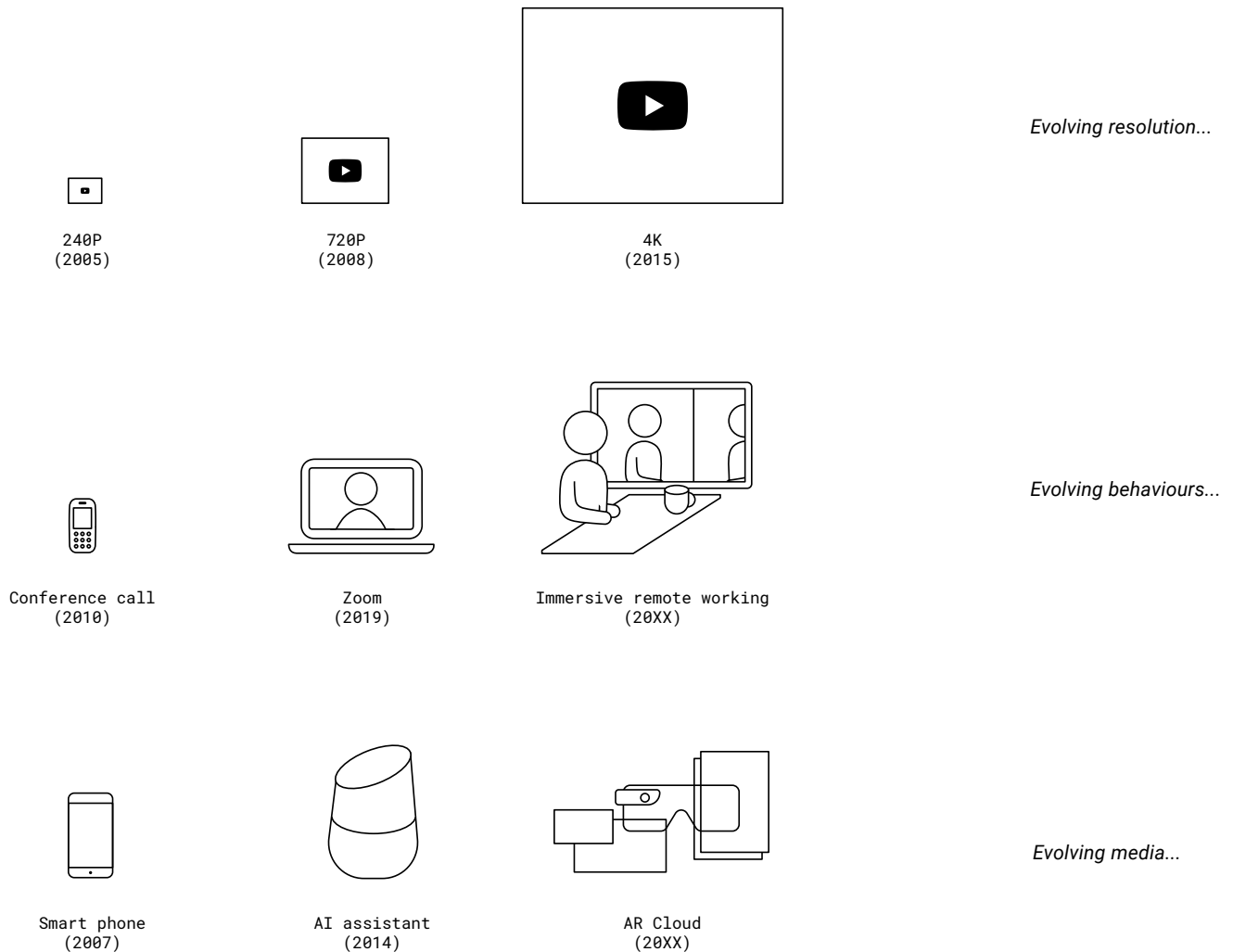


(Credit: Getty Images/Javier Hirschfeld)

Despite the illusion that the Internet related and smart products and services are always resource-saving, the Internet has a startlingly large carbon footprint. The ICT industry accounts for the same amount of global emission as the aviation industry today². The huge amount of energy is used to power the 24/7 growling data centres, network infrastructure, consumer device and so on³. In 2017, Greenpeace estimated in its Clicking Clean study that data centres could account for around 13 percent of global energy demand in 2030⁴.

Yet, it's so intangible and far away for people to be even aware of its impact. When you sit cosily in front of your computer streaming an one hour Netflix episode, the energy consumed by the data centre⁵ and data transmission⁶ behind the scene is able to power your table lamp for 100 hours.

The increasing demand plays a fundamental role in the growth of the Internet environmental impact. The ever developing technology offers higher volume, speed and resolution of content and information, fostering the seemingly necessary consumption. Despite the improvement of energy efficiency, it's hard to suppress the growing impact of the Internet without confronting the demand itself. Facing the urgency of climate change, new systematic approaches, mindset and paradigm should be explored before this giant invisible machine runs completely wild.



This project explores the potential of the role that Internet end users could play, and how design of tools, interfaces, devices or applications could shape carbon-aware Internet experience. A hypothesis is made based on the current signals: the Internet should be powered mainly by renewable energy. EXPs, co-creation workshops and different forms of ideation were carried out through the project to gain understanding of the boundary and opportunity of changing Internet related behaviours in current norm and possible future scenarios.

RESEARCH FRAMEWORK

Project Ethos

“When technological progress increases the efficiency with which a resource is used, the rate of consumption of that resource will rise instead of falling due to increasing demand.”

—Jevons Paradox



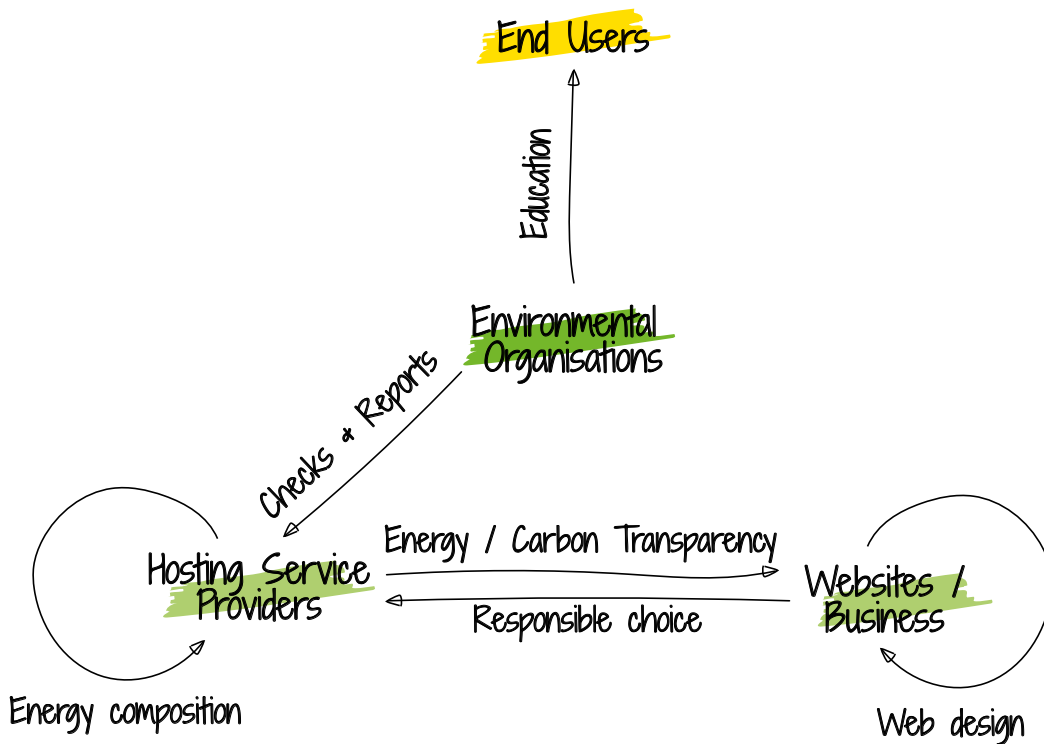
The Project Ethos is an installation demonstrating my understanding of a dynamic of availability, demand and consequence. The two bottles are filled with the same amount of beer. The left has a bigger hole on the bottom, so the beer flows fast, while in the right bottle the beer comes out drop by drop. When I ask people to choose from some cups to place below the two bottles, they tend to place a larger cup on the light and a smaller on the right. Among the cups I prepared, larger one are crappy, one even made of tissue paper, while the small one is delicate. However, it doesn't change the result of a bigger cup ends up on the left, witnessing a fast run-off of the beer.

As Jevons Paradox indicates, the increased availability doesn't solve the energy problems. In fact, it only leads to more, if not over, consumption, even though the demand might be *crappy* or *fake*.

In this project, I take the position of the demand side to explore future possibility to deal with the issue of the Internet environmental impact. How might we develop a future alternative solution that empowers the end users to contribute to a greener internet — potentially a new norm of using the Internet?

RESEARCH FRAMEWORK

Understanding the system and state of art



01 Environmental Organisations

"One day, the Internet will run entirely on renewable energy." —Green Web Foundation

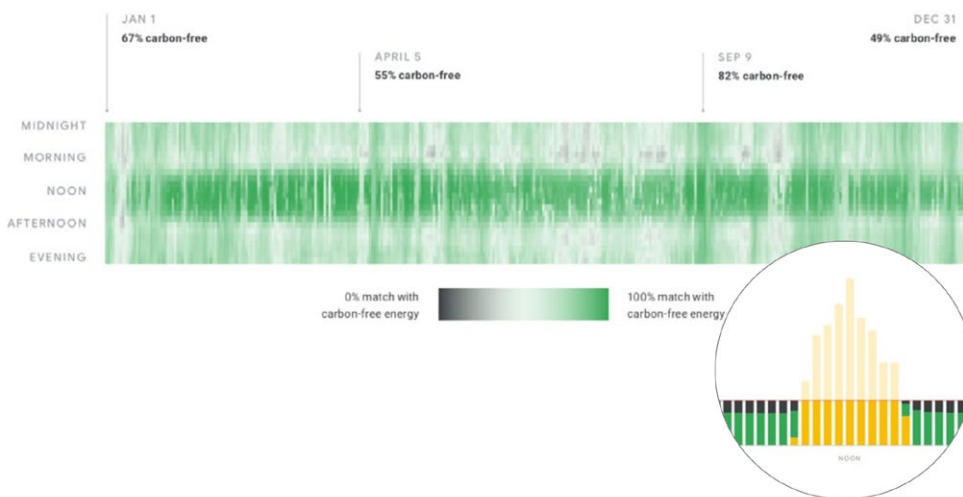
Environmental organisations are calling on Internet companies to lead the way in renewable power. Greenpeace publishes annual report on major companies' adoption of renewable energy, while Green Web Foundation, The Shift Project and Wholegrain Digital develop database⁷ and tools to visualise the kind of energy that powers websites and the carbon footprint of different website weight⁸. The general direction they are pushing for is more renewable energy and more sustainable web design.

02 Hosting Service Providers

The Leading

Large Internet corporates including Google and Microsoft have set goals of achieving carbon neutral or beyond as their long term commitment of sustainability. The first step is to purchase renewable energy to match their electricity consumption. It means buying Renewable Energy Certificates that represent the environmental attributes of the power produced from renewable energy projects, complement by self supporting renewable projects. However, even they have seemingly reached a goal that can be described as 100% renewable powered by offsetting, it doesn't mean they're not providing the services based on fossil fuels at all. There's still effort to make.

Google is striving towards 24x7 carbon-free data centres, meaning that hourly electricity use is met by hourly carbon-free electricity supply on the regional grid at all times, in all places, despite the intermittency⁹. Progress is made through more purchase, developing energy efficient technology and, more interestingly, shifting the load according to carbon intensity¹⁰.



A data centre Carbon Heat Map (Google, 2017)



Carbon-intelligent computing platform (Google, 2020)

The Radical

At a far smaller scale, Low Tech Magazine developed a website that is completely solar-powered and self-hosted¹¹. It runs on a solar panel on the authors' balcony with its own energy storage, and will go off-line during longer periods of cloudy weather. This experiment-like project has demonstrated less than 100% reliability is essential for the sustainability of an off-the-grid solar system due to the environmental downside of batteries.



<https://solar.lowtechmagazine.com/>
(Kris De Decker et al., 2018)

In Between

Switching the power supply to green energy and establishing decentralized generation to support self-sufficiency are among the strategies raised by hosting companies and energy providers. Under the rising energy consciousness and the transition to a cleaner energy source, there's a growing market in on-site renewable energy generation for data centres, both for critical and primary use¹². With the trend, a sensible anticipation can be made that the greenness of data centre will be more directly relative to the exact local generation in terms of amount and time.

03 End Users

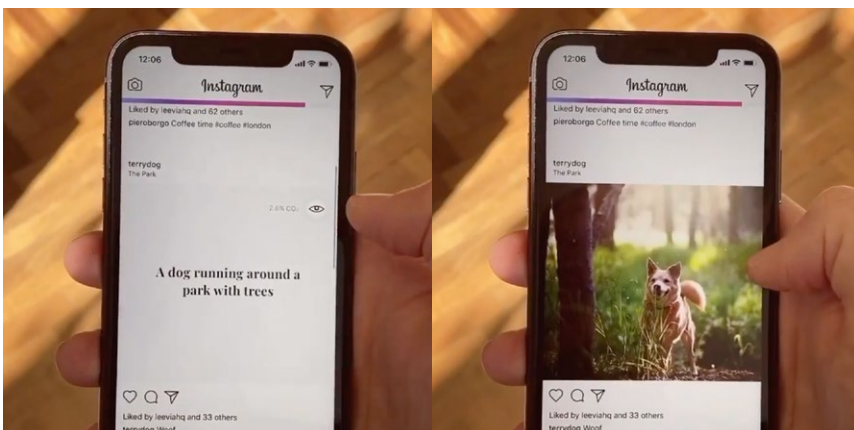
Generally, the public has not been aware of the environmental impact of the internet. While energy consumption has long been recognised as intangible to perceive and influence conservation behaviour, the energy use or carbon footprint of the Internet is even more intangible¹³. Unlike household use, the actual consumption of the Internet is more centralised and distant from the users. Besides, the exact amount of electricity consumed by a single online behaviour is hard to calculate. Yet, environmental organisations are trying to make it understandable by two approach: marking a specific website as environmental friendly or not(according to its adoption of renewable energy), and linking the energy or emission to the volume of data consumed. The incredible accumulating impact of video streaming(60% of global traffic) and social media is highlighted¹⁴.

Is the current transparency delivery working? The visualisation tools by the environment organisations have reached a very small portion of the internet users. From my own experiment with Carbonalyser by The Shift Project¹⁵, participants reported inability of changing behaviours with pure visualisation instead of a different functioning behavioural model.

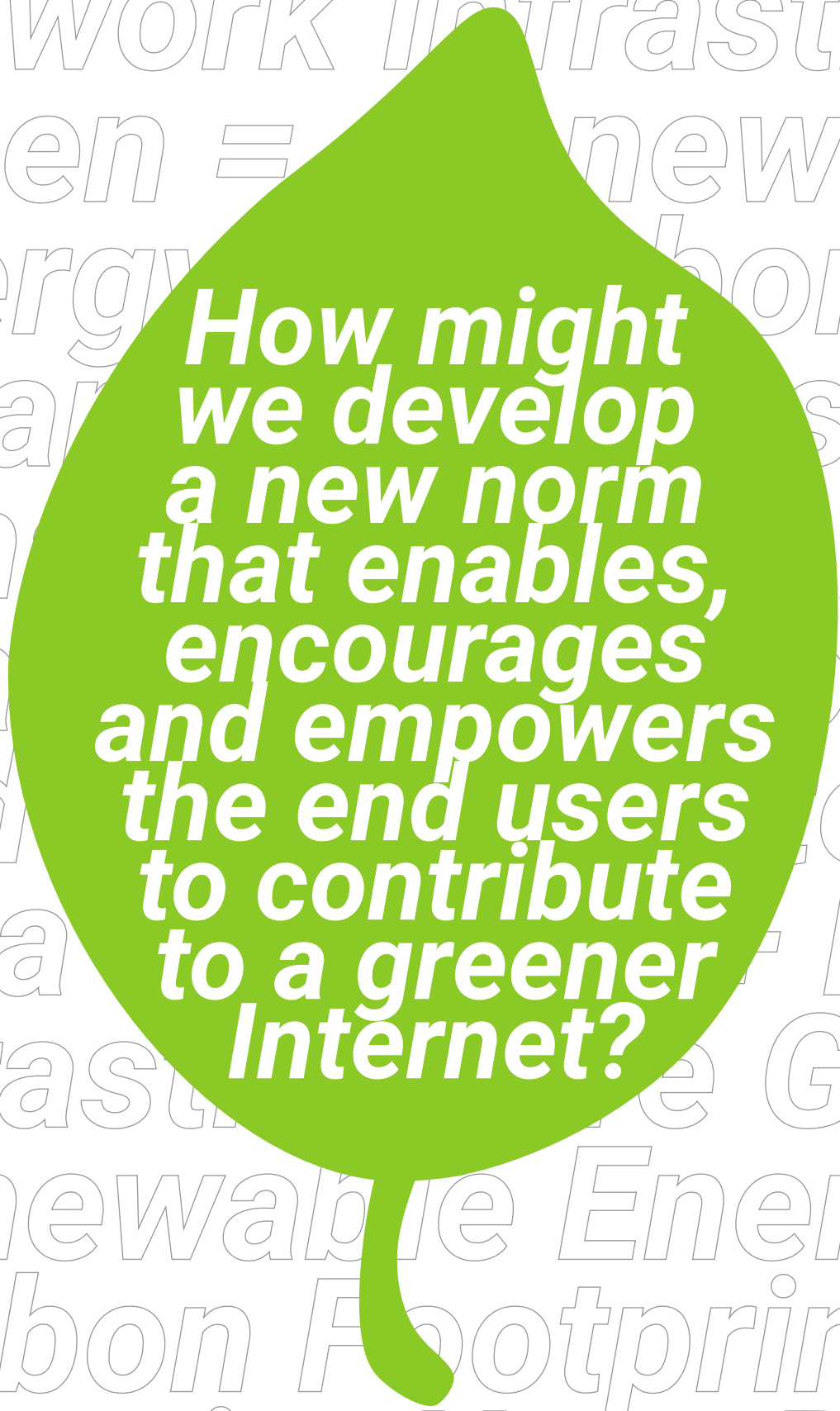
	The Green Web		5,844 Users
Offered by: www.thegreenwebfoundation.org	Carbonalyser by The Shift Project		
★★★★★ 22 Social & Communication 833 users			

Existing tools and user base

Can design make users to think twice of their consumption and real need? One experiment by design studio Normally sketched out a speculation of putting daily carbon footprint allowance to Instagram and use image/facial recognition to describe photos and then allow users to reveal the content they're actually interested in¹⁶.



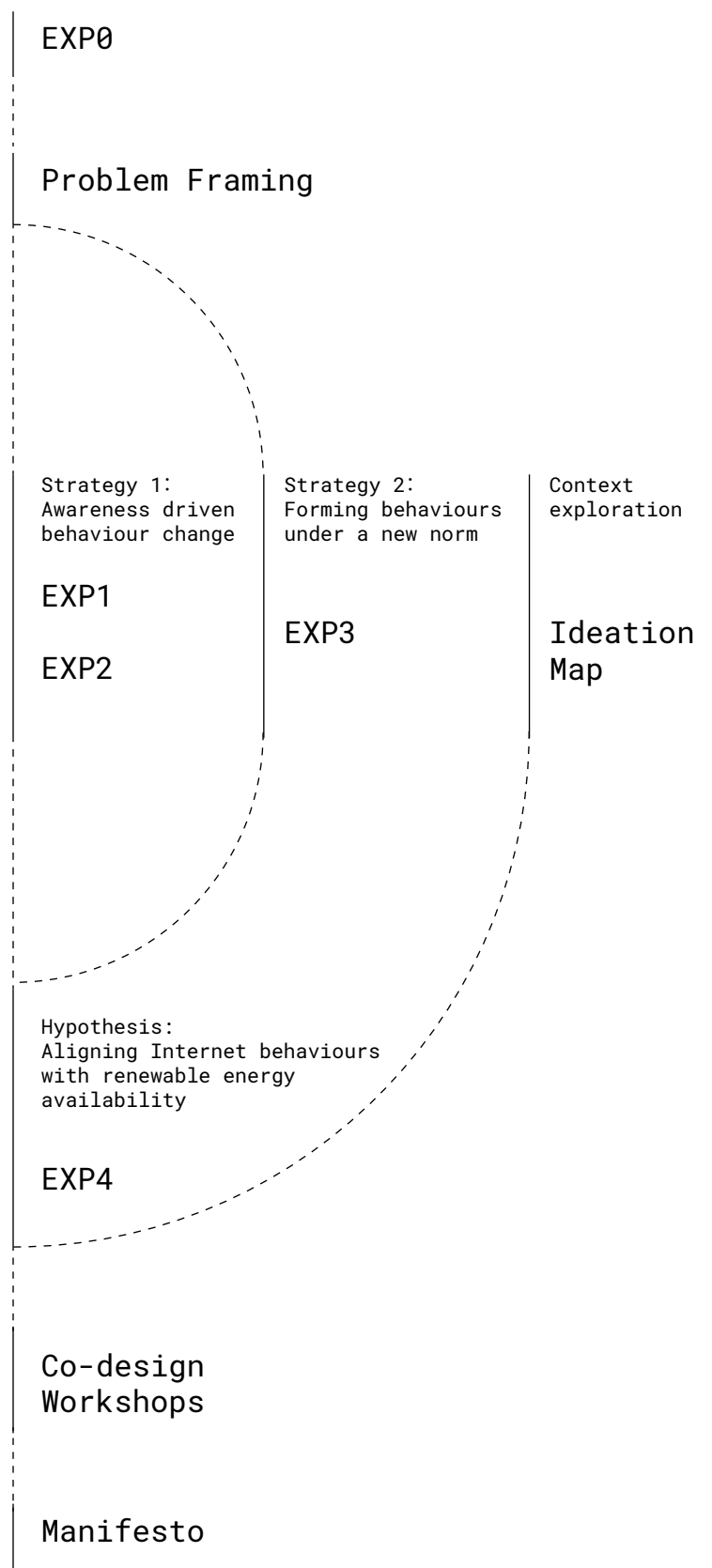
*The carbon cost of data
(Normally, 2019)*

A large, vibrant green speech bubble is centered on the page. It has a rounded, organic shape with a small tail pointing downwards. The text inside is white and bold, posing a question about developing a new norm for a greener internet. The background is white with faint, light-gray outlines of various terms related to technology and sustainability, such as 'Internet = Data Center', 'Network Infrastructure', 'Green = Renewable', 'Energy', 'Carbon Footprint', 'User Behavior', and 'Real-time'.

How might we develop a new norm that enables, encourages and empowers the end users to contribute to a greener Internet?

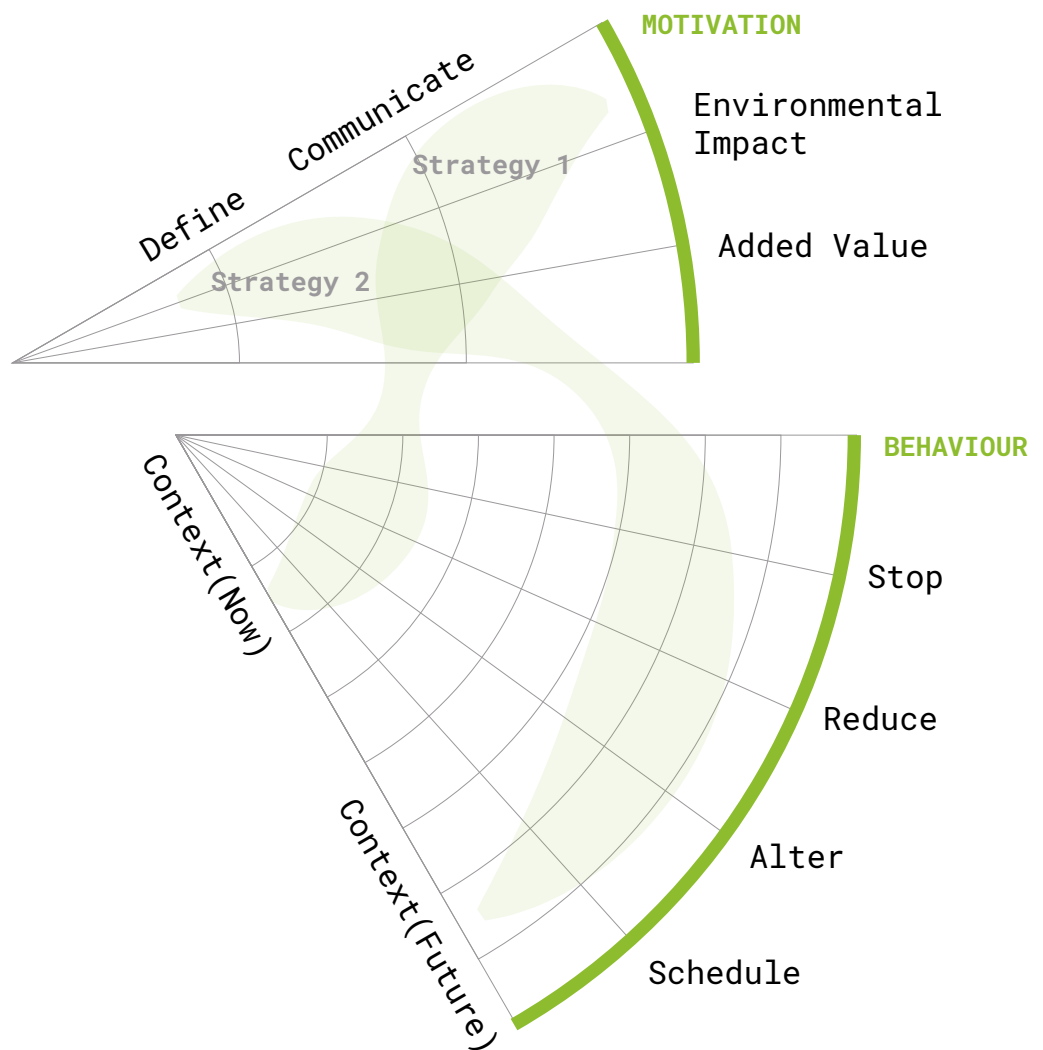
EXPLORATION

Exploration Journey



**“Hey, may I ask you a question?
What if someday in the future you could only use internet
for an hour per day? What would you do with it and why?”**

Problem Framing

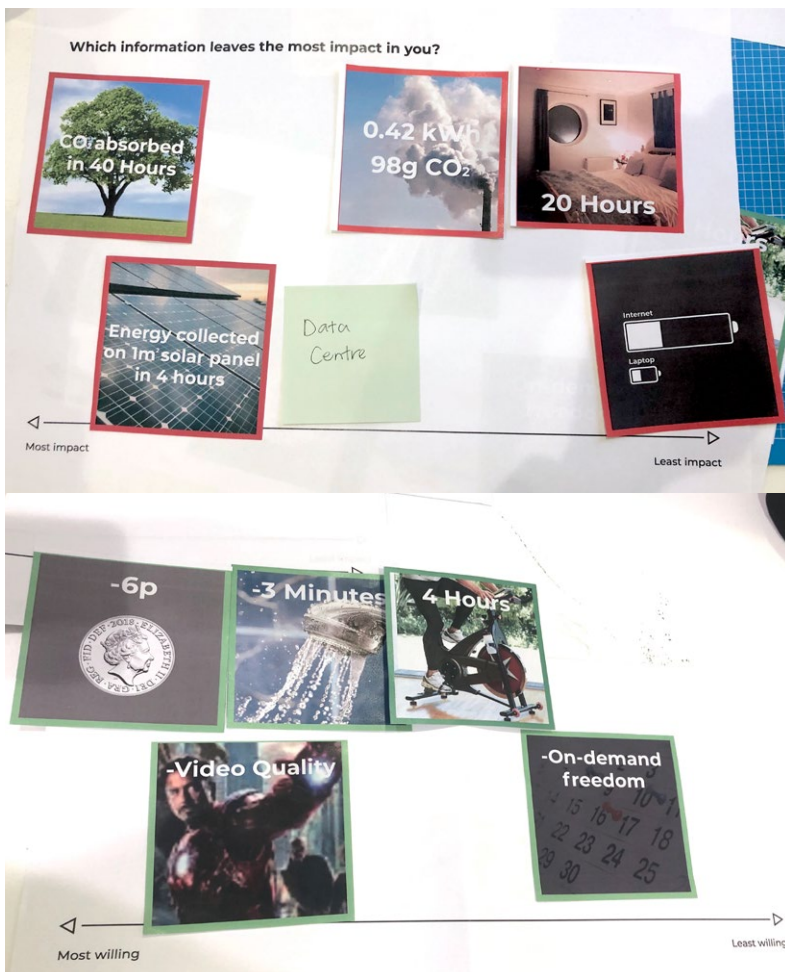


EXP

Strategy 1: Awareness Driven Behaviour Change

EXP1

I invited 10 people (aged 20 to 30) to participate in my one-on-one sessions focusing on understanding how they would feel and might do given more information and choices of their Internet use. First, their current Internet usage profile were outlined by the time they spent in different categories of applications. Then I used card activities to assist a conversation with the participants about their perception and attitude.



Sustainability-aware
Empathic to the nature
Willing to reduce carbon footprint
except for working
Using or used Internet before under
some sort of constraint

"I don't mind living with a limit by scheduling and being cautious of my consumption, especially if it mostly aligns with my routine."

A

Sustainability-aware in general
Not motivated to sacrifice quality
or freedom of Internet

"But I will be happy if the environmental good is an extra benefit of what I need to do anyway."

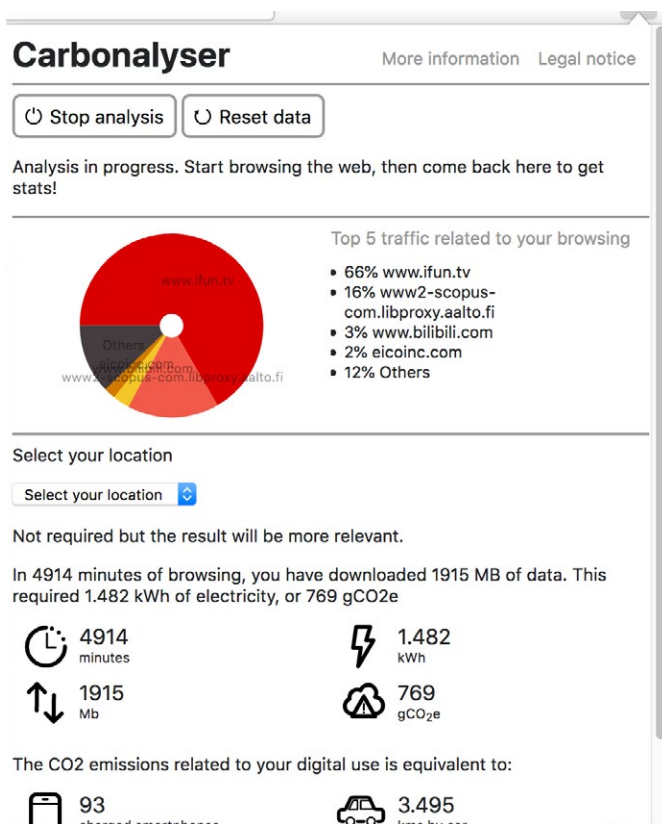
B

Strategy 1: Awareness Driven Behaviour Change

EXP2

Carbonalyser is a tool by The Shift Project, an environmental organisation that has long researched in the environmental impact of the Internet industry. This browser extension visualises the electricity consumption and greenhouse gases emissions that the user's Internet browsing leads to.

I asked 5 people to use it for 5 days and report their feelings and change in behaviours(if any). A self scoring was used to understand their overall habit and lifestyle of sustainability: 1 - Care about sustainability and take actions in every aspect of life; 5 - Don't care about sustainability at all.



A

2/5

"I feel guilty seeing the numbers. But I will keep browsing even the data intense websites for work."

3/5

"It's more energy than I thought. At beginning I felt guilty, but after the first day it couldn't push me to change my behaviours."

"If I got anything from it, it was spend less time on the internet' which isn't going to help me."

B

Suggestion of how the user can better, instead of stop using the Internet

Specify data per time to give a better understanding of different behaviours

Strategy 2: Form Behaviours Under A New Norm

EXP3

What if one day we had to live with a nature-controlled Internet?

I invited 10 people to participate in my one-on-one sessions to go through 5 scenarios in this speculative Internet. Participants were presented with images, videos and audios as the experience mockups. Information of power source, weather and time is provided to complete the contexts.

When a high tide hour ends your video becomes laggy

Get extra download speed during the most sunny time



Alexa becomes stupid in a hot day!

During the night you can't post on Instagram

People feel lacking sense of control because they can't blame the nature.

"If my Internet was just cut off because the wind is not blowing, I must be less annoyed (than knowing a company or an engineer is not working hard) but more frustrated."

People feel more connected to the nature and more empathetic for the energy-requiring artefacts.

"It really makes me think about resources. We might really have to live like this if we keep torturing the earth."

"I feel sorry for Alexa [being unbearably slow in a hot day]. But also I feel happy that finally she does something like a human." but more frustrated."

The nature-controlled scenarios make people rethink their need, priority and digital wellbeing.

"If the tide faded at 11:50pm, also I might be aware that I should go to bed."

Hypothesis:

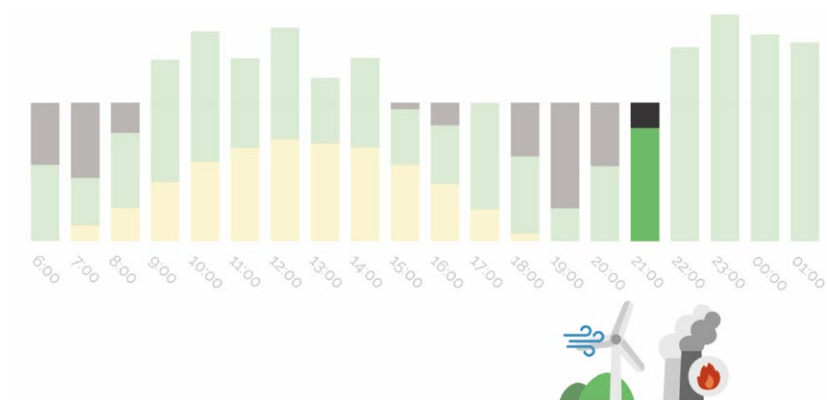
In the future people should align their Internet behaviours with renewable energy availability to minimise carbon footprint.

EXP4

To further explore the idea of carbon-aware Internet use in online browsing(laptop/PC), I invited 5 people(3 young professionals, 2 students) to use a simple tool. Referring to the framework from Google, the chart and icons showed the energy composition of the Internet(simplified) at the moment. A webpage was built to visualise the energy composition, together with a simple demonstrating the data consumption fact of different activities. A google form was embedded in the same webpage to let people log their behaviours. Participants were ask to keep the webpage open, check it whenever they started or finished an activity and log it.

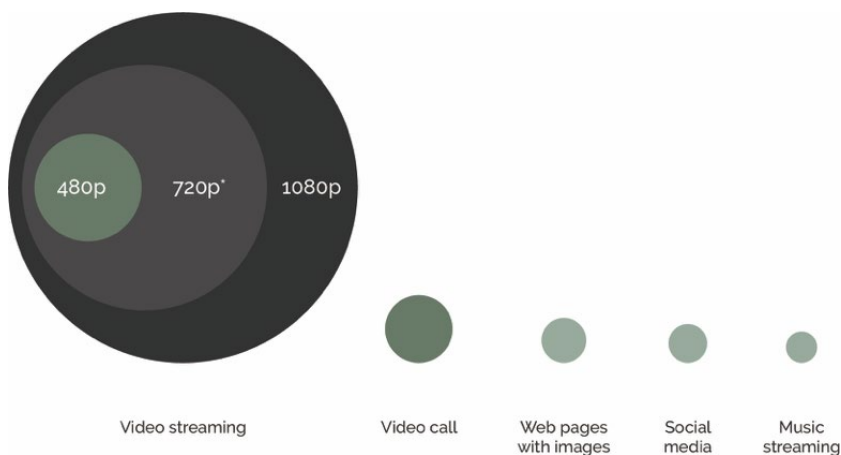


Keep the page open and log your internet use!



The Internet is now powered by **fossil fuels** and a **mild wind** in UK and Ireland.

Watch out for how much data you're using.



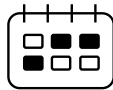
This EXP prototype constructed a simple recurring journey:



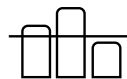
Although the tool was very low-fi and didn't have the well designed interactions built in, the EXP revealed a couple of features to be developed:



Realtime indication of energy status and change of status



Freedom of choosing the time or activities that are included in the behaviour change.



Forecast of the energy status over a period of time.

Besides, some participants reported the influence this EXP brought to them:



More aware of time spent on each activities

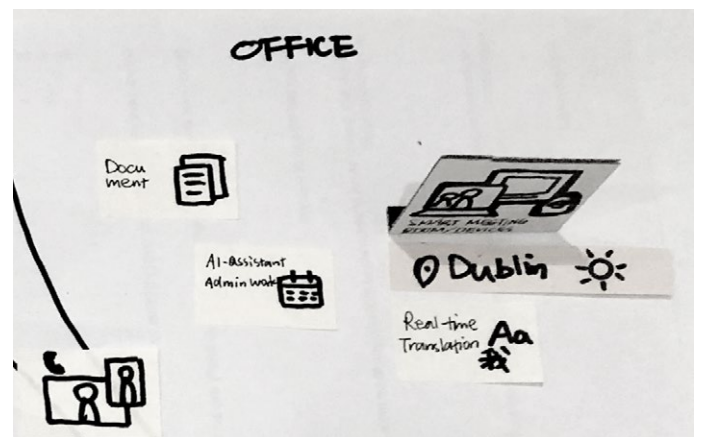
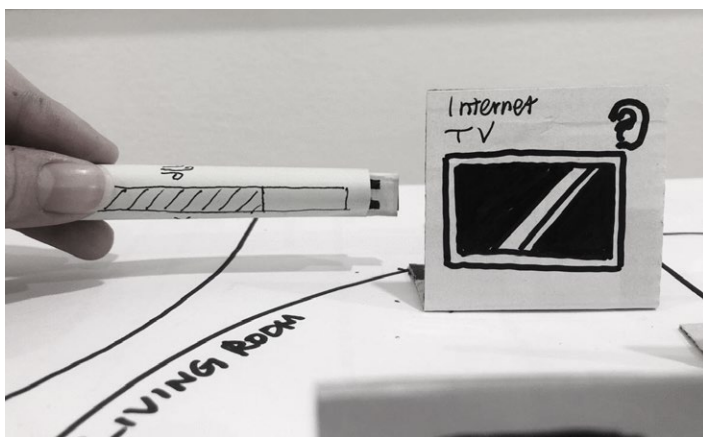
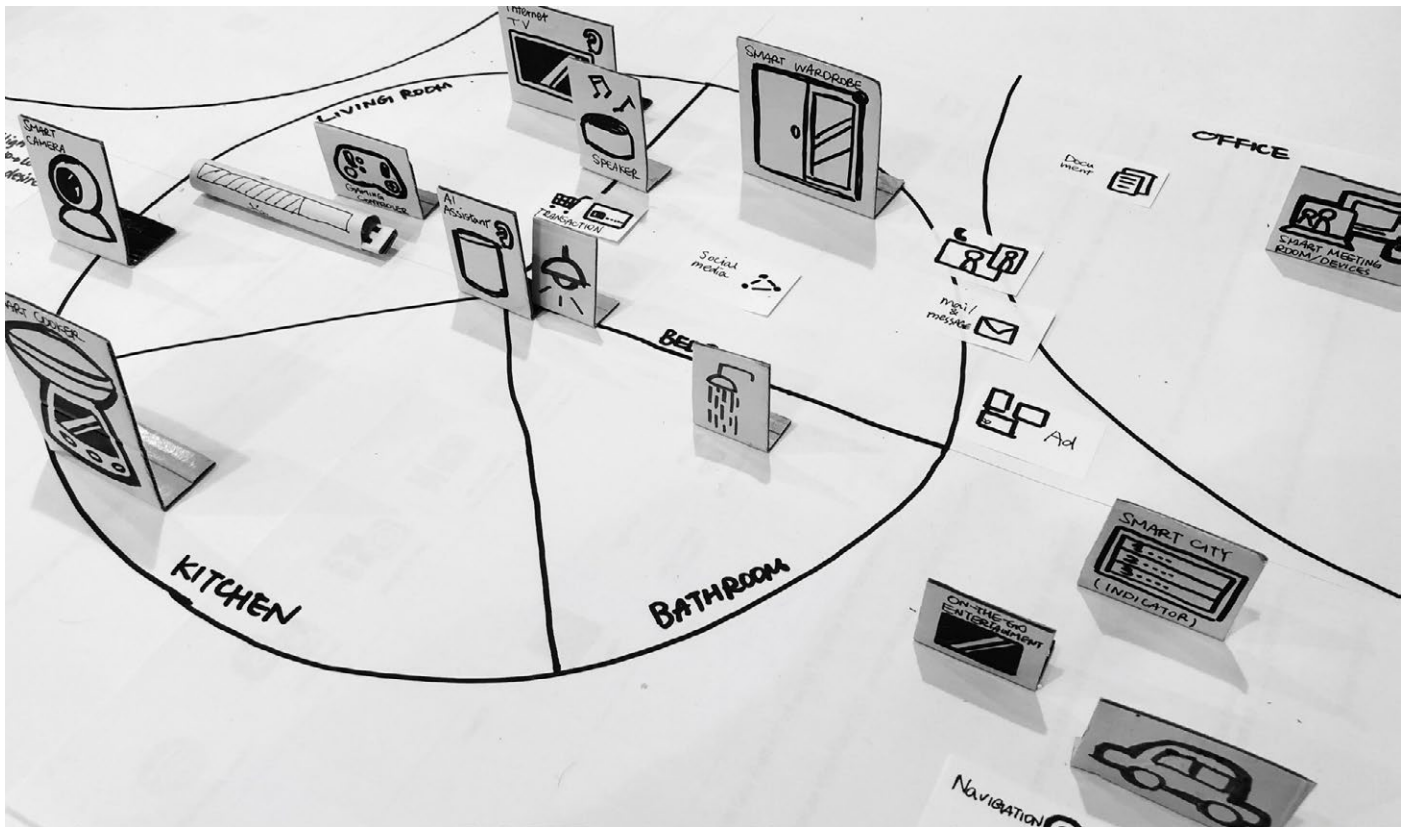
"This tool could potentially help me with my productivity."



A contrast in emotion between seeing renewable icon and fossil fuel icon was obviously felt.

Context Exploration: Brainstorming broader Internet scenarios, from now to future

Ideation Map



01

Mue is my smart personal music and podcast system. I put Mue Speaker in my bedroom. In the morning, Mue Speaker wake me up with a customized alarm, my favourite energy song for weekdays and a light music for weekends...

02

Zoon is the smart office system that my company is using. First of all Zoon is a planning assistant for all the staff. Recently I'm working in a team of 5 on a design research project for a client...

03

With Netflix, I can stream my favourite series everywhere, in the best experience. At home, of course, I will choose to watch the video on the Internet TV, or if I'm on bed I can use my pad for a while...

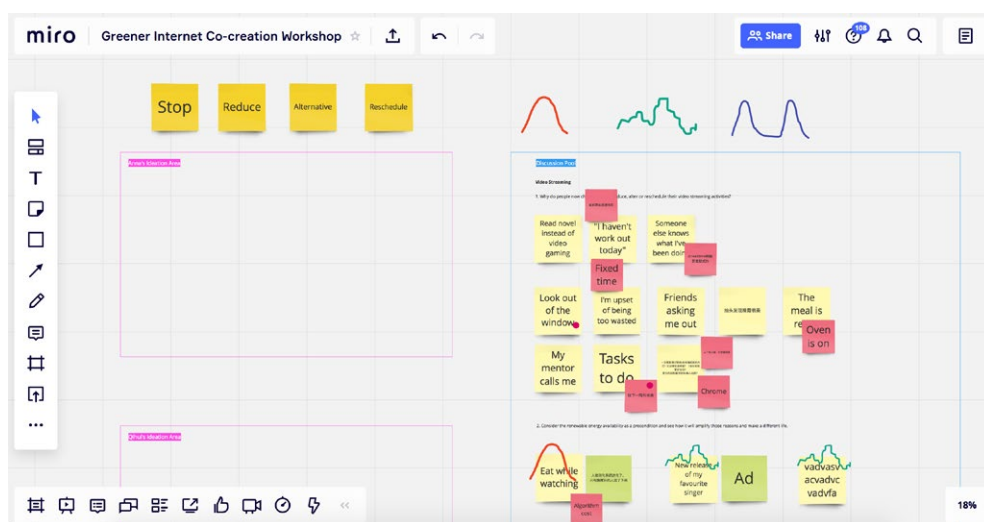
.....

Hypothesis:

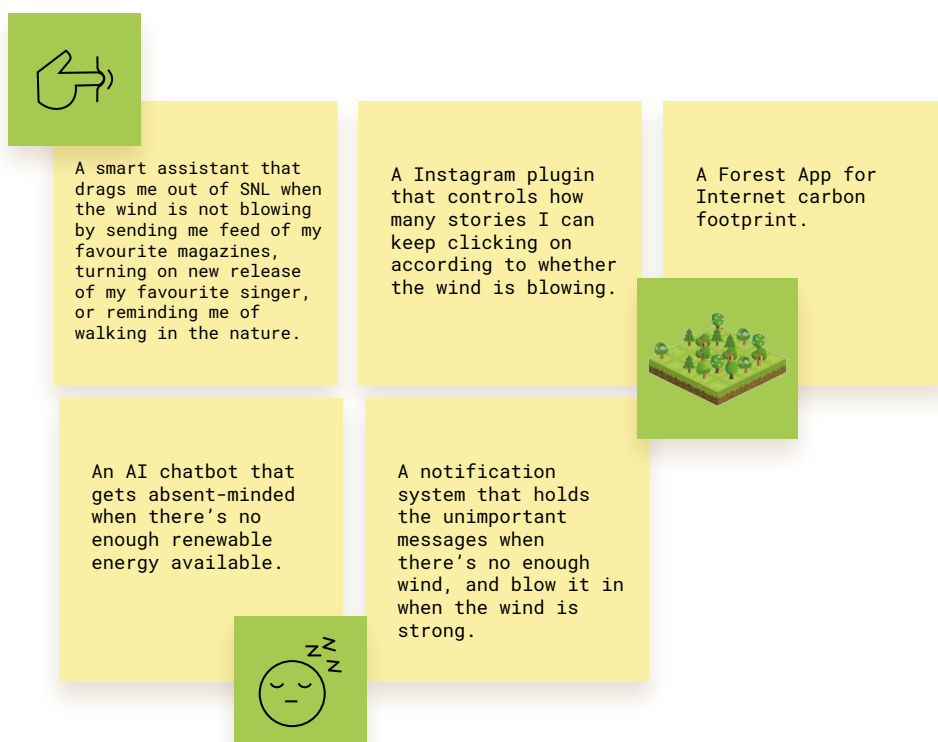
In the future people should align their Internet behaviours with renewable energy availability to minimise carbon footprint.

Co-design Workshop

To further explore behaviour change opportunities and different scenarios, I conducted 4 online co-creation workshops. The first part of the workshop focused on video streaming, a popular data-hungry activity, to understand the current triggers of stopping, reducing, altering and rescheduling. In the second part, I guided participants to brainstorm on how might applications or tools be designed to align different renewable energy availability patterns: solar, wind, tidal.



Online workshops via Miro
3 people per workshop



Some ideas from the workshops

Manifesto

Today's Internet is designed and engineered to be 24/7 available, shaping the 24/7 online Internet users. Facing the urgency of climate change, new systematic approaches, mindset and paradigm should be explored before this giant invisible machine runs completely wild.

A sustainable Internet ecosystem must consist of responsible hosting service providers, business runners, web designers, and most importantly, Internet end users. The need for consumption is stubborn yet not unalterable. Interaction, experience and system design will visualise and start a discussion around the route to a preferable future:

***A renewable energy dominant
user engaged
carbon-minimal Internet***

The following design principles set boundary and help me design carbon-aware Internet experience.

Design a negotiation.


Both the environment and the user have a say in shaping the behaviour being stuck to. The environment, represented by the carbon intensity of the Internet applications, sets a baseline in time and consumption mode. The user inputs preference and is given certain sense of control. The negotiation is facilitated by information transparency, customisation and proper nudges.

Confront unavailability.

The primary goal of the design is being able to challenge "always available" and creating meaningful low data experience. Pure demand shifting should be avoided since it will potentially burden the infrastructure and result in more demand for construction and energy.

Invent alternative satisfaction.

Guilt is not the panacea to cure the earth. The Pandora's box, Internet has been opened. To make a shift in Internet norm sustain, alternative satisfaction has to be built in to distract the user from the current perceived comfort and redirect them to thoughtful decision. Playful interaction, attractive experience and value are among the approaches.



*How might
design of
tools, interfaces,
devices or
applications
shape
carbon-aware
Internet
experience?*

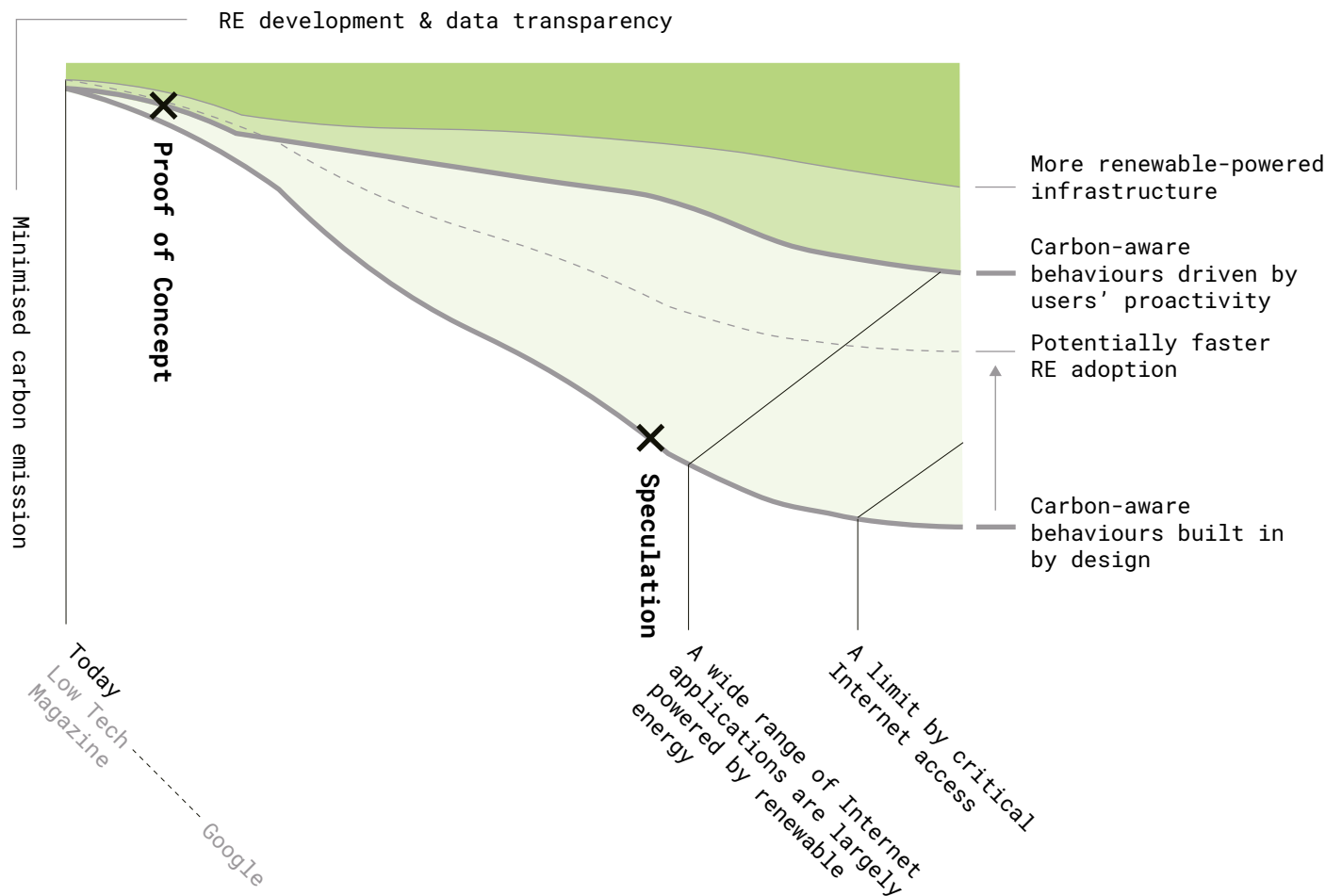
Today in the UK, watching a video during a renewable dominant hour could create only 50% emission of doing so in a fossil fuel heavy hour¹⁷.

This number could theoretically be 1% in the future¹⁸.

EMBODIMENT

Delivery Strategy

The goal of the embodiment is to explore, visualise and validate a route to potential future of the Internet under a carbon-aware, or user behaviour - renewable energy alignment, principle. To make the alignment happen, two hypothesis are made beyond today's situation. First, more and more Internet businesses and applications will be powered largely by renewable energy(RE). Second, the hosting service providers and the applications will inform the users of the energy composition of their infrastructure.



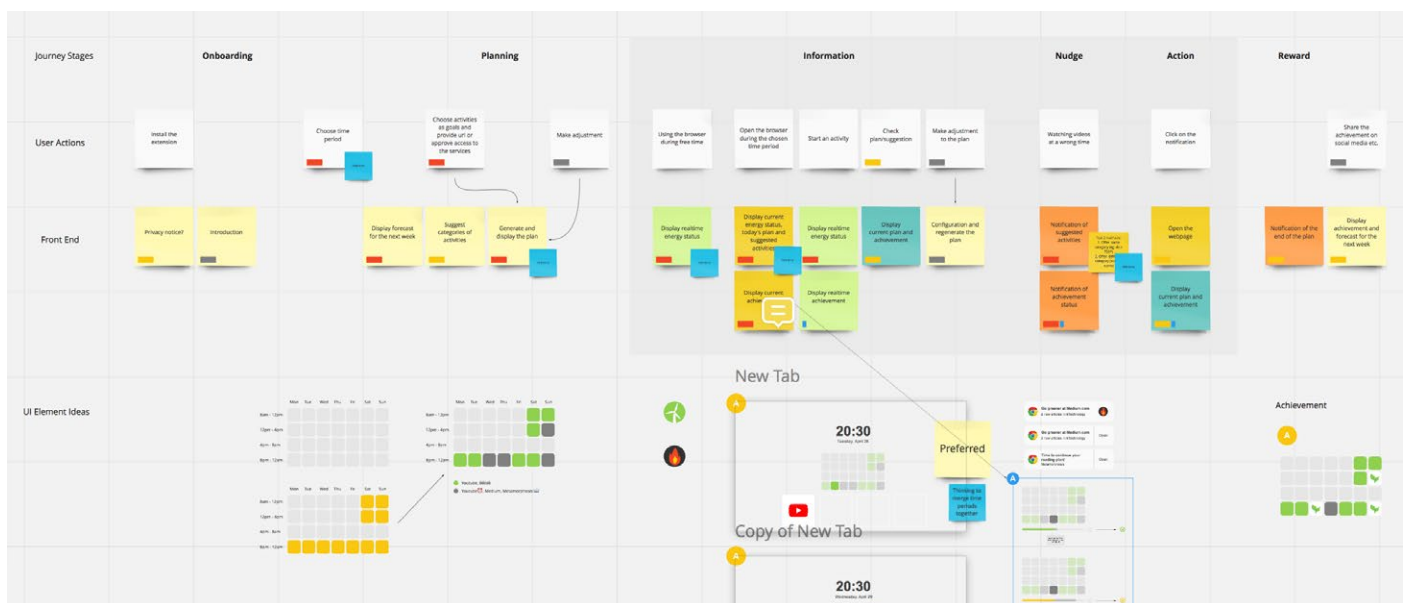
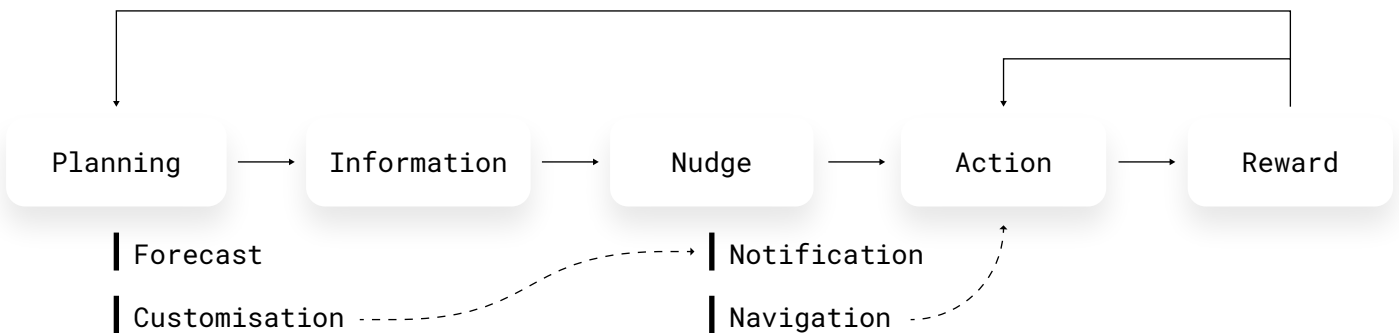
Deliverable of this project consists of two parts: a near-to-today POC built on current behaviours and a design speculation that visualises a future direction.

EMBODIMENT

Proof of Concept

The POC aims to create carbon-aware online behaviours based on today's Internet applications and interfaces. It is built to validate the potential and boundary of users' proactivity in minimising individual's Internet carbon footprint. Insights from the investigation phase are embodied in a browser extension, designed light-weighted and testable.

An advanced journey evolved from EXP4, complemented by insights from the co-design workshops, to empower users by giving **sense of control** and **assistant**.

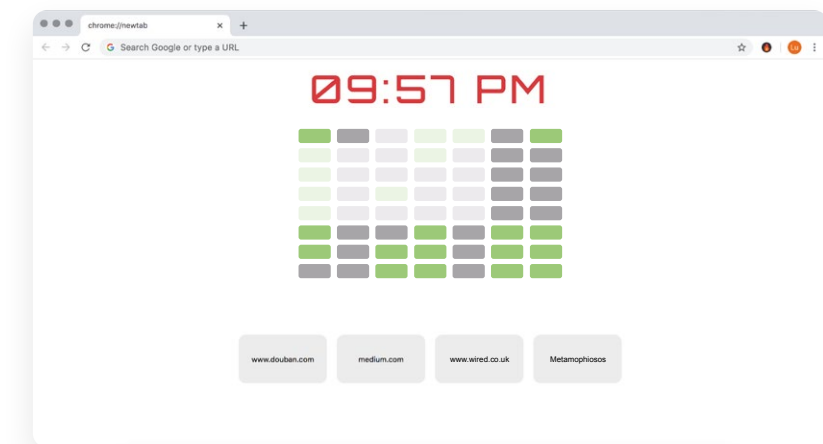
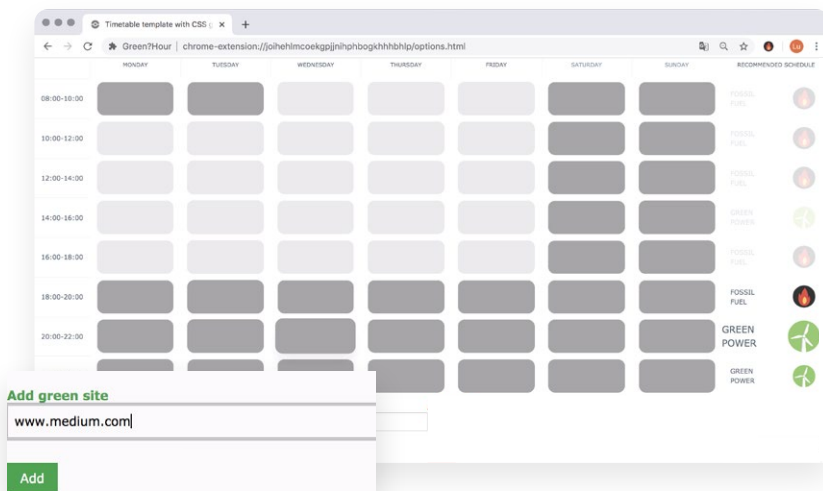
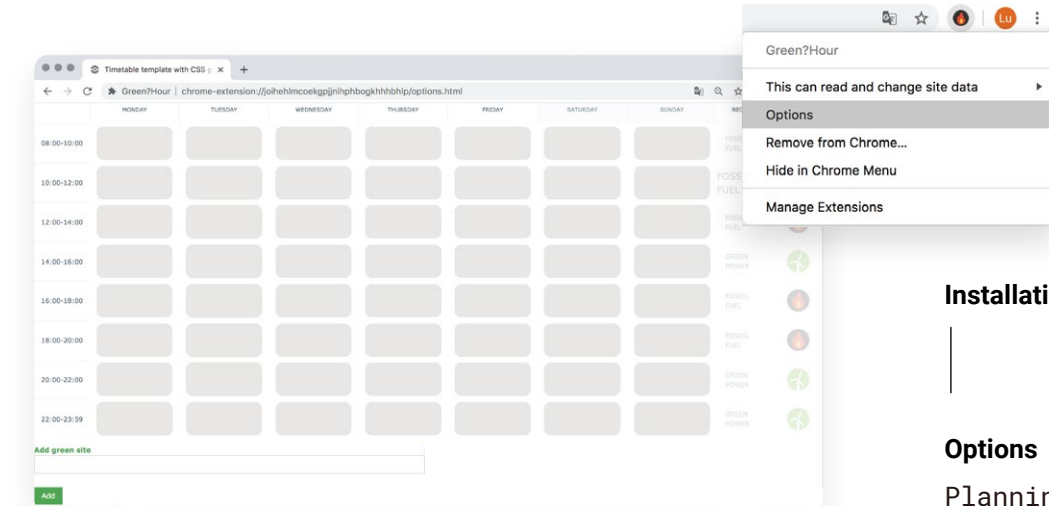


User journey building

Chrome Extension

Version 1.0 *

This extension is built to help people minimise their Internet carbon footprint. It informs you whether a given hour is a Internet “green time”(mostly powered by renewable energy) or “dirty time”(mostly powered by fossil fuel), and encourage you to choose less data- consuming activities(video streaming) during “dirty time”.



Installation

Options

Planning

Time

Drag and select the time that you feel comfortable to make effort for a smaller carbon footprint.

Alternatives

Add light-weighted websites of your interest here for alternatives to video-heavy activities.

New Tab

Information

Icon (Ambient)

Now the Internet application is mainly powered by

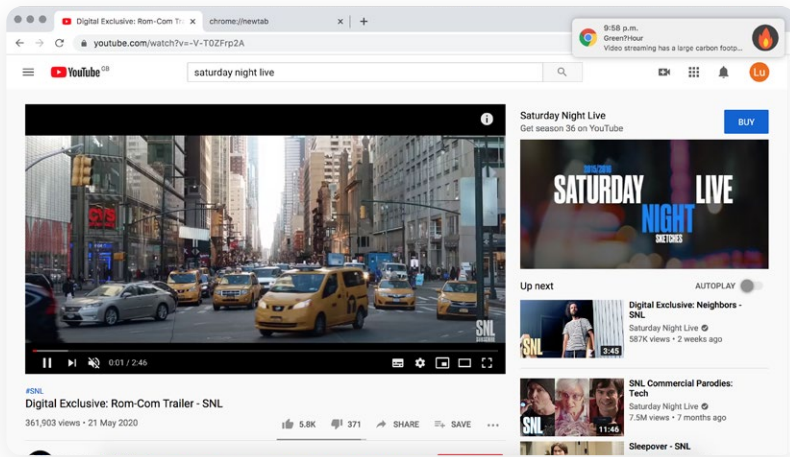
- Renewable energy
- Fossil fuel

Overview of the week

* This version was completed in collaboration with Max Wang(github: Igm3000).

UI design was simplified due to the time constraint.

A demonstration video can be found here: https://drive.google.com/file/d/1OZFkt_iBZDamvoKYsMFMDhm2cIUcy3BW/view?usp=sharing



Video streaming in a “dirty time”

Nudge

Notification

The notifications will either remind you to lower (automatically) the quality of the video or navigate you to a website or an activity you preset.

Action

Navigation

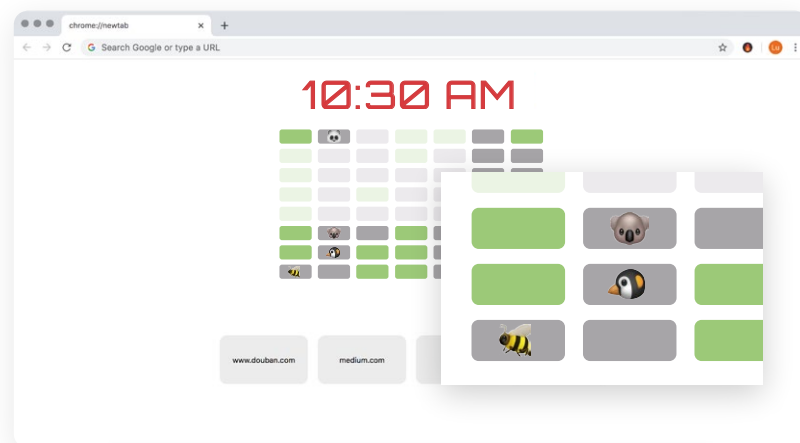
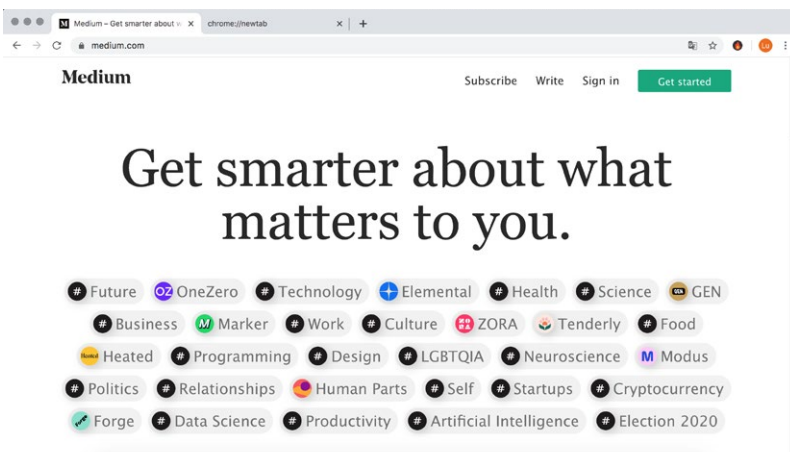
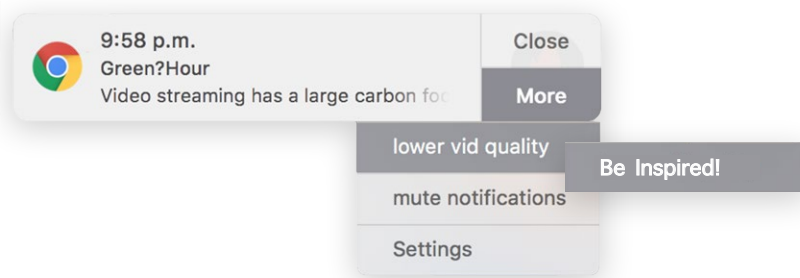
If you click on “Be Inspired”, you the page will randomly jump to a preset website or an activity.

New Tab

Reward

Collection

If you achieve the goal of little video streaming in your committed time, you will be rewarded with a animal badge. The animals are those affected by climate change, and the chance of getting different animals are different.



Chrome Extension Version 1.0 Testing

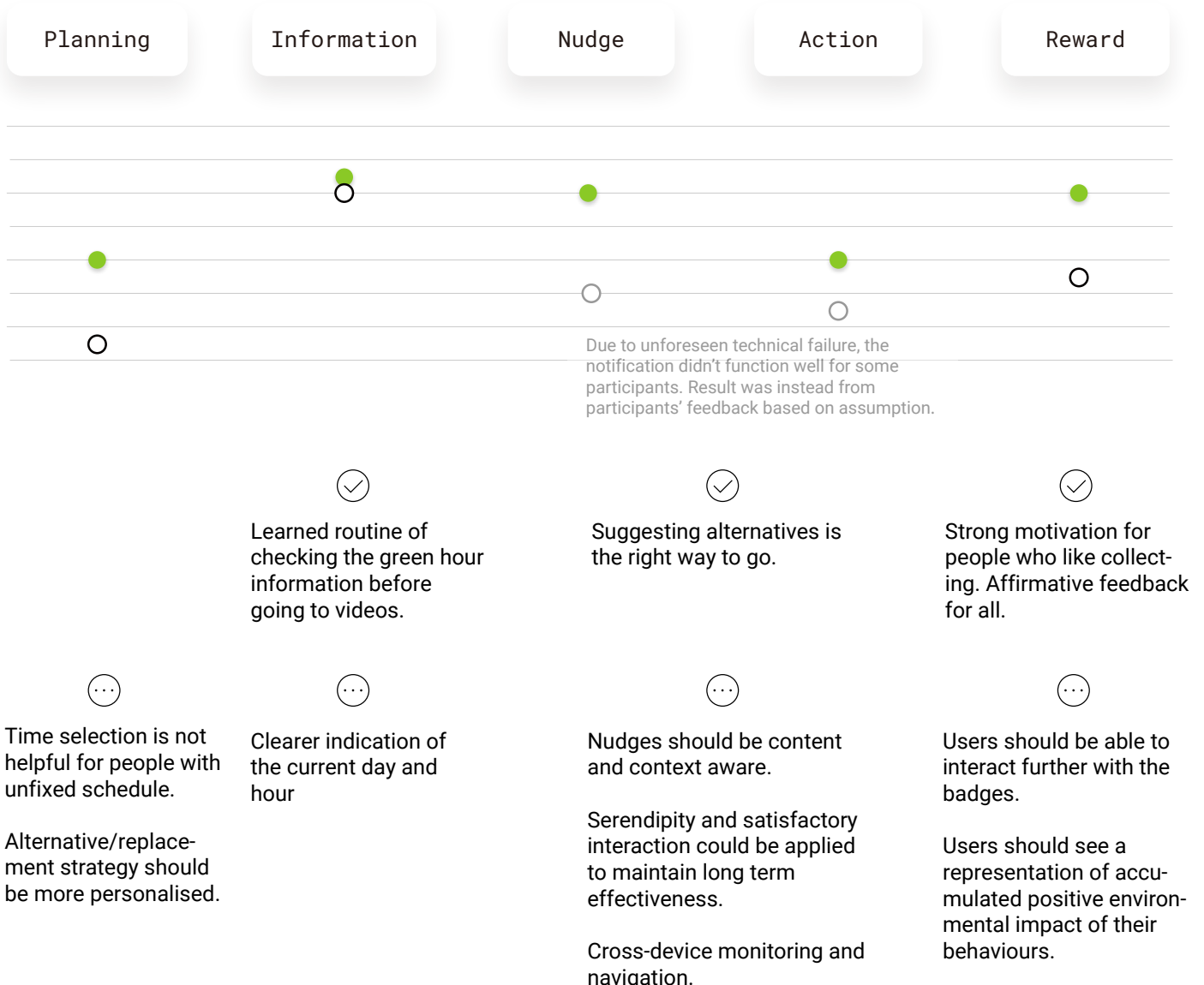
Duration: 24th May (Sunday) - 29th May (Friday)

Trial data source: Time specific data is calculated based on daily wind power generation forecast by Elexon¹⁹ and hourly wind forecast data by XCWeather²⁰.

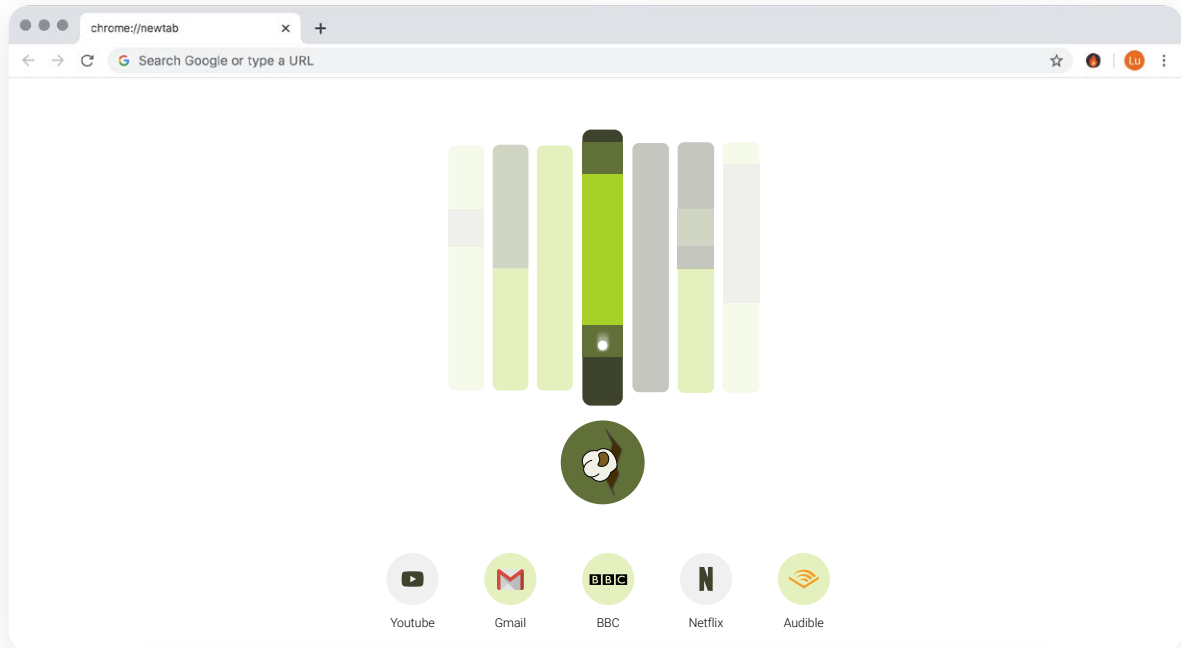
Participants: 7 (Self rating sustainability-aware: 3 are 2/5 and 4 are 3/5)

Result: A qualitative feedback session was done with each participant after the 5-day testing. All the participants reported proactive behaviour change through out the testing in different level.

- Weighted sum of perceived effectiveness
- Estimated effectiveness in next versions



Chrome Extension Version 2.0



Automatically recognized “green sites” from frequently visited websites and Bookmarks

Backend Implementation: Analysing media composition on the webpages + Energy source data from Green Web Foundation

Multi-strategy notifications

Push notifications at the end of the videos. The results of reacting to the notification include the status of the badge.

Gamification of the badges and education

The badges take the name and graphics of endangered animals by climate change. *Hatching* different animals requires different portion of reduced video streaming time, calculated to CO2 emission. Users can interact with the obtained badges to see the exact numbers.

**TODAY THE INTERNET IS
SHAPING OUR BEHAVIOURS.
WHAT IF I TOLD YOU
TOMORROW OUR
BEHAVIOURS COULD
SHAPE THE INTERNET'S
ENVIRONMENTAL IMPACT?**

EMBODIMENT

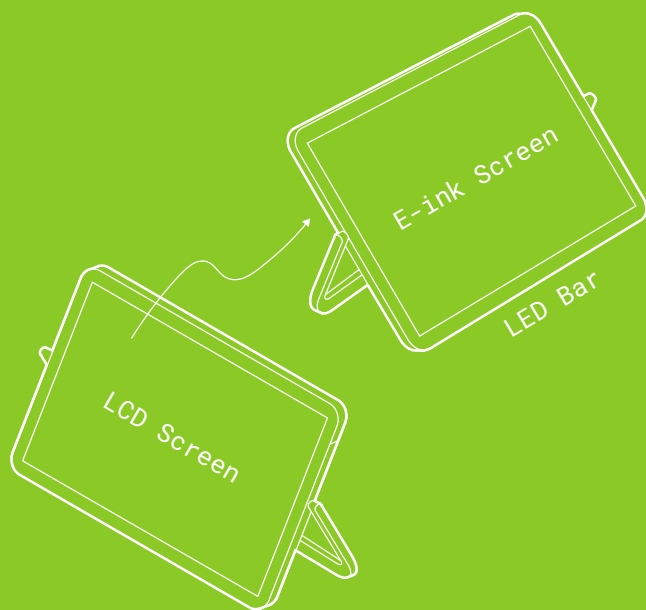
Design Speculation

Advanced Ideation

What do applications and interface for future user engaged carbon-aware Internet look like?

An ideation session was done following the insights from the Investigation phase. Tangible products and interactions was prioritised as an approach to come up with more scenario-focused and fun ideas.

Each idea was then analysed with the journey model from the POC: Planning(P) - Information(I) - Nudge(N) - Action(A) - Reward(R).



#01 A double sided tablet

The tablet is designed for you to switch between video/image heavy content and text-based content. The LED bar indicates wind power availability across the day. During windy hours you use the LCD screen side. In non-windy hour only the e-ink side is usable. To switch, you simply flips the tablet.



Interaction Mockup and Reflection

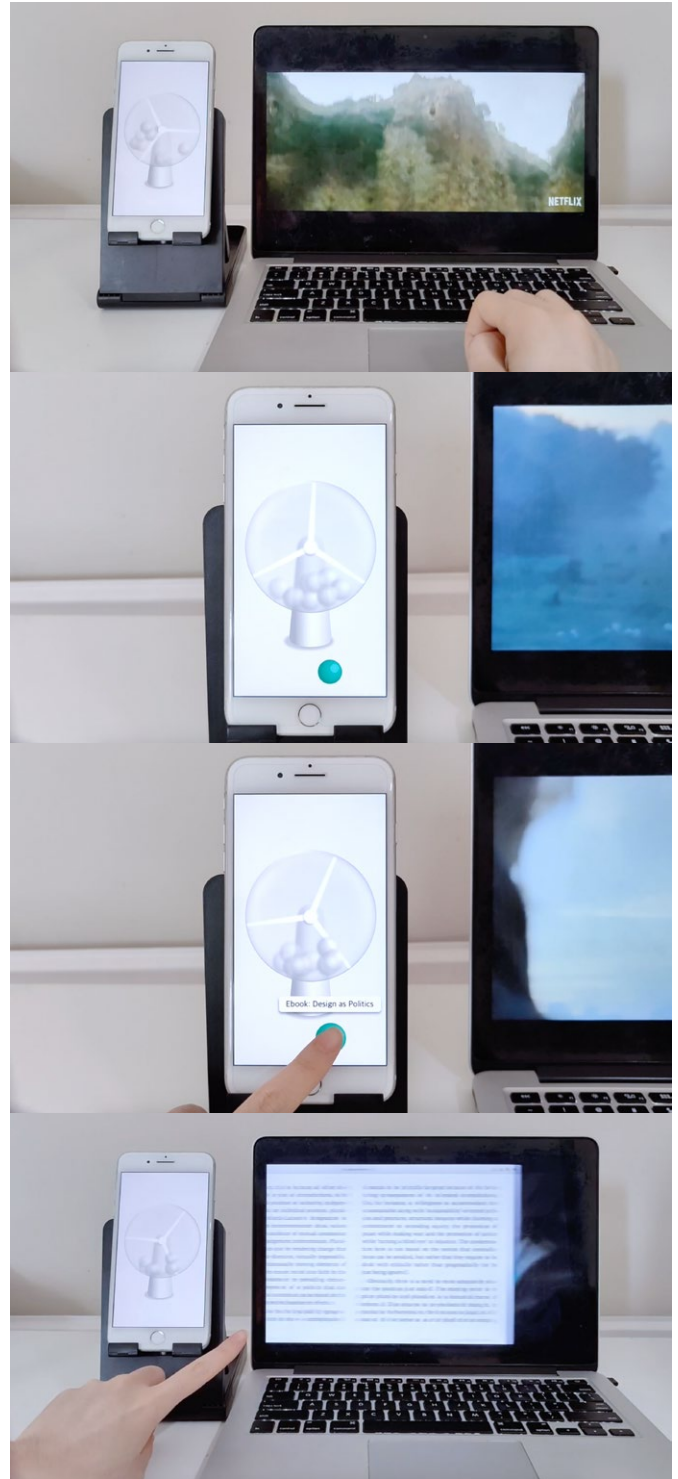
#02, #04 and #06 were chosen for balancing use scenarios and feasibility in demonstration considering the situation. I made a concept video* with experience mockups for detailed storyboarding, idea showcase to others and self reflection.

#02

☺ Fun metaphor embodied in visual and interaction as **alternative satisfaction**

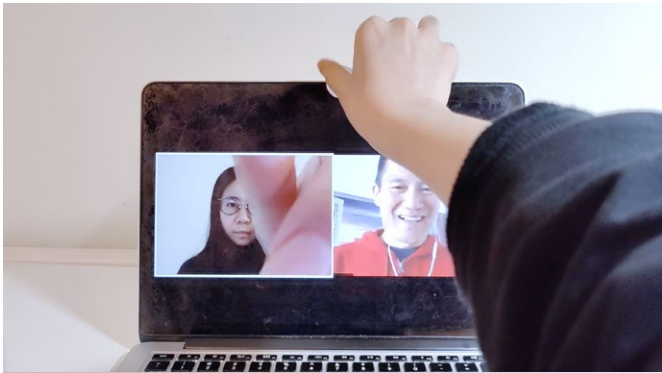
☺ **Neogotiation** accomplished in the same way as the POC.

☺ Need to think of a system, where it all fits together.



* <https://drive.google.com/file/d/1PI8j83VQcd8uauNnWRbuaBXTDsJtpaSC/view?usp=sharing>

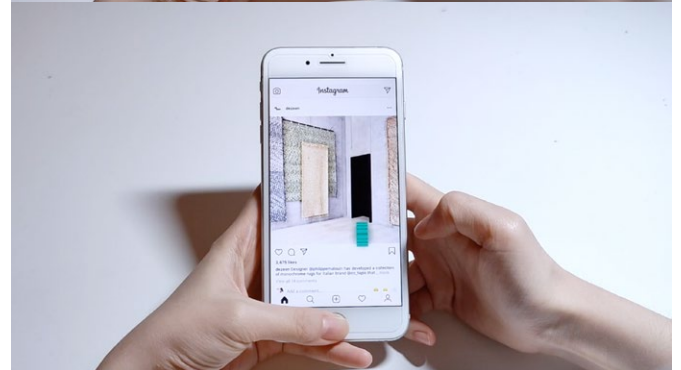
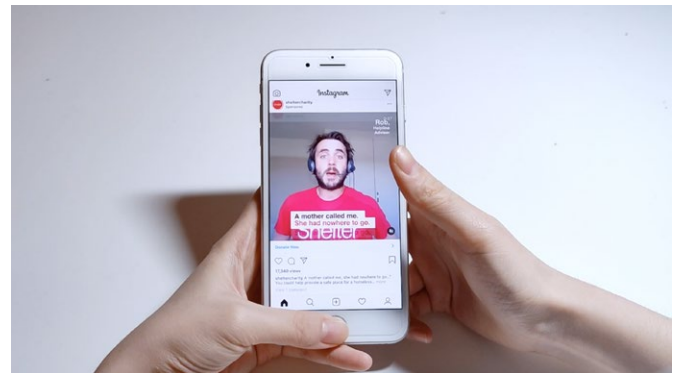
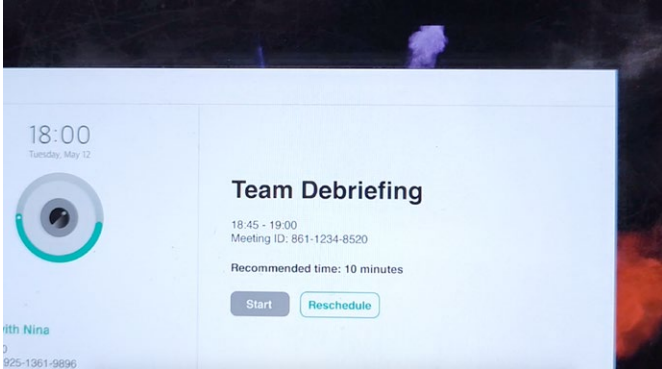
#04



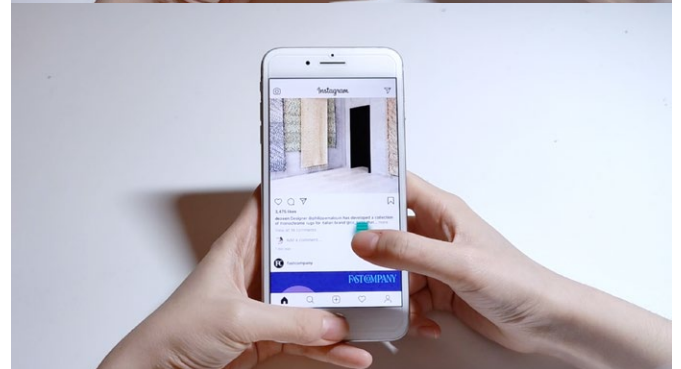
😊 Tangible interaction fits the function



😊 The working context is not strong enough

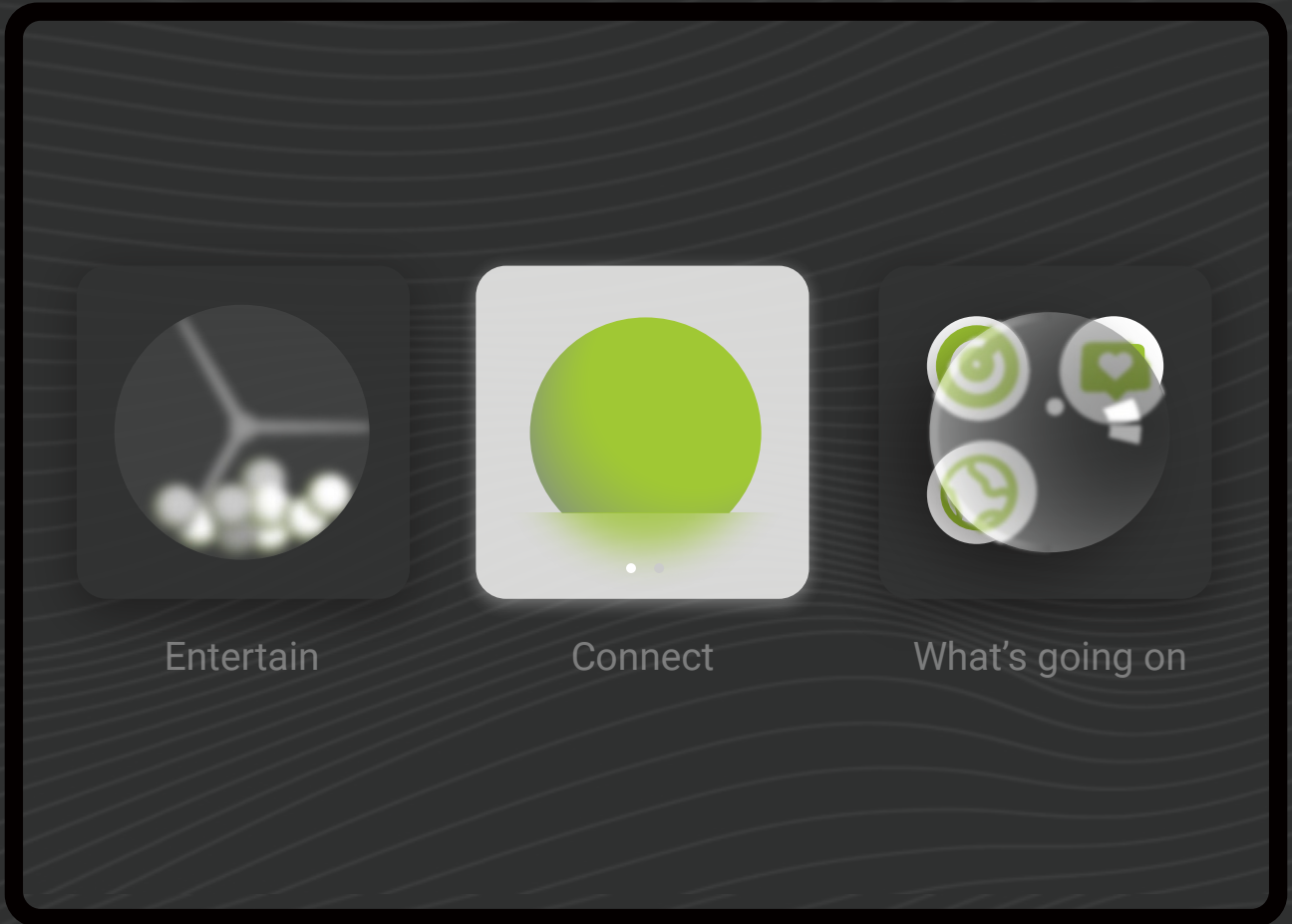


☹️ Negotiation and alternative satisfaction has not been embodied.

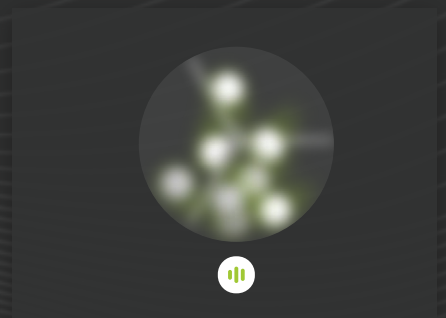


Final Design: Onlign OS and Applications

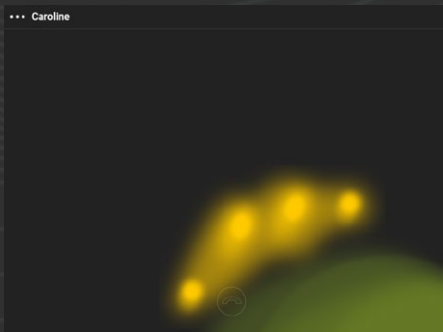
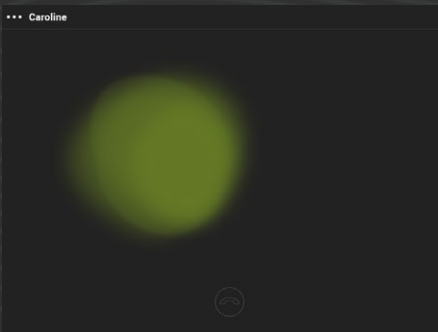
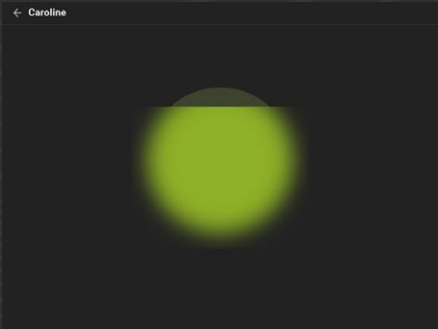
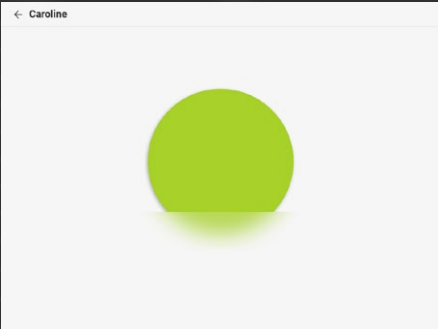
* Draft visuals



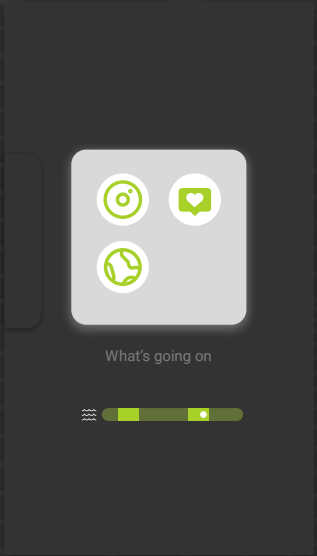
The interaction to enter entertainment applications differs in green hours and dirty hours. During green hours, the user accesses any applications or contents seamlessly with default choosing and clicking. During dirty hours, all the applications are locked in Onlign Lotto. The user spins Onlign Lotto to be granted an access to application as a "serendipity". Time is designated if the application granted is data heavy. After three rounds, the interaction is resumed to the default.



Onlign videotelephony application is run on a solar energy powered cloud. A low data connecting option is offered, where the users' faces are represented graphically, and any touch on the screen will be translated to visual graphics for a subtle sense of connection across the Internet. During non-sunny hour, the low data connecting is recommended.



Onlign manages tidal supported social media applications differently during green hours and dirty hours. During green hours, the user scrolls freely while Onlign Reservoir automatically stores the posts the user would be interested in, and those the user has scrolled through but doesn't spend enough time on. During dirty hours, the user is recommended to scroll through Onlign Reservoir before refreshing for the new content.



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